

**WESTERN PACIFIC ENTERPRISES GP**

**ELECTRICAL TECHNOLOGY AND INSTALLATIONS**

# **Esquimalt Graving Dock – South Side Electrical Supply**

**Standby Power Generation System:**

**PWGSC No. R.057890.003**

**Contract No. EZ108-170397**

## **ELECTRICAL OPERATING & MAINTENANCE MANUAL Volume 2 of 2**

**May, 2017**

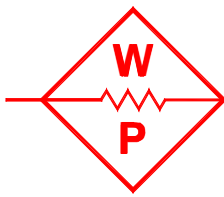
**ELECTRICAL CONSULTANT:**

**AES Engineering Ltd. - Victoria**

**ELECTRICAL CONTRACTOR:**

**WESTERN PACIFIC ENTERPRISES Ltd.**  
1321 Ketch Court, Coquitlam BC, V3K 6X7  
604-540-1321 Fax 604-540-1390



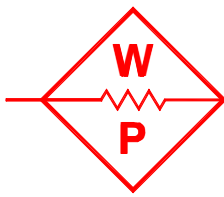


**WESTERN PACIFIC ENTERPRISES GP**

ELECTRICAL TECHNOLOGY AND INSTALLATIONS

**Standby Power Generation System  
PWGSC No. R.057890.003  
Contract No. EZ108-170397  
Electrical Operations &  
Maintenance Manual----- Volume 2 of 2**





**WESTERN PACIFIC ENTERPRISES GP**

**ELECTRICAL TECHNOLOGY AND INSTALLATIONS**

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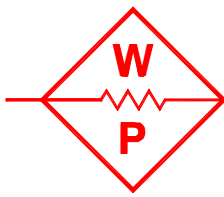
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# marathon™ Thomson Power Systems

Generator Control System

System Description  
and  
Sequence of Operation

Esquimalt Graving Dock

TPS Customer Order No. C-054107

TPS Work Order No. W-095112

January 11, 2017

Rev.1

**System Description / Sequence of Operation**

**Generator Control System**

**ESQUIMALT GRAVING DOCK**

**C-054107, W-095112**

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**Rev 1.** Modifications to PSS Write and Read tables in section 8. Highlighted in green.

# System Description / Sequence of Operation

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### 1. System Description

Thomson Power Systems work order numbers:

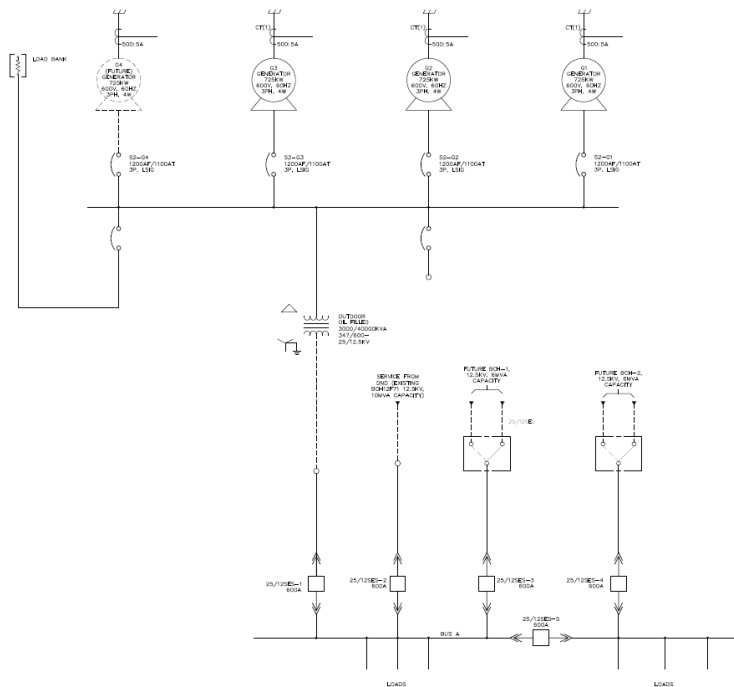
W-095112 Generator Control Panel (5 sections)

W-095113 600V Outdoor Loadbank

The generator control panel is certified to ANSI C22.2. No.14, NEMA 1, metal-enclosed.

Simplified single line diagram:

(Refer to TPS DWG W-095112-030A for detailed single line diagram)



The system consists of three utility incoming supplies, one tie breaker and three 725KW, 600V, standby diesel driven generators.

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*Note: At present only three generators are operational. A fourth generator will be added in the future. Also, only the DND utility is operational at present time.*

The generator control panel provides automatic standby operation with open transition transfer as well as close transition soft load transfer between the utility and generator supply. The normal mode of operation is with the tie breaker closed and "bus 1" and "bus 2" loads fed from any one of three utilities. All three utility breakers are mechanically interlocked in such a way that only one of three utility breakers can be closed at a time. The generators are available to provide backup power to these loads in the event of utility failure.

Hardwired control switches are provided to allow an operator to manually operate the system in the event automatic operation fails. The generator, utility and tie breaker close circuits are hardwired via sync check permissive close contacts so they may only be closed when safe to do so.

A Modbus TCP communication port is provided for customer SCADA use. Data may be accessed at this communication port. The information will include breaker position, generator status (modes, alarms) and metering parameters direct from digital metering units.



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## 2. Description of Controls

The generator control panel includes:

- Digital Sync and Load Control (DSL-2)
- Master Sync and Load Control (MSLC-2)
- Generator Manual Controls
- Breaker Manual Controls
- System Manual Controls
- Protection Relays and Digital Meters
- System Control PLC
- OIT Display - 19" LCD Color Touch Screen Computer
- DM550 Local Engine Controller

The following is a functional description of each control element. Refer to the sequence of operation section for a description of the overall system operation.

### 2.1. Digital Sync and Load Control (DSL-2)

The Woodward DSL-2 is digital automatic synchronizer and load control module designed for generator applications. A DSL-2 controller is installed for each generator.

Refer to the DSL-2 instruction manual for further details.

### 2.2. Master Sync and Load Control (MSLC-2)

The Woodward MSLC-2 is microprocessor based load control designed for three phase power generation sites equipped with Woodward DSL-2 controllers on the generators. MSLC-2 controllers are installed for the three incoming utility breakers as well as the generator main breaker.

Refer to the MSLC-2 instruction manual for further details.

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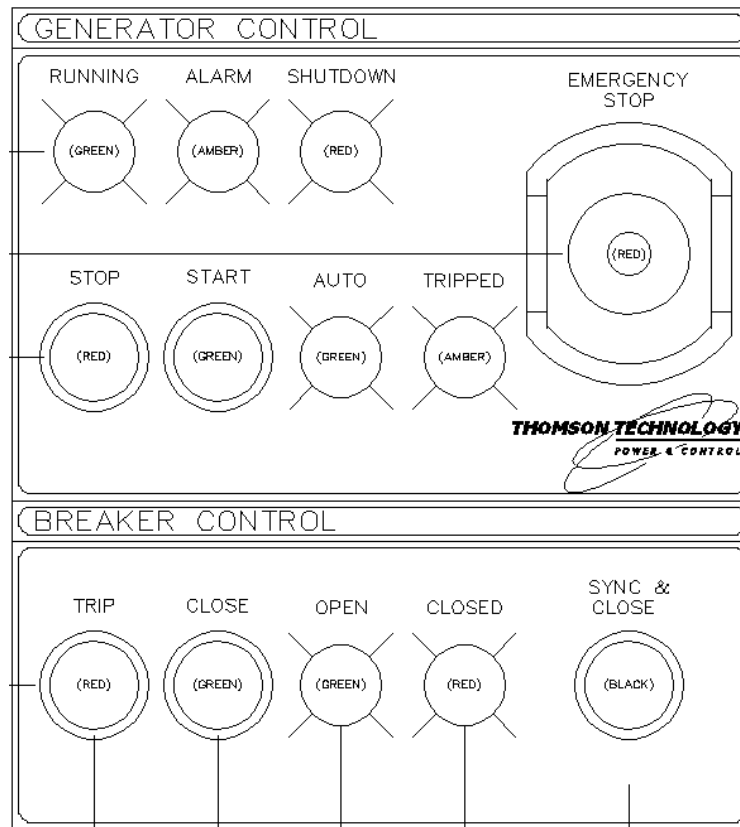
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### 2.3. Generator Manual Controls (GCP)

Manual operation is generally used only when the automatic operation has failed.

The series 2200 manual controls are always active. If the system control switch is left in auto and for instance, breaker trip pushbutton is pressed, it will immediately open the breaker. However, when released the system may automatically reclose the breaker.

*Note: To operate the system manually without interference from the automatic controls, switch the system control switch to manual.*



#### Running, Alarm, Shutdown, Auto Lights

Indicate generator running feedback, common generator alarm, common generator shutdown, and "in auto" status as signaled by the DM550 controller.

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|                                  |  |
|----------------------------------|--|
| <b>Emergency Stop Pushbutton</b> | Immediately trips the generator breaker and stops the engine. The emergency stop button is a push-pull type. To reset the emergency stop, pull the button out to the reset position. |
| <b>Start Pushbutton</b>          | Press the START pushbutton to start the engine. The DM550 will start the engine and the generator will ramp to rated speed and voltage.  |
| <b>Stop Pushbutton</b>           | Press the STOP pushbutton to stop the engine. The DM550 will run the engine for a cooldown time then stop the engine.  |
| <b>Tripped Light</b>             | This light illuminates when the protection relay has tripped the breaker on a fault.   |

|                                       |  |
|---------------------------------------|--|
| <b>Breaker Trip/Close Pushbuttons</b> | Pressing the TRIP pushbutton will immediately open the breaker.<br><br>Pressing the CLOSE pushbutton will close the breaker, as allowed by the protection relay synchronism check.   |
| <b>Breaker Open/Closed Lights</b>     | Monitors the breaker auxiliary contacts to indicate the breaker position, open or closed.  |
| <b>Sync &amp; Close Pushbutton</b>    | To synchronize and close the generator manually onto a live bus, press and hold the "sync and close" pushbutton. The DSLC-2 controller will synchronize the generator to the bus and close the selected generator breaker.<br><br>Once online, the generator will load share with other generators on the generator bus. |

|                              |  |
|------------------------------|--|
| <b>Breaker Lockout Relay</b> | In the event of an electrical fault, the SEL700G protection relay will activate the lockout relay. Once activated, the lockout relay will open the breaker and prevent closure until the fault is cleared and the lockout relay is manually reset. |
|------------------------------|--|

### **Generator Sync Selector Switch**

## System Description / Sequence of Operation

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A sync selector switch is provided for each generator. This switch can be used during manual synchronization to check the phase angle difference between the bus and the incoming generator.

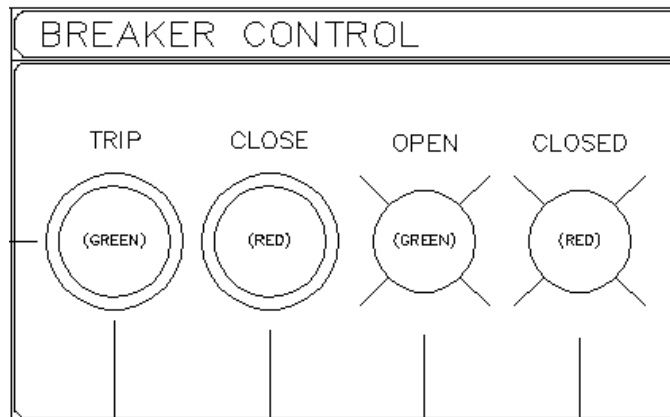
|            |   |
|------------|---|
| <b>OFF</b> | The synchroscope is de-energized.                   |
| <b>ON</b>  | Connects the synchroscope across generator breaker. |

#### 2.4. Breaker Manual Controls (BCP)

Manual operation is generally used only when the automatic operation has failed.

The series 2200 manual controls are always active. If the system control switch is left in auto and for instance, breaker trip pushbutton is pressed, it will immediately open the breaker. However, when released the system may automatically reclose the breaker.

*Note: To operate the system manually without interference from the automatic controls, switch the system control switch to manual.*



|                                       |   |
|---------------------------------------|---|
| <b>Breaker Trip/Close Pushbuttons</b> | <p>Pressing the TRIP pushbutton will immediately open the breaker.</p> <p>Pressing the CLOSE pushbutton will close the breaker, as allowed by the protection relay synchronism check.</p> |
|---------------------------------------|---|

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|   |  |
|---|--|
| <b>Breaker Open/<br/>Closed Lights</b>                                  | Monitors the breaker auxiliary contacts to indicate the breaker position, open or closed.                                      |
| <b>Utility Available /<br/>Emergency<br/>Power Available<br/>Lights</b> | Illuminate when the utility source (DND, BCH-1, BCH-2) or generator source is available (voltage and frequency within limits). |

## 2.5. System Manual Controls (SCP)

|  |  |
|--|--|
| <b>System Control<br/>Switch<br/>(4-position<br/>selector)</b> | <p>In <b>MANUAL</b> the operator can control the system manually without interference from the automatic controls. No automatic operation from the PLC occurs in this mode.</p> <p>In <b>AUTO</b> the generator control PLC is enabled and will automatically control the generators and transfer breakers. <b>This is the default mode.</b></p> <p>In <b>START</b> the generators will start, synchronize and close to the generator bus. However, the load will remain powered by utility (no transfer will occur) as long as the utility remains healthy. If the utility fails in this position, the automatic controls will perform a transfer.</p> <p>In <b>TEST</b> the generators will start, synchronize and close to the generator bus followed by a transfer of load from the utility to generator source.</p> <p>When switching from <b>AUTO</b> to <b>MANUAL</b> the system will remain in its last state (e.g. connected generators would continue to run to serve the load).</p> |
|--|--|

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|   |   |
|---|---|
| <b>ALARM Light,<br/>HORN and<br/>SILENCE<br/>Pushbutton</b> | <p>The system alarm light will be illuminated if any active alarms are present. The alarm detail will be displayed on the OIT display.</p> <p>The horn will sound when an alarm occurs. Press the silence pushbutton to silence the horn.</p> <p>If the alarm is silenced a subsequent alarm will resound the horn (the alarm light will remain on until all alarms are reset).</p> |
|---|---|

## 2.6. Transition Mode Switch

*This is a keyswitch lockable in either position.*

|               |  |
|---------------|--|
| <b>Open</b>   | In open transition, if both utility and generator supplies are energized the transfer controller performs a break-before-make, open transition transfer. |
| <b>Closed</b> | In closed transition mode, if both supplies are available the transfer controller parallels the two sources and performs a soft load transfer.           |

## 2.7. System Sync Selector Switch

A sync selector switch is provided for the system. This switch can connect two live sources to a synchroscope during manual synchronization to determine the phase angle difference between the bus and the incoming. It also enables frequency and voltmeters to check the voltage and frequency differences between the bus and the incoming.

|                 |  |
|-----------------|--|
| <b>OFF</b>      | The synchroscope is de-energized.  |
| <b>DND</b>      | Connects the synchroscope across DND (utility 1) and the 25kV bus 1.               |
| <b>BCH-1</b>    | Connects the synchroscope across BCH-1 (utility 2) and the 25kV bus 1.             |
| <b>BCH-2</b>    | Connects the synchroscope across BCH-2 (utility 3) and the 25kV bus 2.             |
| <b>Gen Main</b> | Connects the synchroscope across the incoming emergency supply and the 25kV bus 1. |

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## 2.8. Protection Relays and Digital Meters

### 2.8.a. SEL 700G (GPR)

The SEL700G is a comprehensive multifunction relay that provides primary generator protection. It is equipped with current protection and synchronism check. Each of the 4 generator breakers is equipped with a SEL 700G protection relay. Please refer to the "SEL 700G multifunction generator relay instruction manual" for more information.

### 2.8.b. ION7650 (DMS)

The Square D ION7650 multifunction digital meter. Each of the 4 generator breakers is equipped with a ION7650 digital meter. Refer to the Square D instruction manuals for more information.

### 2.8.c. PM8240 (DMS)

The Square D PM8240 multifunction digital meter. The load bank control panel is equipped with a PM8240 digital meter. Refer to the Square D instruction manuals for more information.

## 2.9. System Control PLC

Allen Bradley ControlLogix PLC CPU, I/O modules and power supply are all mounted in the system control section. This PLC executes the TSC (transfer control system) logic.

## 2.10. OIT Display - 19" LCD Color Touch Screen Computer

The OIT display is a 19" color touch screen PC, running the Windows 7 Professional OS platform. It is mounted on the front door of the control panel section 5. This display communicates with the system control PLC for visualization and control.

## 2.11. DM550 Local Engine Controller

Each generator is locally equipped with DM550 unit mount auto start generator control panel. These controllers automatically start and stop the generators as signaled by control panel, as well as monitor and protect the generator set.

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### 3. S2400 Software

S2400 software provides three major functions:

- Provide user control
- Allow parameter adjustment
- Display system status information

#### 3.1. Header

The header is displayed at all times.



The following information is provided on this screen:

- Current user that is logged in
- Alarm banner displaying the most recent active alarm (if any)
- A Menu button providing Log In/Log Out functions.



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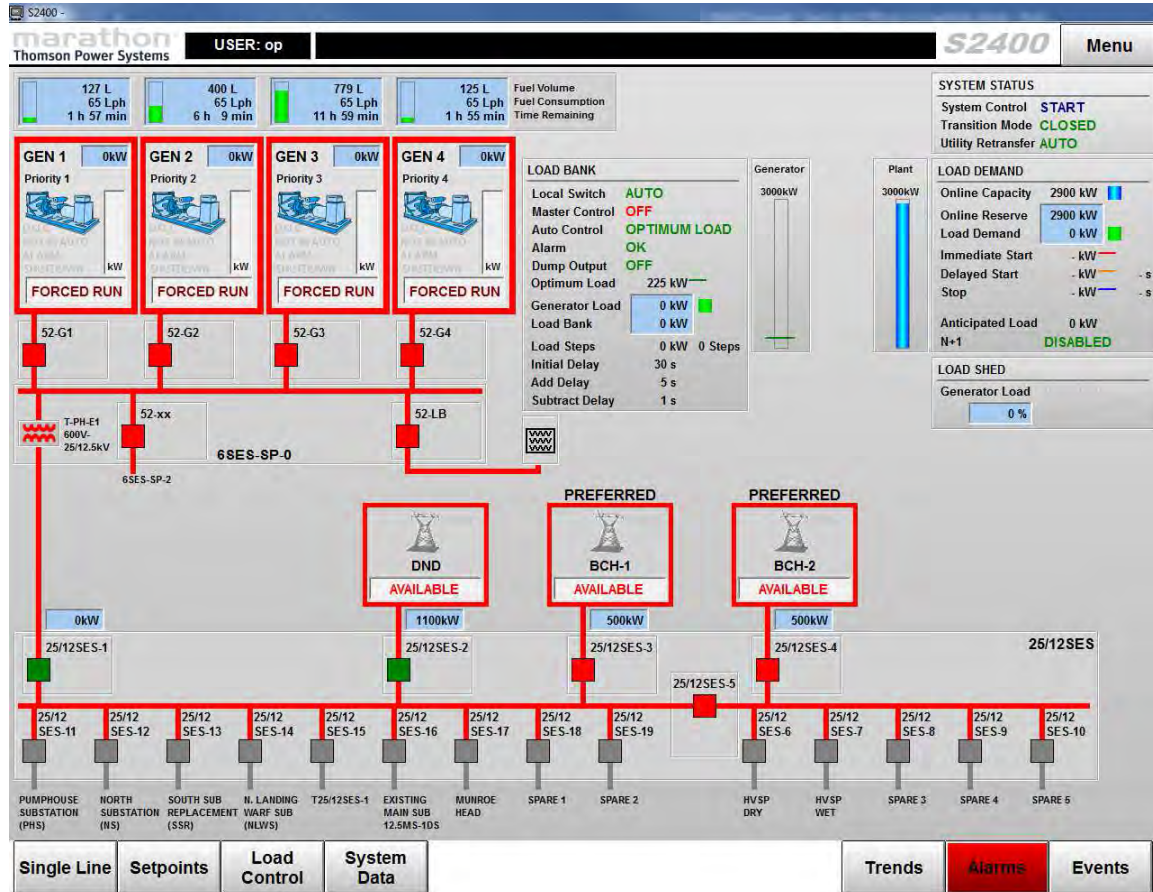
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### 3.2. System Overview Single Line Screen

The single line screen is a dynamic overview of the entire system.



The following information is provided on the screen:

- **Breakers Status:** The breaker symbol will be red when the breaker is closed and green when the breaker is open.
  - **SYNC ### / #** - breaker is attempting to close with the numbers representing the time and number of attempts.
  - **OPEN FAIL** - breaker has failed to open when commanded by the PLC.
  - **CLOSE FAIL** - breaker has failed to close when commanded by the PLC.
  - **TRIPPED** - protection relay has opened the breaker on a fault.

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- **RLY ALM** - protection relay has signaled a self-test failure or has lost power.
- **Generator data:** The generator data is provided by a combination of indicators, text message displays and bar graph representations.
  - **Fuel Status** displays the following information:
    - **Fuel Volume** - current measured fuel volume in the generator fuel tank (L). This is also represented in the bar graph.
    - **Fuel Consumption** - estimated fuel consumption based on the current generator load (10-second average) and a 5-point fuel consumption curve.
    - **Time Remaining** - estimated runtime remaining based on the measured fuel volume and calculated fuel consumption. When the generator is not running, the time remaining is based on the lowest fuel consumption.
    - **Low Fuel** - alarm will appear when the fuel volume falls below the “Low Fuel Alarm (L)” setpoint on the setpoints screen.
  - **The Text Indicators** illuminate for the following conditions:
    - **DSLCL** - the Woodward DSLC-2 controller has signaled a self-test failure or has lost power.
    - **Not In Auto** - the DM550 controller is in manual or off mode of operation and the system controller is not able to control it.
    - **Alarm** - a common alarm has been generated by the DM550 controller.
    - **Shutdown** - a shutdown by the DM550 controller has stopped the generator and it is not available due to a serious malfunction.
  - **The Text Messages** display the following conditions:
    - **NOT READY** – The generator has stopped and an alarm, shutdown or Not In Auto condition will prevent it from being automatically controlled.
    - **STOPPED** – The generator is stopped and the system control is in manual.

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- **READY** – The generator is stopped and the system control is in auto (i.e. the generator ready for operation).
  - **STARTING** – The generator has been commanded to start, but a running feedback signal has not yet been detected.
  - **RUNNING** – The generator is running normally and serving the bus when the breaker is closed.
  - **FORCE RUN** – The generator is running based on a system test.
  - **MANUAL RUN** – The generator is running, but the PLC has not commanded it to run.
  - **LOADING** – The DSLC has been commanded to load the generator kW. Load on this generator should ramp up.
  - **UNLOADING** – The DSLC has been commanded to unload the generator kW. Load on this generator should ramp down.
  - **COOLDOWN** – The generator breaker is open and the engine is running for the pre-programmed cooldown time.
  - **MIN RUN REQ** – The generator is running during a minimum run request period, after which the load demand controls will decide if it should continue to run.
  - **BASE LOAD** – The DSLC is commanded to run the generator at a fixed kW level.
  - **LOAD STOP** – The generator has been stopped due to load demand calculations.
- **Utility data:** The utility data is provided by a combination of indicators and text message displays.
    - **The Text Indicators** illuminate for the following conditions:
      - **MSLC** - the Woodward MSLC-2 controller has signaled a self-test failure or has lost power.
    - **The Text Messages** display the following conditions:
      - **FAILED** – The protection relay at this utility has indicated it is out of limits.
      - **NOT AVAIL** – A condition has made this utility unavailable (breaker fail to close, breaker tripped).

## System Description / Sequence of Operation

### Generator Control System

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- **AVAILABLE**– The protection relay at this utility has indicated it is within limits and available.
  - **LOADING** – The MSLC-2 at this utility has been commanded to increase kW load (command the DSLC-2's at online generators to decrease kW load).
  - **UNLOADING** – The MSLC-2 at this utility has been commanded to decrease kW load (command the DSLC-2's at online generators to increase kW load).
  - **STABILIZE ###**– The protection relay at this utility has indicated it is within limits and the PLC is timing the utility retransfer delay.
  - **FAIL ###** – The protection relay at this utility has indicated it is out of limits and the PLC is timing the source failure delay.
- **System Status:** This section shows the status of the two panel mounted selector switches and the utility retransfer mode (see the “Setpoints” screen for more information).
  - **Load Demand:** This section displays the current start / stop kW levels and timer countdowns for generator load demand.
    - **Online Capacity (kW)** – sum of the online generator nameplate ratings. Shown as blue on the bar graph to the left.
    - **Online Reserve (kW)** – online capacity less the measure generator kW load (ie) maximum load that can be added to the generators before they are loaded to 100%.
    - **Load Demand (kW)** – measured load through the generator main breaker (plant load). This is the load level used to start/stop generators for load demand logic. Shown as green on the bar graph to the left. Does not include load bank load nor load to 6SES-SP-2.
    - **Immediate Start, Delayed Start, Stop** - displays the current start / stop kW levels and timer countdowns for generator load demand logic. Values change as generators come on and offline. These kW levels are shown as red, orange and blue lines on the bar graph to the left.
    - **Anticipated Load (kW)** – sum of the anticipated but not yet online loads as signaled by the PSS via communications.

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- **N+1** – status of the N+1 redundancy setpoint (see Setpoints screen).
- **Load Shed Status:** This displays the calculated generator load (in %). The OVERLOAD, UNDERFREQUENCY and DEAD BUS indicates will blink red when that condition is active. See the “Load Control” screen for more information.
- **Load Bank Status:** This displays the current state of the load bank system. See the “Load Control” screen for more information.
  - **Local Switch** – position of the switch on the load bank controller (either AUTO or NOT IN AUTO).
  - **Master Control** – status of the master control relay in the load bank controller.
  - **Auto Control** – load bank auto mode, as selected on the Load Control screen.
  - **Alarm** – blinks ALARM when the PLC has requested to add load steps but the load bank controller has an alarm and cannot add load.
  - **Dump Output** – status the PLC output that commands the load bank controller to immediately open all load steps.
  - **Optimum Load (kW)** – the calculated load level for the generators based on the ‘Optimum Gen Load (%)’ when the ‘Optimum Load’ mode is selected. This also reflects internal limits applied to this level to coordinate it with load demand setpoints. This value is shown as a green line on the bar graph to the right.
  - **Generator Load (kW)** – sum of the measured online generator kW. This value is shown in the bar graph to the right.
  - **Load Bank (kW)** – measured load bank kW.
  - **Load Steps (kW)** – estimated load bank kW and number of steps commanded by the PLC.
  - **Initial Delay (s)** – counts down prior to the load bank optimum load logic begins.
  - **Add Delay (s)** – counts down prior to adding a load bank step.
  - **Subtract Delay (s)** – counts down prior to subtracting a load bank step.

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### 3.3. Setpoints Screen

The setpoints screen provides access to system parameters/control selections. Setpoints and parameter changes require operator login.

The screenshot displays the 'Setpoints' interface for the Marathon S2400 Generator Control System. The interface is organized into several functional areas:

- SYSTEM MODES:** Controls for Utility Retransfer (Manual/Auto), Gen Fail to Sync Action (Fail Generator/Keep Trying), and Preferred Utility (DND, BCH-1, BCH-2).
- GENERAL SETPOINTS:** A grid of numerical values for parameters such as Breaker Fail to Sync (10), Breaker Fail to Close (5), Breaker Fail to Open (5), Gen Fail to Start (30), Gen Warmup (10), Gens Required For Transfer (3), Wait For Req'd Gens (30), Utility Retransfer Delay (5), Source Failure Delay (5), Live Bus Delay (3), Neutral Delay (3), Source Unloaded Level (200), Extended Run Time (15), and Breaker Fail to Unload (50).
- LOAD DEMAND SETPOINTS:** Controls for Load Demand, N+1 Redundancy, Low Fuel Action, Gen Alarm Action, and Anticipated Loads, with associated numerical values like Immediate Start (200 kW), Delayed Start (400 kW), Stop (500 kW), Bus Minimum Run Time (5 sec), Delayed Start Delay (15 sec), Stop Delay (15 sec), and various load types (Main De-Watering Pumps, Auxiliary De-Watering Pumps, Travelling Cranes, Air Compressors, Building Loads).
- GENERATOR PRIORITY:** A grid for Gen 1-4 with OFF, 1, 2, 3, 4 buttons.

Navigation buttons at the bottom include Single Line, Setpoints, Load Control, System Data, Trends, Alarms, and Events.

The screen consists of a selection of controls and setpoints that define the actions the system will take under specific conditions.

- **Utility Retransfer:** This selector controls how load is transferred back to utility supply when the utility returns from a failure.
  - If **Manual Retransfer** is selected, a “Retransfer To Utility” button will appear on the Single Line screen once a utility returns. The user must press this button in order to transfer load back to the utility supply.

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- If **Auto Retransfer** is selected, a utility retransfer timer will start when a utility has returned. When this timer expires, the system will automatically transfer load back to the utility.
  
- **Gen Fail to Sync Action:**
  - If **Fail Generator** is selected and a generator has a Fail To Sync alarm, the PLC will consider the generator unavailable. Attempts to synchronize the generator will cease. If the generator is running, it will shutdown.
  - If **Keep Trying** is selected and a generator generates a Fail To Sync alarm, the alarm will be annunciated but the generator will keep trying to synchronize. No further action will be taken.
  
- **Preferred Utility:** This selects the utility breaker(s) that will power the 25kV bus. If the preferred utility selection is changed while utility is powering the 25kV bus, there will be an open transition transfer to the new utility (the 25kV loads will be de-energized for the duration of the neutral delay). This is regardless of the transfer mode selected.
  - If **DND** is selected, the DND utility breaker 25/12SES-2 is normally closed when the DND utility is healthy. Other utility breakers remain normally open. Load will be transferred to and from generators based on the DND utility status. The status of other utilities is ignored.
  - If **BCH-1** is selected, the BCH-1 utility breaker 25/12SES-3 is normally closed when the BCH-1 utility is healthy. Other utility breakers remain normally open. Load will be transferred to and from generators based on the BCH-1 utility status. The status of other utilities is ignored.
  - If **BCH-2** is selected, the BCH-2 utility breaker 25/12SES-4 is normally closed when the BCH-2 utility is healthy. Other utility breakers remain normally open. Load will be transferred to and from generators based on the BCH-2 utility status. The status of other utilities is ignored.
  - If **BCH-1/ BCH-2** is selected, the BCH-1 and BCH-2 utility breakers 25/12SES-3 and 25/12SES-4 are normally closed when the BCH-1 and BCH-2 utilities are healthy. Other utility breaker remains normally open. Load will be transferred to and from generators based on the BCH-1 and BCH-2 utility status. The status of the other utility is ignored.

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- **Breaker Fail to Sync (sec):** This timer monitors the amount of time two sources requires to synchronize and the breaker to close. If synchronization and closure cannot be achieved by the end of three (3) of these sync periods, a Fail to Close alarm will be generated. If this is for a generator, the action taken will be based on the 'Gen Fail to Sync Action' selection made.
- **Breaker Fail to Close (sec):** This timer monitors the amount of time a breaker takes to close once a close command is issued. If the close time exceeds this setpoint, a Fail to Close alarm will be generated. This timer only applies to breakers connecting only one possible live source.
- **Breaker Fail to Open (sec):** This timer monitors the amount of time a breaker takes to open once an open command is issued. If the open time exceeds this setpoint, a Fail to Open alarm will be generated.
- **Generator Fail to Start Delay (sec):** When a run command is issued to a generator, a start timer will monitor the generator startup sequence. If a "generator running" signal is not received before the time elapses, a Fail To Start alarm is generated. **NOTE: The engine controller independently monitors the fail to start time of the engine. This S2400 fail to start timer should be set LONGER than the engine controller fail to start timer to ensure the engine controller detects the fail to start event first (overcrank). This engine controller overcrank shutdown will appear at the PLC as a 'common shutdown'.**
- **Generator Warm-up (sec):** When a generator is called to run to support a load transfer (when utility is still supporting the load), the PLC will run this warm-up delay prior to synchronizing / closing a generator to the 600V generator bus. During this warm-up, a button will appear on the Single Line for each generator allowing the operator to bypass the timer. If the generator is called to start for a utility failure, the warm-up delay is automatically bypassed.
- **Gens Required For Transfer and Wait For Required Gens (sec):** When generators are required to take over the load, there must be a



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- certain number of generators closed (**Gens Required For Transfer**) to the 600V generator bus prior to closing the generator main breaker.
- During a load test (when utility is still supporting the load), this requirement must be met. Load will not be transferred to generators otherwise.
  - During a utility failure (when the load is dead), a timer begins once the first generator energized the 600V generator bus. If the required number of generators cannot close the 600V generator bus within the **Wait For Required Gens (sec)** time, the generator main will close anyway. This logic can be blocked by setting this setpoint to '0' (system will wait indefinitely for the required generators prior to closing the generator main).
  - As well during a utility failure, the PLC determines generators that are not available and not expected to come online (shutdown, breaker tripped, not in auto, etc). If the PLC determines that all available generators are online, the generator main will be allowed to close.
- **Utility Retransfer Delay (sec):** After a utility failure, when the utility supply returns a utility retransfer timer will delay the transfer to utility to ensure a stable utility source. This timer is only applicable when the "utility retransfer" is selected as "auto retransfer".
  - **Source Failure Delay (sec):** When the utility fails, the PLC applies this delay prior to starting generators. If the utility returns prior to expiration of this timer, generators will not start.
  - **Live Bus Delay (sec):** After a source closes on a dead bus, a short period of time is allowed for stability purposes. Other sources are allowed to synchronize to this bus only after this time has expired.
  - **Neutral Delay (sec):** After a bus goes dead, the bus must remain dead for this period of time before the PLC will command a source to close to this bus.

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- **Source Unloaded Level (kW):** During a soft load transfer, the exiting source breaker will open when the kW load across it drops below this level. **NOTE: this applies to the generator main breaker only. Other breakers open according to the setpoint in the DSLC-2 or MSLC-2 controller.**
  
- **Extended Run Time (sec):** After generators are no longer required to run (generator main breaker open), the generators will run for this amount of time before cooling down and stopping.
  
- **Breaker Fail to Unload (sec):** When soft loading, the PLC monitors the amount of time for the transfer. If sources cannot unload within this time, the PLC continues to open the exiting breaker regardless of load.
  
- **Load Demand:** This selector controls if load demand starting and stopping of generators is enabled.
  - If **Disable** is selected, any event that requires generators will cause all available generators to start and run online to support the load. Regardless of plant load or excessive online generator capacity, all generators will run online during the event.
  - If **Enable** is selected, generators will be started and stopped to optimize the online generator capacity based on the plant load during the event.
  
- **N+1 Redundancy:** This selector controls if extra generator capacity should be kept online when the load is powered by generators.
  - If **Disable** is selected, load demand logic will maintain the number of generators online according to the setpoints (below).
  - If **Enable** is selected, the equivalent of one generator (nameplate kW rating) is internally added to the load demand setpoints. This has the effect of keeping one extra generator online than would normally be online due to load demand logic.
  
- **Low Fuel Action and Low Fuel Alarm (L):** When the measured generator fuel falls below the 'Low Fuel Alarm (L)' setpoint, a low fuel

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alarm is annunciated. This selector controls the action a generator will take if a low fuel alarm is generated. Note this logic is only active when Load Demand is enabled.

- If **Replace Generator** is selected and a single online generator generates a low fuel alarm, the lower priority generator (if not already online) will start. Once the replacement unit is online, the generator in alarm will be taken offline. Once the alarm condition is rectified and the alarm is reset, the generator will become available and be part of the sequencing again. If the alarmed generator is the last one in sequence or no other generator is available to replace it, it will remain online.
- If **Keep Running** is selected and the single online generator generates a low fuel alarm, the generator will keep running and the alarm will be annunciated. No further action will be taken.
- **Gen Alarm Action:** This selector controls the action a generator will take if a common alarm is generated. Note this logic is only active when Load Demand is enabled.
  - If **Replace Generator** is selected and a single online generator generates a common alarm, the lower priority generator (if not already online) will start. Once the replacement unit is online, the generator in alarm will be taken offline. Once the alarm condition is rectified and the alarm is reset, the generator will become available and be part of the sequencing again. If the alarmed generator is the last one in sequence or no other generator is available to replace it, it will remain online.
  - If **Keep Running** is selected and the single online generator generates a common alarm, the generator will keep running and the alarm will be annunciated. No further action will be taken.
- **Load Demand Setpoints:** The Load Demand setpoints control the automatic starting and stopping of the generators based on the level of the load the generators are required to take over. All the values are bus reserve capacities (ie. Online generation capacity minus actual online load). The actual calculated kW level of the start and stop setpoints are displayed on the single line screen. The kW values change as generators are started or stopped, and will always show the current level at which the next generator(s) will start or stop. They are as follows:

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- **Immediate Start kW:** When the bus reserve is less than this set point, the lower priority generator will be started immediately. The system will try to rapidly increase the generating capacity under fast changing load conditions and prevent system overload.
  - **Delayed Start kW / Delay:** Under normal conditions, if the load increases and the bus reserve is less than the entered set point for the duration of the entered delay period, the lower priority generator will be started in order to support the demand. This set point must be a greater number than the immediate start set point. The time delay must be set in such way that it would prevent starting of additional generators during short duration load transition periods.
  - **Stop kW / Delay:** The stop set point is used to shut down the lower priority generator in the sequence if the load demand decreases below this point for the duration of the entered delay period. **Note** that the system compares this set point with the bus reserve capacity if the lower priority generator would be taken offline. For example, with two 2000kW generators online with a stop set point set at 300kW, the lower priority generator would be stopped when the bus load fell below 1700kW for the delay time ( $4000\text{kW} - 2000\text{kW} - 300\text{kW} = 1700\text{kW}$ ). The Stop Delay must be set in such way to prevent the generator(s) from be taken offline during short duration transition periods.
  - **Bus Minimum Run Time:** When an event requires generators, all available generators are called to start and close to the bus. Once the generators are powering the load, the bus minimum run timer begins. When this timer expires, the load demand setpoints become active and generators are started and stopped as required.
- **Generator Priority:** A programmable priority (OFF, 1, 2, 3, 4) setting is available for each generator to determine the sequence in which generators will be started and stopped due to load demand. Multiple generators can be assigned the same priority (they will start and stop at the same time). Priorities can be changed while the generator is running, but can only be set to OFF when the generator has stopped.
  - **Anticipated Loads:** The total anticipated load (kW) is the sum of the loads (kW) that are anticipated to come online but are not yet online, as signaled by the PSS. This allows the PSS to increase the online generator capacity prior to starting large site loads.

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- If **Disable** is selected, load demand logic will maintain the number of generators online according to the setpoints (ignore the anticipated loads).
- If **Enable** is selected, the total anticipated load is internally added to the load demand setpoints. This has the effect of increasing the online generator capacity (bring more generators online) so the online generators will be able to accept these oncoming loads without overloading. The 'Anticipated But Not Online" indicator will illuminate red when the PSS wishes to increase the generator capacity by the respective kW value. Once the load is online, the PSS will revoke the signal and the indicator will extinguish.

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### 3.4. Load Control Screen

The Load Control screen provides access to parameters/control selections for the load bank and load shed logic. Access to the screen adjustments and control mode selections requires operator login.

The screenshot displays the 'Load Control' interface. At the top, it shows 'marathon Thomson Power Systems', 'USER: op', and 'S2400 Menu'. The main title is 'Load Control'. The interface is divided into three primary control areas:

- LOAD BANK PLC CONTROL:** Features three mode buttons: 'Off', 'Manual Steps' (highlighted in red), and 'Optimum Load'. Below these are 'READY' indicators and several parameter fields: 'Optimum Gen Load (%)' (85), 'Initial Delay (sec)' (30), 'Add Delay (sec)' (5), 'Remove Delay (sec)' (5), and 'Fast Remove (sec)' (1).
- LOAD BANK MANUAL STEPS:** A grid of 20 steps (Step 1 to Step 20), each with 'Open' and 'Close' buttons.
- LOAD SHED SETUP:** Contains three sections: 'Shed On Overload' (Disable/Enable buttons, Setpoint (%) at 101, Generator Load at 0%), 'Shed On Underfreq' (Disable/Enable buttons, with a note: 'Note: Underfrequency setpoint adjustable in SEL700G configuration'), and 'Shed On Dead Bus' (Disable/Enable buttons).

On the left side, there is a 'LOAD BANK' status panel with indicators for 'Local Switch' (AUTO), 'Master Control' (OFF), 'Auto Control' (MANUAL STEPS), 'Alarm' (OK), and 'Dump Output' (OFF). It also shows 'Optimum Load' (225 kW), 'Generator Load' (0 kW), and 'Load Bank' (0 kW). Below this are 'Load Steps' (0 kW, 0 Steps), 'Initial Delay' (30 s), 'Add Delay' (5 s), and 'Subtract Delay' (1 s). A 'Generator' status indicator shows '3000kW'.

At the bottom, a navigation bar includes 'Single Line', 'Setpoints', 'Load Control', 'System Data', 'Trends', 'Alarms', and 'Events'.

### Load Bank PLC Control

**OFF** - The PLC disables all load steps and disables the load bank master control. ***Load bank control is still available at the local load bank control panel.***

**MANUAL STEPS** - When generators are powering the 600V generator bus, each of the 20 load bank steps can be manually opened/closed via the pushbuttons on to the right.

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**OPTIMUM LOAD** - When generators are powering the 600V generator bus, the PLC will use the load bank to load the online generator(s) to an optimum load level (summation of plant load and load bank load) according to the setpoints below.

- **Optimum Gen Load (%)** - The PLC attempts to add/remove load bank steps to keep the online generators loaded to this setpoint (% of online generator capacity)
- **Initial Delay (sec)** - Once generators have powered the plant and load demand (if enabled) has settled on the number of generators required to serve the plant load, an “initial delay” timer is started. Once expired, the system control PLC will begin load bank control.
- **Add Delay (sec)** - If the generator load is lower than the “optimum gen load” for the duration of the “add delay”, the system control PLC will enable the load bank and add a load step (50kW). If the generator load remains lower than the “optimum gen load” for the duration of another “add delay”, the system control PLC will add another load step (50kW). This continues until the generator load is within 50kW of the optimum load level, or until all load bank steps have been added.
- **Remove Delay (sec)** - If the generator load is higher than the “optimum gen load” for the duration of the “remove delay”, the system control PLC will remove a load step (50kW). If the generator load remains higher than the “optimum gen load” for the duration of another “remove delay”, the system control PLC will remove another load step (50kW). This continues until the generator load is within 50kW of the optimum load level, or until all load bank steps have been removed.
- **Fast Remove Delay (sec)** – All load bank steps will be removed quickly based on the “fast remove delay” prior to a utility retransfer, if anticipated loads are signaled by the PSS or load demand signals a generator will be removed from the bus.

### Load Bank Manual Steps

When the Load Bank PLC Control is selected as ‘Manual Steps’, use the ‘Open’ and ‘Close’ pushbuttons to disable/enable each load step manually. Note that it is possible to overload the generators if too much load is added.

### Load Shed Setup

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- **Shed on Dead Bus:** When enabled, a load shed signal will be given to the PSS when the 25kV bus goes dead prior to transfer to generators.
- **Shed on Overload:** When enabled, a load shed signal will be given to the PSS when the online generators are loaded above the **Setpoint (%)**.
- **Shed on Underfreq:** When enabled, a load shed signal will be given to the PSS when the online generators experience an under frequency condition.



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### 3.5. System Data Screen

The System Data screen provides information on ancillary systems and communications.

The screenshot displays the 'SYSTEM DATA' screen from the S2400 control system. The interface includes a header with the 'marathon' logo, Thomson Power Systems, a user field 'USER: op', the system name 'S2400', and a 'Menu' button. The main content area features a central diagram of a PLC rack connected to an OIT (Operator Interface Terminal) and a Load Bank PM8240. The PLC rack contains four ION7650 / SEL-700G modules. To the right of the diagram are three status tables:

| CPU Status          | I/O Status   | Power Status        |
|---------------------|--------------|---------------------|
| Minor Error         | Slot 1 Fault | 24VDC Supply 1 Fail |
| Major Error         | Slot 2 Fault | 24VDC Supply 2 Fail |
| I/O / Network Error | Slot 3 Fault | 125VDC Supply Fail  |
|                     | Slot 4 Fault |                     |
|                     | Slot 5 Fault |                     |
|                     | Slot 6 Fault |                     |
|                     | Slot 7 Fault |                     |
|                     | Slot 8 Fault |                     |

At the bottom of the screen, there are navigation buttons for 'Single Line', 'Setpoints', 'Load Control', 'System Data', 'Trends', 'Alarms', and 'Events'.

The following information is provided on the screen:

- **CPU Status:** Indicators illuminate red when the condition exists.
- **I/O Status:** Indicators illuminate red when the specified card has indicated a fault.
- **Power Supply:** Indicators illuminate red when the specified power supply has failed.
- **OIT – PLC Communication Alarm** – will appear and flash when the OIT has lost communicating with the PLC.

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- **PSS Communication Alarm** – the PSS is a ModbusTCP client (master) and the PLC a ModbusTCP server (slave). This communication link passes information between the two systems. When the PSS is no longer communicating with the PLC, this alarm will appear and flash.

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### 3.6. Alarm Screen

The Alarms screen is a date and time stamped list of alarms that have occurred. Date and time stamps on this screen are by S2400. This screen provides summary of currently active alarms, the ability to acknowledge alarms, and a history of alarms.

The user can select between online and historical alarms, select which column to be displayed, acknowledge one or multiple alarms at once and has the option to print the alarm list to a .pdf file.

The screenshot displays the S2400 Alarm Screen interface. At the top, the user is logged in as 'op' and the system is identified as 'S2400'. The main area shows a table of alarms with columns for Event Time, Message, and Username. Below the table, there are buttons for 'Active', 'History', 'Columns', 'Filter', 'View All', and 'Print'. A summary section shows 'Total Alarms' and 'Unacknowledged Alarms' counts, along with 'Ack Air', 'Ack Top', and 'Ack All' buttons. At the bottom, there are buttons for 'Single Line', 'Setpoints', 'Load Control', 'System Data', 'Trends', 'Alarms', and 'Events'.

| Event Time          | Message                                    | Username |
|---------------------|--|----------|
| 11/01/2016 11:54:26 | Utility BCH-1 Failed                       | op       |
| 11/01/2016 11:40:51 | Load Bank Alarm                            | op       |
| 11/01/2016 11:13:24 | Generator 2 Common Shutdown                | op       |
| 11/01/2016 11:12:43 | Generator 1 Common Alarm                   | op       |
| 11/01/2016 11:08:53 | Generator Main Breaker (25kV) Fail to Open | op       |
| 11/01/2016 11:08:50 | Loads Shed Issued                          | op       |
| 11/01/2016 11:08:20 | Utility BCH-1 Fail to Close                | op       |

Use the **Filter** button to group or search for specific alarms.

Use the **Columns** buttons at the bottom of the screen to display the data in the desired format.

The **Print** button will print the alarm list to a printer or file depending on the configuration done by pressing the **Printer Settings** button.

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Individual Acknowledge buttons allow the user to acknowledge a specific alarm, only the top alarm or acknowledge all alarms.

An Active / History selection allows for the display of only the on-line (active) alarms, or displays an alarm history.

Also, the total number of alarms and the number of total unacknowledged alarms is displayed at the bottom of the screen.

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### 3.7. Event Screen

The Events screen is a date and time stamped list of events that have occurred. Date and time stamps on this screen are by S2400. The user can sort the list according to any of the columns, and has the option to print the list to a .pdf file.

The screenshot shows the S2400 Event Screen interface. At the top, there is a header bar with the 'marathon' logo, 'Thomson Power Systems', 'USER: op', 'S2400', and a 'Menu' button. Below the header is a table with three columns: 'Event Time', 'Username', and 'Message'. The table contains a list of events starting from 11/01/2016 14:12:17. The events include actions like 'Load Bank PLC Manual Step Control SELECTED', 'Generator 4 Breaker CLOSED', 'Generator 3 Breaker CLOSED', 'Generator 2 Breaker CLOSED', 'Generator 3 RUNNING', 'Generator 4 RUNNING', 'Generator 2 Breaker OPEN', '25kV Generator Main Breaker OPEN', 'Utility BCH-2 Breaker CLOSED', 'Utility BCH-1 Breaker CLOSED', 'Generator 4 NOT RUNNING', 'Generator 3 NOT RUNNING', 'Generator 3 Breaker OPEN', 'Generator 4 Breaker OPEN', 'Load Bank Load Dump Output DE-ENERGIZED', '25kV Generator Main Breaker CLOSED', 'Load Shed on Dead Bus FALSE', 'Utility BCH-2 Breaker OPEN', 'Utility BCH-1 Breaker OPEN', 'Load Shed on Dead Bus TRUE', 'Load Bank Master Control Relay DE-ENERGIZED', 'Load Bank Load Dump Output ENERGIZED', 'Load Bank Master Control Relay ENERGIZED', 'Load Bank PLC Manual Step Control SELECTED', 'Load Bank PLC Optimum Load Control DE-SELECTED', 'Generator 4 Breaker CLOSED', 'Generator 3 Breaker CLOSED', 'Generator 2 Breaker CLOSED', 'Generator 1 Breaker CLOSED', 'System Mode Switch - START', 'System Mode Switch - AUTO', 'Generator 4 RUNNING', 'Generator 2 RUNNING', and 'Generator 3 RUNNING'. Below the table, there are buttons for 'Print' and 'Printer Settings'. At the bottom, there is a navigation bar with buttons for 'Single Line', 'Setpoints', 'Load Control', 'System Data', 'Trends', 'Alarms', and 'Events'.

| Event Time          | Username | Message  |
|---------------------|----------|--|
| 11/01/2016 14:12:17 | op       | Load Bank PLC Manual Step Control SELECTED     |
| 11/01/2016 14:12:17 | op       | Load Bank PLC Optimum Load Control DE-SELECTED |
| 11/01/2016 11:55:04 | op       | Load Bank PLC Manual Step Control DE-SELECTED  |
| 11/01/2016 11:55:04 | op       | Load Bank PLC Optimum Load Control SELECTED    |
| 11/01/2016 11:54:54 | op       | Generator 4 Breaker CLOSED                     |
| 11/01/2016 11:54:54 | op       | Generator 3 Breaker CLOSED                     |
| 11/01/2016 11:54:51 | op       | Generator 2 Breaker CLOSED                     |
| 11/01/2016 11:54:51 | op       | Generator 3 RUNNING                            |
| 11/01/2016 11:54:51 | op       | Generator 4 RUNNING                            |
| 11/01/2016 11:54:49 | op       | Generator 2 Breaker OPEN                       |
| 11/01/2016 11:54:34 | op       | 25kV Generator Main Breaker OPEN               |
| 11/01/2016 11:54:31 | op       | Utility BCH-2 Breaker CLOSED                   |
| 11/01/2016 11:54:31 | op       | Utility BCH-1 Breaker CLOSED                   |
| 11/01/2016 11:54:16 | op       | Generator 4 NOT RUNNING                        |
| 11/01/2016 11:54:16 | op       | Generator 3 NOT RUNNING                        |
| 11/01/2016 11:54:04 | op       | Generator 3 Breaker OPEN                       |
| 11/01/2016 11:54:04 | op       | Generator 4 Breaker OPEN                       |
| 11/01/2016 11:53:59 | op       | Load Bank Load Dump Output DE-ENERGIZED        |
| 11/01/2016 11:53:59 | op       | 25kV Generator Main Breaker CLOSED             |
| 11/01/2016 11:53:59 | op       | Load Shed on Dead Bus FALSE                    |
| 11/01/2016 11:53:56 | op       | Utility BCH-2 Breaker OPEN                     |
| 11/01/2016 11:53:56 | op       | Utility BCH-1 Breaker OPEN                     |
| 11/01/2016 11:53:56 | op       | Load Shed on Dead Bus TRUE                     |
| 11/01/2016 11:53:55 | op       | Load Bank Master Control Relay DE-ENERGIZED    |
| 11/01/2016 11:53:55 | op       | Load Bank Load Dump Output ENERGIZED           |
| 11/01/2016 11:53:35 | op       | Load Bank Master Control Relay ENERGIZED       |
| 11/01/2016 11:53:32 | op       | Load Bank PLC Manual Step Control SELECTED     |
| 11/01/2016 11:53:32 | op       | Load Bank PLC Optimum Load Control DE-SELECTED |
| 11/01/2016 11:53:16 | op       | Generator 4 Breaker CLOSED                     |
| 11/01/2016 11:53:16 | op       | Generator 3 Breaker CLOSED                     |
| 11/01/2016 11:53:15 | op       | Generator 2 Breaker CLOSED                     |
| 11/01/2016 11:53:13 | op       | Generator 1 Breaker CLOSED                     |
| 11/01/2016 11:53:12 | op       | System Mode Switch - START                     |
| 11/01/2016 11:53:12 | op       | System Mode Switch - AUTO                      |
| 11/01/2016 11:53:12 | op       | Generator 4 RUNNING                            |
| 11/01/2016 11:53:12 | op       | Generator 2 RUNNING                            |
| 11/01/2016 11:53:12 | op       | Generator 3 RUNNING                            |

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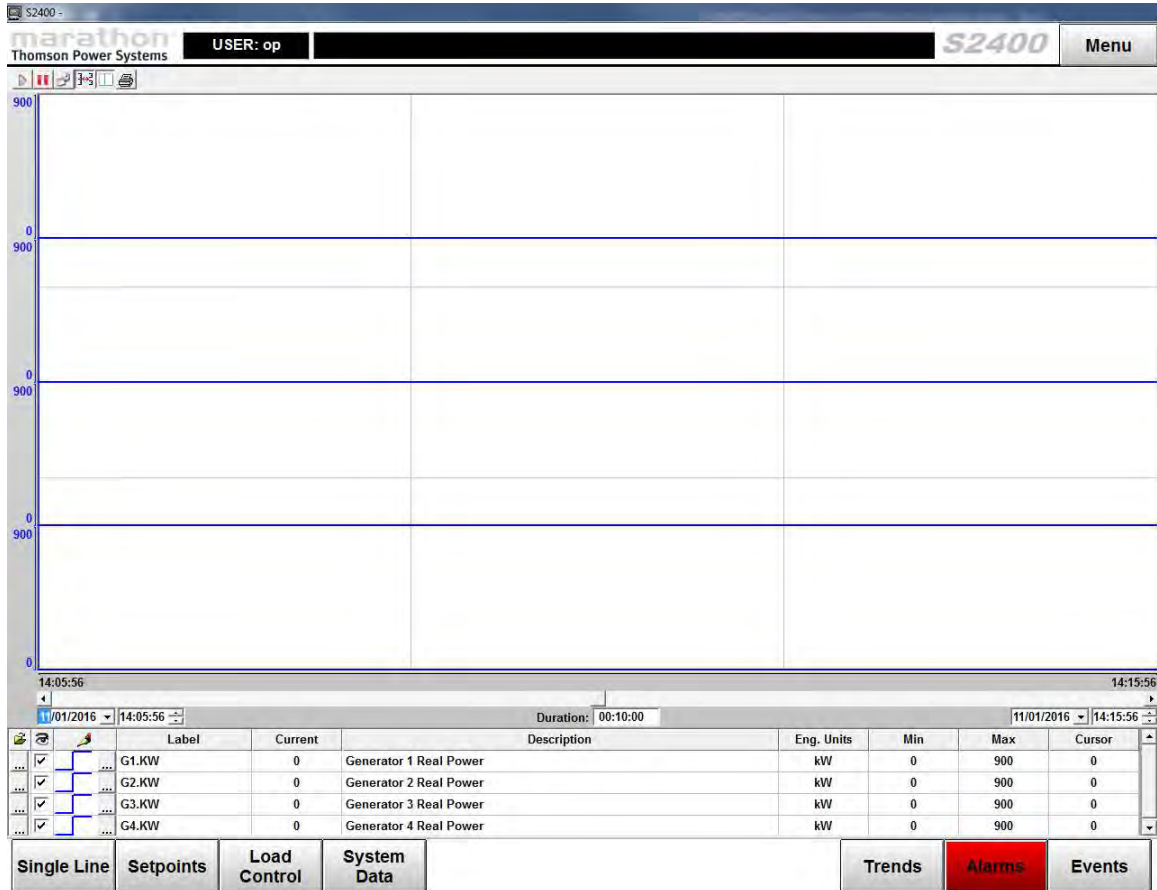
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### 3.8. Trends Screen

The trends screen is a graphical representation of recorded metering data.



The trends log all metering data points that are offered throughout the application. Only four points can be viewed at one time.

The operator can configure the trends during runtime.

- **Toolbar** (at the top of the graph): The commands available in the embedded Toolbar are described in the following table:

| Command | Icon | Description  |
|---------|------|--|
| Run     |      | Sets the Trend to the <i>Play Mode</i> . In this mode, the X axis is continuously updated (Online Mode). This option |

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|                   |   |  |
|-------------------|---|--|
|                   |   | is disabled (grayed out) when the trend is already in <i>Play Mode</i> .   |
| Stop              |    | Sets the Trend to the <i>Stop Mode</i> . In this mode, the X axis is not continuously updated ( <i>History Mode</i> ), so the user can visualize history data in a frozen period of time. This option is disabled (grayed out) when the trend is already in <i>Stop Mode</i> . |
| Period            |    | Launches an embedded dialog, where the user can modify the X axis scale main settings.   |
| Multiple Sections |    | Switches the Y scale to Multiple Sections (a section for each pen) or Single Section (all pens share the same Y scale section).  |
| Cursor            |  | Turns the cursor (ruler) to visible or hidden.   |
| Print             |  | Prints the current state of the Trend display. (Historical data are not printed.)  |

- **Legend** (at the bottom of the graph): The commands available in the embedded Legend are described in the following table:

| <b>Command</b> | <b>Icon</b>   | <b>Description</b>  |
|----------------|---|---|
| Selection      |  | Launches a dialog, where the user can replace the data point associated with the selected pen on the legend |
| Hide           |  | When checked, the selected pen is visible; otherwise, it is hidden.   |

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|           |   |   |
|-----------|---|---|
| Pen Style |  | Launches an embedded dialog, where the user can modify the style of the selected pen. |
|-----------|---|---|

- **Scroll bar:** Using the Scroll bar, the user can slide through the X axis values, according to the period configured for this scale.
- **Time bar:** Using the Time bar, the user can modify the Duration, as well as the Start Date/Time and/or the End Date/Time, for the data displayed on the object.



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## 4. Sequence of Operations

### 4.1. AUTO – Normal Power

- System Control Switch    AUTO
- Transition Mode Switch    OPEN or CLOSED

In AUTO mode, the utility supply is the normal source of power. The generators are stopped and ready to power load if utility fails.

*At present only three generators are operational and the DND is the only operational utility. The fourth generator and two utilities BCH-1, BCH-2 will be installed in the future.*

The normal system configuration is as follows:

- Utility breaker(s) 25/12SES-2 (DND), 25/12SES-3 (BCH-1) or 25/12SES-4 (BCH-2) are closed. This is based on the 'Preferred Utility' selection on the OIT. DND can only be selected by itself. BCH-1 and BCH-2 can be selected together or individually.
- Tie breaker 25/12SES-5 is closed.
- Generator main breaker 25/12SES-1 is open.
- Generator breakers are open.
- Load bank steps are off.
- All 25kV load breakers are closed (by existing protection system in the MV switchgear).

### 4.2. AUTO - Utility Failure

- System Control Switch    AUTO
- Transition Mode Switch    OPEN or CLOSED

*If two preferred utilities are selected (BCH-1 and BCH-2), a failure of either utility will trigger a transfer to generator.*

The utility out-of-limits condition is detected by the protection relays in the 25kV switchgear and relayed to the system control PLC in the generator control panel. The existing protection system in the MV switchgear will automatically open all 25kV load breakers. Generators are commanded to start. The first unit up to speed and voltage will close onto the generator bus.

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Subsequent generators will synchronize and close to the generator bus. Once the required number of generators are closed to the generator bus, the generator control panel will open the utility breaker(s) of the failed utility(s). The 25kV generator main breaker will then be closed. Plant load is now powered by generators. The existing protection system in the MV switchgear will automatically reclose 25kV load breakers as required.

#### 4.3. AUTO - Utility Power Restoration

- System Control Switch      AUTO

*If two preferred utilities are selected (BCH-1 and BCH-2), both utilities must return prior to a retransfer to utility.*

The utility healthy condition is detected by the protection relays in the 25kV switchgear and relayed to the system control PLC in the generator control panel. Based on the 'Utility Retransfer' mode selection on the OIT, retransfer to utility can either be MANUAL or AUTO once the utility returns.

- In MANUAL, a button on the OIT appears once the preferred utility is healthy again. Pressing this button will initiate the retransfer.
- In AUTO, a timer begins once the preferred utility is healthy again. Expiration of this timer will initiate the retransfer.

##### 4.3.a. Open Transition

- Transition Mode Switch      OPEN

When the retransfer is initiated (see section above) the system control PLC will disable all load bank steps (if closed), followed by opening the 25kV generator main breaker. After a neutral delay, the selected 25kV utility breaker(s) is closed (based on the 'Preferred Utility' selection). The existing protection system in the MV switchgear will automatically reclose 25kV load breakers as required. After an extended runtime, the generator breakers open, the generators run for a cooldown time and the generators shut down.

##### 4.3.b. Closed Transition

- Transition Mode Switch      CLOSED

When the retransfer is initiated (see section above) the system control PLC will disable all load bank steps (if closed) and synchronize the generators to the returned utility. Once in synchronism, the utility breaker(s) is closed (based on the 'Preferred Utility' selection). Generators are soft unloaded and once the power flow through the 25kV generator main breaker is below a low

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power threshold, the 25kV generator main breaker is opened. The existing protection system in the MV switchgear will automatically reclose all 25kV load breakers as required (if open). After an extended runtime, the generator breakers open, the generators run for a cooldown time and the generators shut down.

#### 4.4. START - Generator Static Test

- System Control Switch     **START**
- Transition Mode Switch    **OPEN** or **CLOSED**

When the system control switch is moved to **START**, all available generators start. The first unit up to speed and voltage will close onto the generator bus. Subsequent generators will synchronize and close to the generator bus. The generator main breaker remains open and the plant load remains powered by utility.

- Once the generator bus is live, the load bank can be operated to add/remove load from the online generator(s). This can be done locally at the load bank control panel, or via the OIT panel.
- If the utility fails during a generator static test, the auto standby operation begins as described in the above sections. Load will be transferred to generators.

When the system control switch is moved back to **AUTO**, generator breakers open, and after a cooldown time, the generators stop.

#### 4.5. TEST - Site Load Test

- System Control Switch     **TEST**

During a site load test, the plant load will be transferred from utility to generator. Depending on the position of the transition mode switch, transfers between generator and utility will be either open or closed transition.

##### 4.5.a. Open Transition

- Transition Mode Switch    **OPEN**

When the system control switch is moved to **TEST**, all generators are commanded to start. The first unit up to speed and voltage will close onto the generator bus. Subsequent generators will synchronize and close to the

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generator bus. Once the required number of generators are closed to the generator bus, the generator control panel will open the utility breaker(s). The existing protection system in the MV switchgear will automatically open all 25kV load breakers. After a neutral delay, the generator main breaker will close. Plant load is now powered by generators. The existing protection system in the MV switchgear will automatically reclose 25kV load breakers as required.

When the system control switch is moved back to **AUTO**, the system control PLC will disable all load bank steps (if closed), followed by opening the 25kV generator main breaker. After a neutral delay, the selected 25kV utility breaker(s) is closed (based on the 'Preferred Utility' selection). The existing protection system in the MV switchgear will automatically reclose 25kV load breakers as required. After an extended runtime, the generator breakers open, the generators run for a cooldown time and the generators shut down.

#### 4.5.b. Closed Transition

- Transition Mode Switch    CLOSED

When the system control switch is moved to **TEST**, all generators are commanded to start. The first unit up to speed and voltage will close onto the generator bus. Subsequent generators will synchronize and close to the generator bus. Once the required number of generators are closed to the generator bus, the generator control panel synchronizes the generators to the utility supply. Once in synchronism, the generator main breaker is closed. Generators are soft loaded and once the power flow through the utility breaker(s) is below a low power threshold, the utility breaker(s) is opened. Plant load is now powered by generators.

When the system control switch is moved back to **AUTO**, the system control PLC will open all load bank steps (if closed) and synchronize the generators to the utility. Once in synchronism, the utility breaker(s) is closed (based on the 'Preferred Utility' selection). Generators are soft unloaded and once the power flow through the 25kV generator main breaker is below a low power threshold, the 25kV generator main breaker is opened. The existing protection system in the MV switchgear will automatically reclose all 25kV load breakers as required (if open). After an extended runtime, the generator breakers open, the generators run for a cooldown time and the generators shut down.

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#### 4.6. MANUAL - Manual Operation

- System Control Switch     MANUAL
- Transition Mode Switch    OPEN or CLOSED (no impact)

The system control switch may be switched from AUTO to MANUAL and the system will remain in its last state (e.g. a running generator will remain running).

##### 4.6.a. Generator Control

Manual generator controls are provided for each generator.

To start a generator, press the START pushbutton on the panel. The DM550 controller starts the unit.

To close the generator breaker onto a dead bus, press the CLOSE pushbutton until breaker closes.

To close the generator onto a live bus, press and hold the SYNC & CLOSE pushbutton. The DSLC-2 controller will synchronize the generator to the bus and close the generator breaker.

To take a generator off line, press the TRIP pushbutton.

Press the STOP pushbutton on the panel to release the start signal. The generator will continue to run for a cool down period (as programmed in the local DM550) then stop.

##### 4.6.b. Breaker Control

Manual breaker controls are provided for each utility breaker (25/12SES-2/3/4), the 25kV bus tie breaker (25/12SES-5) and the generator main breaker (25/12SES-1).

To close a breaker, press the CLOSE pushbutton until breaker closes. Note the following:

- “Utility Available” lights are provided for 25/12SES-2/3/4 (DND, BCH-1, BCH-2) that will illuminate when the utility source is available (voltage and frequency within limits). A utility breaker can only be closed when the utility is available.
- An “Emergency Power Available” light is provided for generator main breaker 25/12SES-1 that will illuminate when the generator source is available (voltage and frequency within limits). This is for indication only, as the generator main breaker 25/12SES-1 can be closed regardless of availability of the source.

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To open a breaker, press the TRIP pushbutton.

#### 4.7. Load Bank Control

Control of the load bank is dictated by the state of the three-position Control Mode switch on the load bank control panel.

*Note that "air fail" and "over temperature" alarms are locally latched and must be reset at the load bank control panel. A load bank alarm is annunciated at the OIT in this case.*

##### 4.7.a. Off

The load bank will not operate. Fans are off. All load steps are disconnected.

##### 4.7.b. Manual

To **enable** the load bank, start the fans by switching the Master Control Switch to ON. Move the Load Enable Switch to the ON position (spring return). Use the Load Step Switches to enable or disable any of the 20 load steps.

To **disable** the load bank, use the Load Step Switches to disable all 20 load steps. Move the Load Enable Switch to the OFF position (spring return). Switch the Master Control Switch to OFF. The fans will continue to operate for an extended period.

##### 4.7.c. Auto

Control of the load bank is by the system control PLC in the generator control panel. On the OIT Loads screen, the load bank has the following three modes than can be selected.

#### OFF

The PLC disables all load steps and disables the load bank master control.

#### MANUAL STEPS

When generators are powering the 600V generator bus, each of the 20 load bank steps can be manually enabled/disabled via the pushbuttons on the Loads screen.

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When at least one load bank step is selected, the PLC will enable the master control which will cause the load bank fan to run. When no load steps are enabled, the PLC will disable the master control which will cause the load bank fan to stop (after a cooldown time).

#### OPTIMUM LOAD

When generators are powering the 600V generator bus, the PLC will use the load bank to load the online generator(s) to an optimum load level (summation of plant load and load bank load). Via the OIT, the operator can enter the "Optimum Gen Load (%)", "Initial Delay (sec)", "Add Delay (sec)", "Remove Delay (sec)" and "Fast Remove Delay (sec)".

When the PLC resolves the "Optimum Gen Load (%)" into a kW level, it sets an upper limit based on the load demand "Delayed Start (kW)" less 100kW (see section 4.8). This ensures that the load bank will not cause additional generators to come on the bus when not required by the actual plant load.

Once generators have powered the plant and load demand (if enabled) has settled on the number of generators required to serve the plant load, an "initial delay" timer is started. Once expired, the system control PLC will monitor the total generator load.

- If the generator load is **lower** than the "optimum gen load" for the duration of the "add delay", the system control PLC will enable the load bank and add a load step (50kW). If the generator load remains lower than the "optimum gen load" for the duration of another "add delay", the system control PLC will add another load step (50kW). This continues until the generator load is within 50kW of the optimum load level, or until all load bank steps have been added.
- If the generator load is **higher** than the "optimum gen load" for the duration of the "remove delay", the system control PLC remove a load step (50kW). If the generator load remains higher than the "optimum gen load" for the duration of another "remove delay", the system control PLC will remove another load step (50kW). This continues until the generator load is within 50kW of the optimum load level, or until all load bank steps have been removed.

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Load bank steps will be removed during the following situations regardless of the “optimum gen load”. The goal is to quickly remove load without de-stabilizing the generator. Therefore, steps are removed based on the “Fast Remove Delay (sec)”.

- A utility retransfer has been initiated. The load bank is no longer required after the utility retransfer.
- The PSS indicates an anticipated load that is not online yet (see section 4.8.a). Once the anticipated load actually comes online, load bank logic (above) begins again.
- Generator load demand logic is removing a generator because of low plant load. Once the generator comes offline, load bank logic (above) begins again.

During each use of the optimum load logic, the usage of load steps is rotated. For example, on the first usage step 1 is the first load step to be added, followed by step 2, 3, and so forth as required. On the second usage, step 2 is the first load step to be added, followed by step 3, 4, and so forth as required (with step 1 being the last load step added if required). This ensures more even usage of all load elements over time.

#### 4.8. Load Demand

If load demand is **disabled**, all available generators will run when generators are required.

If load demand is **enabled**, all available generators will run when generators are required until the expiration of the ‘bus minimum run time (sec)’. Once the minimum runtime is complete, load demand starting and stopping will be enabled.

- A programmable priority (OFF, 1, 2, 3, 4) setting is available for each generator to determine the sequence in which generators will be started and stopped due to load demand.
- Excess generators will be shut off when the system is lightly loaded and restarted should the load increases.



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- Adjustable bus reserve capacity set points and delays determine when the generators start and stop.
  - **Bus Reserve (kW)** = Online Generation Capacity (kW) – Total Generator Load (kW)
    - Online Generator Capacity (kW) = sum of the nameplate kW rating of each online generator
    - Total Generator Load (kW) = sum of the measured kW of each online generator
- When the bus reserve falls below the ‘immediate start kW’ setpoint, the next priority generator will be started immediately. This setpoint allows the system to rapidly increase the generating capacity under fast changing load conditions and prevent system overload.
- When the bus reserve falls below the ‘delayed start kW’ setpoint for the duration of the ‘delayed start (sec)’ timer, the next priority generator will be started. This setpoint allows starting of additional generators as plant load increases in a slower manner.
- When the bus reserve rises above the ‘stop kW’ setpoint for the duration of the ‘stop (sec)’ timer, the last priority generator will be stopped. This setpoint allows the reduction of generator capacity as plant load decreases.

#### 4.8.a. Total Anticipated Load (kW)

The total anticipated load (kW) is the sum of the loads (kW) that are anticipated to come online but are not yet online, as signaled by the PSS. This allows the PSS to increase the online generator capacity prior to starting large site loads.

The PLC will internally increase the ‘immediate start kW’, ‘delayed start kW’ and ‘stop kW’ setpoints by the ‘total anticipated load (kW)’ (see section above). Load demand logic will then ensure this extra generator capacity is online and will start another generator if necessary.

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The PSS will anticipate the five loads listed in the table below. For each load the PSS will provide an analog value (estimated load in kW), and a digital value (energized when load is anticipated to come online, but not yet online). These will be provided to the system control PLC in the generator control panel via communications (see section 8).

| Load Description           | Load added to 'Total Anticipated Load (kW)' (adjustable) |
|----------------------------|--|
| Main Dewatering Pumps      | 1000 kW  |
| Auxiliary Dewatering Pumps | 250 kW   |
| Travelling Cranes          | - kW   |
| Air Compressors            | - kW   |
| Building Loads             | - kW   |

#### 4.8.b. N+1 Selection

If 'N+1' is **disabled**, the number of generators required by load demand calculations above will be brought online.

If 'N+1' is **enabled**, one more generator will be brought online in addition to the number of generators require by load demand calculations above.

#### 4.8.c. Low Fuel Alarm Selection

The generator control PLC monitors the fuel level for each PLC. When a generator's fuel level falls below the 'Low Fuel (L)' setpoint (adjustable), a low fuel alarm is triggered.

If 'Low Fuel Alarm' is selected as **Keep Running** and a generator develops a low fuel alarm, the generator will keep running and the alarm will be annunciated. No further action will be taken.

If 'Low Fuel Alarm' is selected as **Replace Generator** and a generator develops a low fuel alarm, a lower priority generator will start. Once the replacement unit is online, the generator with the low fuel alarm will be taken offline. Once the low fuel alarm condition is rectified and the alarm is reset, the generator will become available and be part of the sequencing again. If the alarmed generator is the last one in sequence or no other generator is available to replace it, it will remain online.

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#### 4.9. Load Shed / Add

Shedding and adding of site load is by the existing protection system in the plant. Via communications (see section 8), the system control PLC in the generator control panel will communicate the following values to the existing protection system in order for it to determine loads to shed / add while on generator supply.

- **Shed on Dead Bus (binary):** Energized prior to a transfer to generators when the 25kV bus is dead.
- **Shed on Overload (binary):** Energized when the online generators are loaded above the overload setpoint (%; adjustable) with no time delay.
- **Shed on Under frequency (binary):** Energized when the online generators experience an under frequency condition (under frequency setpoint programmed in the SEL 700G relays) with no time delay.
- **Online Generator Capacity kW (analog):** Sum of the nameplate kW ratings of all online generators.
- **Total Generator Load kW (analog):** Sum of the measured kW of all online generators.
- **Generator Bus Reserve kW (analog):** 'Online Generator Capacity kW' minus 'Total Generator Load kW'. Indicates the kW load that could be added before the generators would be loaded to 100%.
- **Total Generator Load % (analog):** 'Total Generator Load kW' divided by 'Online Generator Capacity kW'.

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## 5. Alarm Reset

### 5.1. DM550 Alarm / Shutdown

DM550 alarms and shutdowns must be reset at the respective DM550 engine control panel. To reset shutdowns, switch the DM550 to OFF. Then press the RESET pushbutton. The DM550 may then be returned to AUTO or RUN to restart/re-instate the generator.

### 5.2. Lockout Relay

In the event of an electrical fault, the SEL700G protection relay will activate the lockout relay. Once activated, the lockout relay will open the breaker and prevent closure. The DM550 will be issued an engine shutdown signal.

Prior to reset, investigate and correct the cause of the electrical fault.

To reset the lockout relay, first reset the trip condition on the SEL700G protection relay using the RESET button. Then turn the lockout switch to the RESET position.

### 5.3. Emergency Stop

Pressing the emergency stop button will immediately open the breaker. The DM550 will be issued an emergency stop signal.

To reset the emergency stop, pull the emergency stop button out to the reset position. Then reset the DM550 controller as per the section above.

### 5.4. PLC Initiated Alarms

The following alarms are generated and latched by the PLC. When these alarms occur, the HMI will display an "Alarm Reset" button on the single line screen. An operator must press this button to reset the alarm and allow the automatic operation to continue.

- Breaker Fail to Close
- Breaker Fail to Open
- Generator Fail to Start

Note that alarms other than those listed above are generated by other devices in the system and must be corrected at those devices. They will be annunciated at the HMI, but cannot be reset via the HMI.

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**6. Access Passwords**

**6.1. S2400**

|                    |   |
|--------------------|---|
| <b>View Only</b>   | This security level provides full access to all the screens and setpoints, but as a view only. Breaker controls and setpoints cannot be modified under this level of security.<br>User Name: Guest<br>Password: (blank) |
| <b>Full access</b> | This security level provides full access and control to all screens.<br>User Name: op<br>Password: 123  |

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## 7. Data Logging

The system keeps a log of the following parameters:

- Alarms
- Events

Alarm and event data is stored for 365 days. Alarms and events older than 365 days will be automatically deleted (first in, first out). This will occur at midnight every day.

### 7.1. Alarms List

The following alarms are monitored and stored in S2400 alarm database (viewable on the S2400 Alarm screen).

| Alarms   |
|--|
| Generator # Common Alarm                         |
| Generator # Common Shutdown                      |
| Generator # Not In Auto                          |
| Generator # Protection Tripped                   |
| Generator # Protection Relay Alarm               |
| Generator # DSLC Alarm                           |
| Generator # Fail to Close                        |
| Generator # Fail to Open                         |
| Generator # Fail to Unload                       |
| Generator # Fail to Start Alarm                  |
| Generator # Low Fuel Alarm                       |
| Bus Tie Breaker (25kV) Protection Tripped        |
| Bus Tie Breaker (25kV) Fail to Close             |
| Bus Tie Breaker (25kV) Fail to Open              |
| Generator Main Breaker (25kV) Protection Tripped |
| Generator Main Breaker (25kV) MSLC Alarm         |
| Generator Main Breaker (25kV) Fail to Close      |
| Generator Main Breaker (25kV) Fail to Open       |
| Generator Main Breaker (25kV) Fail to Unload     |
| System Not In Auto                               |
| PAC Minor Error                                  |
| PAC Major Error                                  |

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|                                    |
|------------------------------------|
| PAC IO Error                       |
| SCADA Modbus Communication Stopped |
| Transformer Tripped                |
| Main Rack Slot 3 IF16 Fault        |
| Main Rack Slot 4 OF8 Fault         |
| Main Rack Slot 5 IV32 Fault        |
| Main Rack Slot 6 IV32 Fault        |
| Main Rack Slot 7 IV32 Fault        |
| Main Rack Slot 8 OB32 Fault        |
| Main Rack Slot 9 OB32 Fault        |
| Main Rack Slot 10 OB32 Fault       |
| 125VDC Supply Failed               |
| 24VDC Supply 1 Failed              |
| 24VDC Supply 2 Failed              |
| Load Bank Alarm                    |
| Load Bank Not In Auto              |
| Loads Shed Issued                  |
| Utility BCH-1 Protection Tripped   |
| Utility BCH-1 Failed               |
| Utility BCH-1 MSLC Alarm           |
| Utility BCH-1 Fail to Close        |
| Utility BCH-1 Fail to Open         |
| Utility BCH-1 Fail to Unload       |
| Utility BCH-2 Protection Tripped   |
| Utility BCH-2 Failed               |
| Utility BCH-2 MSLC Alarm           |
| Utility BCH-2 Fail to Close        |
| Utility BCH-2 Fail to Open         |
| Utility BCH-2 Fail to Unload       |
| Utility DND Protection Tripped     |
| Utility DND Failed                 |
| Utility DND MSLC Alarm             |
| Utility DND Fail to Close          |
| Utility DND Fail to Open           |
| Utility DND Fail to Unload         |
| Communication Fail - OIT to PLC    |

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## 7.2. Event List

The following events are monitored and stored in S2400 event database (viewable on the S2400 Events screen).

| Events  |
|---|
| 25kV Bus Tie Breaker CLOSED / OPEN                        |
| 25kV Generator Main Breaker CLOSED / OPEN                 |
| Load Bank Breaker CLOSED / OPEN                           |
| Feeder Breaker 6SES-SP-2 CLOSED / OPEN                    |
| Generator 1 Breaker CLOSED / OPEN                         |
| Generator 2 Breaker CLOSED / OPEN                         |
| Generator 3 Breaker CLOSED / OPEN                         |
| Generator 4 Breaker CLOSED / OPEN                         |
| Utility BCH-1 Breaker CLOSED / OPEN                       |
| Utility BCH-2 Breaker CLOSED / OPEN                       |
| Utility DND Breaker CLOSED / OPEN                         |
| Generator 1 RUNNING / NOT RUNNING                         |
| Generator 2 RUNNING / NOT RUNNING                         |
| Generator 3 RUNNING / NOT RUNNING                         |
| Generator 4 RUNNING / NOT RUNNING                         |
| Utility BCH-1 selected as PREFERRED / NOT PREFERRED       |
| Utility BCH-2 selected as PREFERRED / NOT PREFERRED       |
| Utility DND selected as PREFERRED / NOT PREFERRED         |
| Load Bank Local Switch IN AUTO / NOT IN AUTO              |
| Load Bank PLC Optimum Load Control SELECTED / DE-SELECTED |
| Load Bank PLC Manual Step Control SELECTED / DE-SELECTED  |
| Load Bank Load Dump Output ENERGIZED / DE-ENERGIZED       |
| Load Bank Master Control Relay ENERGIZED / DE-ENERGIZED   |
| Load Shed on Dead Bus TRUE / FALSE                        |
| Load Shed on Overload TRUE / FALSE                        |
| Load Shed on Underfrequency TRUE / FALSE                  |
| System Mode Switch - AUTO TRUE / FALSE                    |
| System Mode Switch - MANUAL TRUE / FALSE                  |
| System Mode Switch - START TRUE / FALSE                   |
| System Mode Switch - TEST TRUE / FALSE                    |
| Source Failure Delay Preset changed to #####              |
| Dead Bus Delay Preset changed to #####                    |
| Dead Bus Window Preset changed to #####                   |



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|  |
|--|
| Gen Extended Runtime Preset changed to #####                     |
| Fail to Close Delay Preset changed to #####                      |
| Fail to Open Delay Preset changed to #####                       |
| Fail to Sync Delay Preset changed to #####                       |
| Fail to Start Delay Preset changed to #####                      |
| Fail to Unload Delay Preset changed to #####                     |
| Load Bank Step Add Delay Timer Preset changed to #####           |
| Load Bank Initial Delay Timer Preset changed to #####            |
| Load Bank Step Subtract Delay Timer Preset changed to #####      |
| Load Bank Step Fast Subtract Delay Timer Preset changed to ##### |
| Live Bus Delay Preset changed to #####                           |
| Load Demand Delayed Start Timer Preset changed to #####          |
| Load Demand Delayed Stop Timer Preset changed to #####           |
| Minimum Run Time Preset changed to #####                         |
| Neutral Delay Preset changed to #####                            |
| Utility Retransfer Delay Preset changed to #####                 |
| Gen Warm Up Time Preset changed to #####                         |
| Low Fuel Alarm Setpoint (L) changed to #####                     |
| Number of generators required for transfer changed to #####      |
| Load Bank Optimum Load Setpoint (%) changed to #####             |
| Load Demand Delayed Start Setpoint (kW) changed to #####         |
| Load Demand Delayed Stop Setpoint (kW) changed to #####          |
| Load Demand Immediate Start Setpoint (kW) changed to #####       |
| Fuel Consumption at 0% Load (Lph) changed to #####               |
| Fuel Consumption at 25% Load (Lph) changed to #####              |
| Fuel Consumption at 50% Load (Lph) changed to #####              |
| Fuel Consumption at 75% Load (Lph) changed to #####              |
| Fuel Consumption at 100% Load (Lph) changed to #####             |
| Load Shed Overload Setpoint (%) changed to #####                 |
| Feeder Unloaded Setpoint (kW) changed to #####                   |
| Common Alarm Action changed to KEEP RUNNING / REPLACE GENERATOR  |
| Fail to Sync Action changed to KEEP TRYING / FAIL GENERATOR      |
| Low Fuel Action changed to KEEP RUNNING / REPLACE GENERATOR      |
| Load Demand Anticipated Loads ENABLED / DISABLED                 |
| Load Demand ENABLED / DISABLED                                   |
| Load Demand - N+1 Redundancy ENABLED / DISABLED                  |
| Load Shed on Dead Bus ENABLED / DISABLED                         |

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|  |
|--|
| Load Shed on Overload ENABLED / DISABLED       |
| Load Shed on Underfrequency ENABLED / DISABLED |
| Transfer Mode changed to CLOSED / OPEN         |
| Utility Retransfer changed to AUTO / MANUAL    |

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## 8. Customer Remote Connections

A ModbusTCP server connection is available on the 8ESW1 Ethernet switch in section 5 (W-095112-030D). The ModbusTCP server is the Prosoft MVI56E-MNET card in slot 2 of the PLC rack. Alarm, status and metering information is exchanged with the PSS system via this connection.

- **Port Configuration:**
  - **Connection:** 8ESW1 any free port
  - **Slave ID:** 1
  - **IP Address:** 192.168.250.2; port 502
  - **Protocol:** RTU

### 8.1. PSS Write Data

The following data is read/write intended to be written to by the PSS system (PSS configured as ModbusTCP client).

| PSS Write Data   |        |   |         |     |       |
|--|--------|---|---------|-----|-------|
| Holding Registers (4xxxx) (Read / Write)                       |        |   |         |     |       |
| All data 16-bit unsigned integer; 16-bit word if bit-addressed |        |   |         |     |       |
| System   | Source | Description   | Address | Bit | Units |
| -  | PSS    | Watchdog value (change at least once per 10 sec)        | 41001   |     | -     |
|  |        | Anticipated Load - Main Dewatering Pumps                | 41002   |     | kW    |
|  |        | Anticipated Load - Auxiliary Dewatering Pumps           | 41003   |     | kW    |
|  |        | Anticipated Load - Travelling Cranes                    | 41004   |     | kW    |
|  |        | Anticipated Load - Air Compressors                      | 41005   |     | kW    |
|  |        | Anticipated Load - Building Loads                       | 41006   |     | kW    |
|  |        | Anticipated Load - reserved 6                           | 41007   |     | kW    |
|  |        | Anticipated Load - reserved 7                           | 41008   |     | kW    |
|  |        | Anticipated Load - reserved 8                           | 41009   |     | kW    |
|  |        | Anticipated Load - reserved 9                           | 41010   |     | kW    |
|  |        | Anticipated But Not Online - bit not used               | 41011   | 0   |       |
|  |        | Anticipated But Not Online - Main Dewatering Pumps      |         | 1   |       |
|  |        | Anticipated But Not Online - Auxiliary Dewatering Pumps |         | 2   |       |
|  |        | Anticipated But Not Online - Travelling Cranes          |         | 3   |       |
|  |        | Anticipated But Not Online - Air Compressors            |         | 4   |       |
|  |        | Anticipated But Not Online - Building Loads             |         | 5   |       |
|  |        | Anticipated But Not Online - reserved 6                 |         | 6   |       |
|  |        | Anticipated But Not Online - reserved 7                 |         | 7   |       |

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|--|---|----------|---|---|
|  | Anticipated But Not Online - reserved 8 |          | 8 |   |
|  | Anticipated But Not Online - reserved 9 |          | 9 |   |
|  | reserved                                | 41012-20 |   |   |
|  | Generator 1 Fuel Volume                 | 41021    |   | L |
|  | Generator 2 Fuel Volume                 | 41022    |   | L |
|  | Generator 3 Fuel Volume                 | 41023    |   | L |
|  | Generator 4 Fuel Volume                 | 41024    |   | L |

## 8.2. PSS Read Data

The following data is read-only intended to be read by the PSS system (PSS configured as ModbusTCP client).

| <b>PSS Read Data</b>   |        |   |          |     |       |
|--|--------|---|----------|-----|-------|
| Holding Registers (4xxxx) (Read Only)                          |        |   |          |     |       |
| All data 16-bit unsigned integer; 16-bit word if bit-addressed |        |   |          |     |       |
| System   | Source | Description                                     | Address  | Bit | Units |
| System Status  | PLC    | System Mode Switch - AUTO                       | 40001    | 0   |       |
|  |        | System Mode Switch - MANUAL                     |          | 1   |       |
|  |        | System Mode Switch - START                      |          | 2   |       |
|  |        | System Mode Switch - TEST                       |          | 3   |       |
|  |        | Block the System TEST Mode                      |          | 4   |       |
|  |        | 25kV Bus 1 Live Bus                             |          | 5   |       |
|  |        | 25kV Bus 2 Live Bus                             |          | 6   |       |
|  |        | 600V Generator Bus Live Bus                     |          | 7   |       |
|  |        | reserved  | 40002-10 |     |       |
| Setpoints  |        | Common Alarm Action (0=replace; 1=keep running) | 40011    | 0   |       |
|  |        | Fail to Sync Action (0=replace, 1=keep trying)  |          | 1   |       |
|  |        | Fail to Start Action (0=replace, 1=keep trying) |          | 2   |       |
|  |        | Low Fuel Action (0=replace; 1=keep running)     |          | 3   |       |
|  |        | Load Demand - Anticipated Loads Enabled         |          | 4   |       |
|  |        | Load Demand Enabled                             |          | 5   |       |
|  |        | Load Demand - N+1 Redundancy Enabled            |          | 6   |       |
|  |        | Load Shed on Dead Bus Enabled                   |          | 7   |       |
|  |        | Load Shed on Overload Enabled                   |          | 8   |       |
|  |        | Load Shed on Underfrequency Enabled             |          | 9   |       |
|  |        | Closed Transition Selected                      |          | 10  |       |

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|----------------------------|---|----------|----|-----|
|                            | Utility Retransfer in Auto  |          | 11 |     |
|                            | Low Fuel Alarm Setpoint (L)   | 40012    |    | L   |
|                            | Number of generators required for transfer                          | 40013    |    | -   |
|                            | Load Bank Optimum Load Setpoint (%)                                 | 40014    |    | %   |
|                            | Load Demand Delayed Start Setpoint (kW)                             | 40015    |    | kW  |
|                            | Load Demand Delayed Stop Setpoint (kW)                              | 40016    |    | kW  |
|                            | Load Demand Immediate Start Setpoint (kW)                           | 40017    |    | kW  |
|                            | Load Shed Overload Setpoint (%)                                     | 40018    |    | %   |
|                            | Feeder Unloaded Setpoint (kW)                                       | 40019    |    | kW  |
|                            | Source Failure Delay Preset   | 40020    |    | sec |
|                            | Gen Extended Runtime Preset   | 40021    |    | sec |
|                            | Fail to Close Delay Preset  | 40022    |    | sec |
|                            | Fail to Open Delay Preset   | 40023    |    | sec |
|                            | Fail to Sync Delay Preset   | 40024    |    | sec |
|                            | Fail to Start Delay Preset  | 40025    |    | sec |
|                            | Fail to Unload Delay Preset   | 40026    |    | sec |
|                            | Load Bank Step Add Delay Timer Preset                               | 40027    |    | sec |
|                            | Load Bank Initial Delay Timer Preset                                | 40028    |    | sec |
|                            | Load Bank Step Subtract Delay Timer Preset                          | 40029    |    | sec |
|                            | Load Bank Step Fast Subtract Delay Timer Preset                     | 40030    |    | sec |
|                            | Live Bus Delay Preset   | 40031    |    | sec |
|                            | Load Demand Delayed Start Timer Preset                              | 40032    |    | sec |
|                            | Load Demand Delayed Stop Timer Preset                               | 40033    |    | sec |
|                            | Minimum Run Time Preset   | 40034    |    | sec |
|                            | Neutral Delay Preset  | 40035    |    | sec |
|                            | Utility Retransfer Delay Preset                                     | 40036    |    | sec |
|                            | Wait For Required Gens Timer Preset                                 | 40037    |    | sec |
|                            | Gen Warm Up Time Preset   | 40038    |    | sec |
|                            | reserved  | 40039-50 |    |     |
| Generator<br>Bus<br>Status | 600V Generator Bus Load in kW                                       | 40051    |    | kW  |
|                            | 600V Generator Bus Load in %  | 40052    |    | %   |
|                            | 600V Generator Bus Reserve kW                                       | 40053    |    | kW  |
|                            | 600V Generator Bus Number of Generators Online                      | 40054    |    | -   |
|                            | 600V Generator Bus Capacity of Online Generators (kW)               | 40055    |    | kW  |
|                            | 600V Generator Bus Load Demand HMI Load Demand Immediate Start (kW) | 40056    |    | kW  |
|                            | 600V Generator Bus Load Demand HMI Load Demand Delayed Start (kW)   | 40057    |    | kW  |
|                            | 600V Generator Bus Load Demand HMI Load Demand Stop (kW)            | 40058    |    | kW  |

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|                           | 600V Generator Bus Load Demand HMI Load Demand Delayed Start Time (sec) | 40059    |   | sec |
|                           | 600V Generator Bus Load Demand HMI Load Demand Stop Time (sec)          | 40060    |   | sec |
|                           | 600V Generator Bus Load Shed Load Shed on Dead Bus                      | 40061    | 0 |     |
|                           | 600V Generator Bus Load Shed Load Shed on Overload                      |          | 1 |     |
|                           | 600V Generator Bus Load Shed Load Shed on Underfrequency                |          | 2 |     |
|                           | 600V Generator Bus Load Shed Loads have been Shed                       |          | 3 |     |
|                           | reserved  | 40062-70 |   |     |
| Misc<br>Breaker<br>Status | 25kV Bus Tie Breaker Closed   | 40071    | 0 |     |
|                           | 25kV Bus Tie Breaker Protection Tripped                                 | 40072    | 1 |     |
|                           | 25kV Bus Tie Breaker Fail to Close                                      | 40073    | 0 |     |
|                           | 25kV Bus Tie Breaker Fail to Open                                       |          | 1 |     |
|                           | Feeder Breaker 6SES-SP-2 Closed   | 40074    | 0 |     |
|                           | Load Bank Breaker Breaker Closed  | 40075    | 0 |     |
|                           | Load Bank Breaker kW  | 40076    |   | kW  |
|                           | 25kV Generator Main Breaker Synchronize Output                          | 40077    | 0 |     |
|                           | 25kV Generator Main Breaker Breaker Closed                              |          | 1 |     |
|                           | 25kV Generator Main Breaker Protection Tripped                          | 40078    | 1 |     |
|                           | 25kV Generator Main Breaker MSLC Alarm                                  |          | 3 |     |
|                           | 25kV Generator Main Breaker Fail to Close                               | 40079    | 0 |     |
|                           | 25kV Generator Main Breaker Fail to Open                                |          | 1 |     |
|                           | 25kV Generator Main Breaker Fail to Unload                              |          | 2 |     |
|                           | 25kV Generator Main Breaker kW  | 40080    |   | kW  |
|                           | 25kV Generator Main Breaker Sync Attempts                               | 40081    |   | -   |
|                           | 25kV Generator Main Breaker Sync Time                                   | 40082    |   | sec |
| reserved                  | 40083-90  |          |   |     |
| Load<br>Bank<br>Status    | Load Bank Switch in AUTO  | 40091    | 0 |     |
|                           | Load Bank PLC Control AUTO  |          | 1 |     |
|                           | Load Bank PLC Control MANUAL  |          | 2 |     |
|                           | Load Bank Dump Output   |          | 3 |     |
|                           | Load Bank Master Control Relay is Energized                             |          | 4 |     |
|                           | Load Bank Okay to Add/Subtract Steps in AUTO                            |          | 5 |     |
|                           | Load Bank Okay to Add Steps in MANUAL                                   |          | 6 |     |
|                           | Load Bank Alarm   |          | 7 |     |
|                           | Load Bank Not In Auto Alarm   |          | 8 |     |
|                           | -   | 40092    | 0 |     |
|                           | Load Bank Energize Load Step 1  |          | 1 |     |

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|---------------------------------|-------|----|--|
| Load Bank Energize Load Step 2  |       | 2  |  |
| Load Bank Energize Load Step 3  |       | 3  |  |
| Load Bank Energize Load Step 4  |       | 4  |  |
| Load Bank Energize Load Step 5  |       | 5  |  |
| Load Bank Energize Load Step 6  |       | 6  |  |
| Load Bank Energize Load Step 7  |       | 7  |  |
| Load Bank Energize Load Step 8  |       | 8  |  |
| Load Bank Energize Load Step 9  |       | 9  |  |
| Load Bank Energize Load Step 10 |       | 10 |  |
| Load Bank Energize Load Step 11 |       | 11 |  |
| Load Bank Energize Load Step 12 |       | 12 |  |
| Load Bank Energize Load Step 13 |       | 13 |  |
| Load Bank Energize Load Step 14 |       | 14 |  |
| Load Bank Energize Load Step 15 |       | 15 |  |
| Load Bank Energize Load Step 16 | 40093 | 0  |  |
| Load Bank Energize Load Step 17 |       | 1  |  |
| Load Bank Energize Load Step 18 |       | 2  |  |
| Load Bank Energize Load Step 19 |       | 3  |  |
| Load Bank Energize Load Step 20 |       | 4  |  |
| -                               | 40094 | 0  |  |
| Load Bank Manual Close Step 1   |       | 1  |  |
| Load Bank Manual Close Step 2   |       | 2  |  |
| Load Bank Manual Close Step 3   |       | 3  |  |
| Load Bank Manual Close Step 4   |       | 4  |  |
| Load Bank Manual Close Step 5   |       | 5  |  |
| Load Bank Manual Close Step 6   |       | 6  |  |
| Load Bank Manual Close Step 7   |       | 7  |  |
| Load Bank Manual Close Step 8   |       | 8  |  |
| Load Bank Manual Close Step 9   |       | 9  |  |
| Load Bank Manual Close Step 10  |       | 10 |  |
| Load Bank Manual Close Step 11  |       | 11 |  |
| Load Bank Manual Close Step 12  |       | 12 |  |
| Load Bank Manual Close Step 13  |       | 13 |  |
| Load Bank Manual Close Step 14  |       | 14 |  |
| Load Bank Manual Close Step 15  |       | 15 |  |
| Load Bank Manual Close Step 16  | 40095 | 0  |  |
| Load Bank Manual Close Step 17  |       | 1  |  |

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|-----------------------|--|-----------|----|-----|
|                       | Load Bank Manual Close Step 18                 |           | 2  |     |
|                       | Load Bank Manual Close Step 19                 |           | 3  |     |
|                       | Load Bank Manual Close Step 20                 |           | 4  |     |
|                       | Load Bank Load Steps Required                  | 40096     |    | -   |
|                       | Load Bank Load Steps Online                    | 40097     |    | -   |
|                       | Load Bank Optimum Load Setpoint (kW) Internal  | 40098     |    | kW  |
|                       | Load Bank Load Bank kW Calculated (Load Steps) | 40099     |    | kW  |
|                       | Load Bank HMI Initial Delay Time (sec)         | 40100     |    | sec |
|                       | Load Bank HMI Add Delay Time (sec)             | 40101     |    | sec |
|                       | Load Bank HMI Subtract Delay Time (sec)        | 40102     |    | sec |
|                       | reserved                                       | 40103-110 |    |     |
| System Alarms         | System Not In Auto                             | 40111     | 0  |     |
|                       | PAC Minor Error                                |           | 9  |     |
|                       | PAC Major Error                                |           | 10 |     |
|                       | PAC IO Error                                   |           | 11 |     |
|                       | Modbus - Watchdog Alarm                        |           | 15 |     |
|                       | Transformer Alarm                              | 40112     | 0  |     |
|                       | Transformer Tripped                            |           | 1  |     |
|                       | Transformer Protection Relay Alarm             |           | 2  |     |
|                       | Main Rack Slot 3 IF16 Fault                    |           | 6  |     |
|                       | Main Rack Slot 4 OF8 Fault                     |           | 7  |     |
|                       | Main Rack Slot 5 IV32 Fault                    |           | 8  |     |
|                       | Main Rack Slot 6 IV32 Fault                    |           | 9  |     |
|                       | Main Rack Slot 7 IV32 Fault                    |           | 10 |     |
|                       | Main Rack Slot 8 OB32 Fault                    |           | 11 |     |
|                       | Main Rack Slot 9 OB32 Fault                    |           | 12 |     |
|                       | Main Rack Slot 10 OB32 Fault                   |           | 13 |     |
|                       | 125VDC Supply Failed                           | 40113     | 0  |     |
|                       | 24VDC Supply 1 Failed                          |           | 1  |     |
|                       | 24VDC Supply 2 Failed                          |           | 2  |     |
|                       | Load Bank Alarm                                |           | 8  |     |
| Load Bank Not In Auto |  | 9         |    |     |
| Loads have been shed  |  | 15        |    |     |
| reserved              | 40114-120                                      |           |    |     |
| Generator 1           | Generator 1 Available                          | 40121     | 0  |     |
|                       | Generator 1 Available (Regardless of Alarm)    |           | 1  |     |



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|----------------|---|-----------|---|---------|
|                | Generator 1 Engine Start                    |           | 2 |         |
|                | Generator 1 Sync to Bus                     |           | 3 |         |
|                | Generator 1 Running                         |           | 4 |         |
|                | Generator 1 Breaker Closed                  |           | 5 |         |
|                | Generator 1 Common Alarm                    | 40122     | 0 |         |
|                | Generator 1 Common Shutdown                 |           | 1 |         |
|                | Generator 1 Local Breaker Open              |           | 2 |         |
|                | Generator 1 Not In Auto                     |           | 3 |         |
|                | Generator 1 Breaker Withdrawn               |           | 4 |         |
|                | Generator 1 Protection Tripped              |           | 5 |         |
|                | Generator 1 Protection Relay Alarm          |           | 6 |         |
|                | Generator 1 DSLC Alarm                      |           | 7 |         |
|                | Generator 1 Fail to Close                   | 40123     | 0 |         |
|                | Generator 1 Fail to Open                    |           | 1 |         |
|                | Generator 1 Fail to Unload                  |           | 2 |         |
|                | Generator 1 Fail to Start Alarm             |           | 3 |         |
|                | Generator 1 Low Fuel Alarm                  |           | 4 |         |
|                | Generator 1 Entered Priority                | 40124     |   | -       |
|                | Generator 1 kW                              | 40125     |   | kW      |
|                | Generator 1 Fuel Consumption (Lph)          | 40126     |   | Lph     |
|                | Generator 1 Fuel Time Remaining (Hours)     | 40127     |   | Hours   |
|                | Generator 1 Fuel Time Remaining (Minutes)   | 40128     |   | Minutes |
|                | Generator 1 Fuel Volume (L)                 | 40129     |   | L       |
|                | Generator 1 Sync Attempts                   | 40130     |   | -       |
|                | Generator 1 Sync Time                       | 40131     |   | sec     |
|                | Generator 1 Warmup Time                     | 40132     |   | -       |
|                | reserved                                    | 40133-140 |   |         |
| Generator<br>2 | Generator 2 Available                       | 40141     | 0 |         |
|                | Generator 2 Available (Regardless of Alarm) |           | 1 |         |
|                | Generator 2 Engine Start                    |           | 2 |         |
|                | Generator 2 Sync to Bus                     |           | 3 |         |
|                | Generator 2 Running                         |           | 4 |         |
|                | Generator 2 Breaker Closed                  |           | 5 |         |
|                | Generator 2 Common Alarm                    | 40142     | 0 |         |
|                | Generator 2 Common Shutdown                 |           | 1 |         |
|                | Generator 2 Local Breaker Open              |           | 2 |         |
|                | Generator 2 Not In Auto                     |           | 3 |         |

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|---------------------------------|---|-----------|---|---------|
|                                 | Generator 2 Breaker Withdrawn               |           | 4 |         |
|                                 | Generator 2 Protection Tripped              |           | 5 |         |
|                                 | Generator 2 Protection Relay Alarm          |           | 6 |         |
|                                 | Generator 2 DSLC Alarm                      |           | 7 |         |
|                                 | Generator 2 Fail to Close                   | 40143     | 0 |         |
|                                 | Generator 2 Fail to Open                    |           | 1 |         |
|                                 | Generator 2 Fail to Unload                  |           | 2 |         |
|                                 | Generator 2 Fail to Start Alarm             |           | 3 |         |
|                                 | Generator 2 Low Fuel Alarm                  |           | 4 |         |
|                                 | Generator 2 Entered Priority                | 40144     |   | -       |
|                                 | Generator 2 kW                              | 40145     |   | kW      |
|                                 | Generator 2 Fuel Consumption (Lph)          | 40146     |   | Lph     |
|                                 | Generator 2 Fuel Time Remaining (Hours)     | 40147     |   | Hours   |
|                                 | Generator 2 Fuel Time Remaining (Minutes)   | 40148     |   | Minutes |
|                                 | Generator 2 Fuel Volume (L)                 | 40149     |   | L       |
|                                 | Generator 2 Sync Attempts                   | 40150     |   | -       |
|                                 | Generator 2 Sync Time                       | 40151     |   | sec     |
|                                 | Generator 2 Warmup Time                     | 40152     |   | -       |
|                                 | reserved                                    | 40153-160 |   |         |
| Generator<br>3                  | Generator 3 Available                       | 40161     | 0 |         |
|                                 | Generator 3 Available (Regardless of Alarm) |           | 1 |         |
|                                 | Generator 3 Engine Start                    |           | 2 |         |
|                                 | Generator 3 Sync to Bus                     |           | 3 |         |
|                                 | Generator 3 Running                         |           | 4 |         |
|                                 | Generator 3 Breaker Closed                  |           | 5 |         |
|                                 | Generator 3 Common Alarm                    | 40162     | 0 |         |
|                                 | Generator 3 Common Shutdown                 |           | 1 |         |
|                                 | Generator 3 Local Breaker Open              |           | 2 |         |
|                                 | Generator 3 Not In Auto                     |           | 3 |         |
|                                 | Generator 3 Breaker Withdrawn               |           | 4 |         |
|                                 | Generator 3 Protection Tripped              |           | 5 |         |
|                                 | Generator 3 Protection Relay Alarm          |           | 6 |         |
|                                 | Generator 3 DSLC Alarm                      |           | 7 |         |
|                                 | Generator 3 Fail to Close                   | 40163     | 0 |         |
|                                 | Generator 3 Fail to Open                    |           | 1 |         |
|                                 | Generator 3 Fail to Unload                  |           | 2 |         |
| Generator 3 Fail to Start Alarm |   | 3         |   |         |

## System Description / Sequence of Operation

### Generator Control System ESQUIMALT GRAVING DOCK

C-054107, W-095112

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|                             |   |           |   |         |
|-----------------------------|---|-----------|---|---------|
|                             | Generator 3 Low Fuel Alarm                  |           | 4 |         |
|                             | Generator 3 Entered Priority                | 40164     |   | -       |
|                             | Generator 3 kW                              | 40165     |   | kW      |
|                             | Generator 3 Fuel Consumption (Lph)          | 40166     |   | Lph     |
|                             | Generator 3 Fuel Time Remaining (Hours)     | 40167     |   | Hours   |
|                             | Generator 3 Fuel Time Remaining (Minutes)   | 40168     |   | Minutes |
|                             | Generator 3 Fuel Volume (L)                 | 40169     |   | L       |
|                             | Generator 3 Sync Attempts                   | 40170     |   | -       |
|                             | Generator 3 Sync Time                       | 40171     |   | sec     |
|                             | Generator 3 Warmup Time                     | 40172     |   | -       |
|                             | reserved                                    | 40173-180 |   |         |
| Generator<br>4              | Generator 4 Available                       | 40181     | 0 |         |
|                             | Generator 4 Available (Regardless of Alarm) |           | 1 |         |
|                             | Generator 4 Engine Start                    |           | 2 |         |
|                             | Generator 4 Sync to Bus                     |           | 3 |         |
|                             | Generator 4 Running                         |           | 4 |         |
|                             | Generator 4 Breaker Closed                  |           | 5 |         |
|                             | Generator 4 Common Alarm                    | 40182     | 0 |         |
|                             | Generator 4 Common Shutdown                 |           | 1 |         |
|                             | Generator 4 Local Breaker Open              |           | 2 |         |
|                             | Generator 4 Not In Auto                     |           | 3 |         |
|                             | Generator 4 Breaker Withdrawn               |           | 4 |         |
|                             | Generator 4 Protection Tripped              |           | 5 |         |
|                             | Generator 4 Protection Relay Alarm          |           | 6 |         |
|                             | Generator 4 DSLC Alarm                      |           | 7 |         |
|                             | Generator 4 Fail to Close                   | 40183     | 0 |         |
|                             | Generator 4 Fail to Open                    |           | 1 |         |
|                             | Generator 4 Fail to Unload                  |           | 2 |         |
|                             | Generator 4 Fail to Start Alarm             |           | 3 |         |
|                             | Generator 4 Low Fuel Alarm                  |           | 4 |         |
|                             | Generator 4 Entered Priority                | 40184     |   | -       |
|                             | Generator 4 kW                              | 40185     |   | kW      |
|                             | Generator 4 Fuel Consumption (Lph)          | 40186     |   | Lph     |
|                             | Generator 4 Fuel Time Remaining (Hours)     | 40187     |   | Hours   |
|                             | Generator 4 Fuel Time Remaining (Minutes)   | 40188     |   | Minutes |
| Generator 4 Fuel Volume (L) | 40189                                       |           | L |         |
| Generator 4 Sync Attempts   | 40190                                       |           | - |         |

## System Description / Sequence of Operation

### Generator Control System ESQUIMALT GRAVING DOCK

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|--|--|----------------------------------|-------|-----|
|  | Generator 4 Sync Time                                  | 40191                            |       | sec |
|  | Generator 4 Warmup Time                                | 40192                            |       | -   |
|  | reserved   | 40193-200                        |       |     |
| Utility<br>BCH-1                                       | Utility BCH-1 Synchronize Output                       | 40201                            | 0     |     |
|  | Utility BCH-1 Not Available                            |                                  | 1     |     |
|  | Utility BCH-1 Utility Out of Limits (Protection Relay) |                                  | 2     |     |
|  | Utility BCH-1 Preferred                                |                                  | 3     |     |
|  | Utility BCH-1 Breaker Closed                           |                                  | 4     |     |
|  | -  | 40202                            | 0     |     |
|  | Utility BCH-1 Protection Tripped                       |                                  | 1     |     |
|  | -  |                                  | 2     |     |
|  | Utility BCH-1 Utility Failed                           |                                  | 3     |     |
|  | Utility BCH-1 MSLC Alarm                               |                                  | 4     |     |
|  | Utility BCH-1 Fail to Close                            | 40203                            | 0     |     |
|  | Utility BCH-1 Fail to Open                             |                                  | 1     |     |
|  | Utility BCH-1 Fail to Unload                           |                                  | 2     |     |
|  | Utility BCH-1 Fail Time                                | 40204                            |       | sec |
|  | -  | 40205                            |       |     |
|  | Utility BCH-1 Retransfer Time                          | 40206                            |       | sec |
|  | Utility BCH-1 Sync Attempts                            | 40207                            |       | -   |
|  | Utility BCH-1 Sync Time                                | 40208                            |       | sec |
|  | reserved   | 40209-220                        |       |     |
|  | Utility<br>BCH-2                                       | Utility BCH-2 Synchronize Output | 40221 | 0   |
| Utility BCH-2 Not Available                            |  |                                  | 1     |     |
| Utility BCH-2 Utility Out of Limits (Protection Relay) |  |                                  | 2     |     |
| Utility BCH-2 Preferred                                |  |                                  | 3     |     |
| Utility BCH-2 Breaker Closed                           |  |                                  | 4     |     |
| -  |  | 40222                            | 0     |     |
| Utility BCH-2 Protection Tripped                       |  |                                  | 1     |     |
| -  |  |                                  | 2     |     |
| Utility BCH-2 Utility Failed                           |  |                                  | 3     |     |
| Utility BCH-2 MSLC Alarm                               |  |                                  | 4     |     |
| Utility BCH-2 Fail to Close                            |  | 40223                            | 0     |     |
| Utility BCH-2 Fail to Open                             |  |                                  | 1     |     |
| Utility BCH-2 Fail to Unload                           |  |                                  | 2     |     |
| Utility BCH-2 Fail Time                                |  | 40224                            |       | sec |

## System Description / Sequence of Operation

### Generator Control System ESQUIMALT GRAVING DOCK

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|                |  |           |   |     |
|----------------|--|-----------|---|-----|
|                | -  | 40225     |   |     |
|                | Utility BCH-2 Retransfer Time                        | 40226     |   | sec |
|                | Utility BCH-2 Sync Attempts                          | 40227     |   | -   |
|                | Utility BCH-2 Sync Time                              | 40228     |   | sec |
|                | reserved   | 40229-240 |   |     |
| Utility<br>DND | Utility DND Synchronize Output                       | 40241     | 0 |     |
|                | Utility DND Not Available                            |           | 1 |     |
|                | Utility DND Utility Out of Limits (Protection Relay) |           | 2 |     |
|                | Utility DND Preferred                                |           | 3 |     |
|                | Utility DND Breaker Closed                           |           | 4 |     |
|                | -  | 40242     | 0 |     |
|                | Utility DND Protection Tripped                       |           | 1 |     |
|                | -  |           | 2 |     |
|                | Utility DND Utility Failed                           |           | 3 |     |
|                | Utility DND MSLC Alarm                               |           | 4 |     |
|                | Utility DND Fail to Close                            | 40243     | 0 |     |
|                | Utility DND Fail to Open                             |           | 1 |     |
|                | Utility DND Fail to Unload                           |           | 2 |     |
|                | Utility DND Fail Time                                | 40244     |   | sec |
|                | -  | 40245     |   | kW  |
|                | Utility DND Retransfer Time                          | 40246     |   | sec |
|                | Utility DND Sync Attempts                            | 40247     |   | -   |
|                | Utility DND Sync Time                                | 40248     |   | sec |
|                | reserved   | 40249-260 |   |     |

## Bill of Materials for Work Order Number W-095112

| PART#  | DESCRIPTION  | DEV# | QTY  |
|--------|--|------|------|
| 011176 | METER, FREQUENCY, 55-65HZ, 120V, 4.5"<br>YOKOGAWA/103-372-ANAN   |      | 1.00 |
| 011415 | METER, VOLTS, 0-750V, ES150, 4.5", 1%<br>YOKOGAWA/103-021-PZSM   |      | 4.00 |
| 015082 | METER, VOLTS, 0-30KV, ES144, 4.5"<br>YOKOGAWA/103-021-PZXS   |      | 2.00 |
| 013915 | METER, WATTS, 3PH, 4W, 120V, 4.5", 1%<br>PT= 600:120V, CT= 1000:5A, 60HZ, SCALE: 0- 1000KW<br>YOKOGAWA/103-251-A****   | PT3  | 4.00 |
| 011176 | METER, FREQUENCY, 55-65HZ, 120V, 4.5"<br>YOKOGAWA/103-372-ANAN   |      | 6.00 |
| 010802 | METER, VAR, 3PH, 4W, 4.5", 1%<br>PT= 600:120, CT= 1000:5, SCALE: -500 -0- 500KVAR<br>YOKOGAWA/103-292-A****  |      | 4.00 |
| 011988 | METER, PWR FACTOR, 3PH, 3/4W, 120V<br>5A, 0.5LG-1-0.5LD, 4.5", 1%<br>YOKOGAWA/103-402-FCAD   |      | 4.00 |
| 008764 | METER, AMPS, 0-1000A, ES5, 4.5", 1%<br>YOKOGAWA/103-131-LSSS   |      | 4.00 |
| 010352 | SWITCH, VOLTMETER, L-L/L-N, 3PH<br>ROUND KNURLED HNDL<br>SHALLCO/2605C   |      | 4.00 |
| 009436 | SWITCH, AMMETER, ROUND KNURLED HNDL<br>SHALLCO/2610C   |      | 4.00 |
| 011177 | METER, SYNCHROSCOPE, 120V, 50/60HZ, 4.5"<br>YOKOGAWA/106-452-ADAA  |      | 5.00 |
| 009430 | SWITCH, 7 THROW ROTARY, 4 DECKS<br>SHALLCO/26304B  |      | 1.00 |
| 009399 | SWITCH, ESCUTCHEON PLATE<br>TITLE: SYNC SELECTOR<br>0-DEG: OFF<br>45-DEG: GM<br>90-DEG: DND<br>135-DEG: BCH-1<br>180-DEG: BCH-2<br>225-DEG: ..<br>270-DEG: ..<br>315-DEG: ..<br>SHALLCO/10 | 8SW3 | 1.00 |

|        |  |      |       |
|--------|--|------|-------|
| 011517 | SWITCH, SYNC, OFF-ON, 2 DECKS<br>FIXED OVAL HNDL<br>SHALLCO/2624B  | #SW1 | 4.00  |
| 009399 | SWITCH, ESCUTCHEON PLATE<br>TITLE: SYNC SELECTOR<br>0-DEG: OFF<br>45-DEG: ON<br>90-DEG:<br>135-DEG:<br>180-DEG:<br>225-DEG: ..<br>270-DEG: ..<br>315-DEG:<br>SHALLCO/10                    | #SW1 | 4.00  |
| 002376 | FUSE HOLDER, 3P, 30A, 600V, 200KA, CC<br>MARATHON SPECIAL PRODUCTS/6SC30A3-C   |      | 11.00 |
| 002374 | FUSE HOLDER, 1P, 30A, 600V, 200KA, CC<br>MARATHON SPECIAL PRODUCTS/6SC30A1-C   |      | 21.00 |
| 004858 | FUSE, 1A, 600VAC, CLASS CC<br>FERRAZ/ATDR1   |      | 1.00  |
| 003633 | FUSE, 3A, 600VAC, CLASS CC<br>FERRAZ/ATDR3   |      | 17.00 |
| 003634 | FUSE, 5A, 600VAC, CLASS CC<br>FERRAZ/ATDR5   |      | 27.00 |
| 001277 | FUSE, 10A, 600VAC, CLASS CC,<br>FERRAZ/ATDR10  |      | 9.00  |
| 009428 | SWITCH, 7 THROW ROTARY, 2 DECKS<br>SHALLCO/26302B  | 8SW2 | 1.00  |
| 009399 | SWITCH, ESCUTCHEON PLATE<br>TITLE: SYSTEM MODE<br>0-DEG: AUTO<br>45-DEG: START<br>90-DEG: TEST<br>135-DEG: ..<br>180-DEG: ..<br>225-DEG: ..<br>270-DEG: ..<br>315-DEG: MAN<br>SHALLCO/10   | 8SW2 | 1.00  |
| 015105 | SWITCH, DOUBLE THROW, 4 DECK, LOCKABLE<br>ESCUTCHEON TEXT:<br>TITLE: <NO TITLE - LEAVE BLANK><br>0-DEG: CLOSED<br>45-DEG: OPEN<br>KEY REMOVABLE IN BOTH POSITIONS.<br>SHALLCO/26204B 17793 |      | 1.00  |
| 010999 | SWITCH, ENET, 16-PORT, 10-30VDC AUX<br>N-TRON/116-TX   |      | 2.00  |

|        |  |      |      |
|--------|--|------|------|
| 000478 | RECTIFIER, BRIDGE, 400V, 35A, RoHS,<br>FAIRCHILD/GBPC3504  | BR.. | 3.00 |
| 006800 | POWER SUPPLY, 120/240VAC/DC-24VDC, 240W<br>240W, 85-264VAC / 100-350VDC PRIMARY, 10A @ 24VDC SECONDARY<br>IDEC CANADA/PS5R-SG24  |      | 2.00 |
| 008297 | DISTRIBUTION BLOCK, 2P, 310A<br>(1) #6-350MCM IN, (12) #4-14 OUT<br>USES DISTRIBUTION COVER #008687<br>BUSSMAN/16370-2   |      | 1.00 |
| 008687 | DISTRIBUTION BLOCK, COVER, 163, 2-POLE<br>ACCESSORY FOR #008297<br>BUSSMAN/CPDB-2  |      | 1.00 |
| 012087 | PC, INDUSTRIAL, 19", 24VDC AUX<br>PANEL MNT, PENTIUM DUAL CORE G6XXT > 2.2GHZ, 2GB RAM, (4) RS232, (6) USB 2.0, (2) USB 3.0, (1) RS485, (2) LAN, (1) SATA, (1) PCIE MINI P/N: PPC-5190AD-H61-P/R-R10<br>IEI/PPC-5190AD-H61-P/R-R10 |      | 1.00 |
| 012408 | PC, SSD, 120GB, 2.5", SATA3, MLC,<br>NCIX SKU# 84151<br>INTEL/SSDSC2BB120G401  |      | 1.00 |
| 012202 | PC, MEMORY, CF CARD, 16GB<br>TRANSCEND/TS16GF170   |      | 1.00 |
| 011333 | SOFTWARE, WIN7 PRO, 32-BIT, DVD, OEM<br>PURCHASE W/ HDD 012491<br>MUST BE BOUGHT IN MULTIPLES OF 3<br>OLD# FQC-000730<br>MICROSOFT/SERVICE PACK 1  |      | 1.00 |
| 007704 | SOFTWARE, WEB STUDIO, 1500 TAG, RT<br>7 COMM. DRIVERS.<br>INCLUDES USB HARDKEY PART # OM-USB-HK.<br>INDUSOFT/OM-920NT-RT-7DRV + OM-USB-HK  |      | 1.00 |
| 012888 | SOFTWARE, SHADOW DEFENDER, LIC-KEY<br>20/PKG FOR PRICING.<br>SHADOWDEFENDER/SHADOWDEFENDER   |      | 1.00 |
| 012054 | POWER SUPPLY, DC UPS, CONTROLLER, 24V,<br>QUINT-UPS/24DC/24DC/5 - MAIN PS CONTROLLER.<br>PHOENIX/2320212   |      | 1.00 |
| 012055 | POWER SUPPLY, DC UPS, BATTERY, 1.3AH, 24V<br>1.3AH, QUINT UPS-BATTERY/VRLA/24DC/ 1.3AH BATTERY<br>PHOENIX/2320296  |      | 1.00 |
| 012056 | POWER SUPPLY, DC UPS, USB DATA CABLE,<br>IFS-USB-DATA CABLE  |      | 1.00 |



|        |   |        |       |
|--------|---|--------|-------|
| 010527 | DSLC-2, 480/120VAC, 5A CT INPUT<br>WOODWARD/8440-1878                       |        | 4.00  |
| 010547 | MSLC-2, 480/120VAC, 5A CT INPUT<br>WOODWARD/8440-1877                       |        | 4.00  |
| 015020 | DIG, METER, ENET, 85-240VAC/110-330VDC<br>SEL/P7650A0C0B6E0K0A              |        | 4.00  |
| 009420 | 86 LOCKOUT RELAY, 120VAC/DC, 5 DECKS<br>30/140VDC - 120VAC<br>SHALLCO/7605D |        | 1.00  |
| 015019 | SEL700G, GEN. PROT.RELAY, 125V AUX<br>SEL/0700G01ABA0X74850600              |        | 4.00  |
| 009417 | 86 LOCKOUT RELAY, 120VAC/DC, 2 DECK<br>30/140VDC - 120VAC<br>SHALLCO/7602D  |        | 4.00  |
| 004931 | TEST BLOCK, FT-1, C-C C-C C-C C-C C-C<br>GE/FT-082                          |        | 4.00  |
| 005183 | TEST BLOCK FT-1, P P P P P P P P<br>GE/FT-066                               |        | 4.00  |
| 005556 | P/B, 22MM, BLACK, 1 N/O<br>IDEC/HW4B-M1F10-B                                | PB..   | 5.00  |
| 005564 | P/B, 22MM, RED, 1-N/O,<br>IDEC/HW4B-M1F10-R                                 |        | 13.00 |
| 005563 | P/B, 22MM, GREEN, 1-N/O,<br>FLUSH<br>IDEC/HW4B-M1F10-G                      |        | 13.00 |
| 005585 | PILOT LIGHT, 22MM, GREEN LED, 24V<br>IDEC/HW4P-2FQD-G-24V                   | L..    | 18.00 |
| 005588 | PILOT LIGHT, 22MM, RED LED, 24V<br>IDEC/HW4P-2FQD-R-24V                     |        | 13.00 |
| 005605 | PILOT LIGHT, 22MM, AMBER LED, 24V<br>IDEC/HW4P-2FQD-A-24V                   |        | 9.00  |
| 005586 | PILOT LIGHT, 22MM, GREEN LED, 120VAC<br>IDEC/HW4P-2FQD-G-120V               |        | 3.00  |
| 005589 | PILOT LIGHT, 22MM, RED LED, 120VAC<br>IDEC/HW4P-2FQD-R-120V                 |        | 1.00  |
| 009891 | P/B, 22MM, RED M/H, 1-N/C, PUSH-PULL<br>IDEC/HW4B-Y2F01-R                   | E-STOP | 4.00  |

|        |  |        |        |
|--------|--|--------|--------|
| 002944 | P/B, 22MM, E-STOP GUARD, YELLOW<br>IDEC/HW9Z-KG1-TK2120  |        | 4.00   |
| 001643 | SONALERT, 6/28VDC, 18MA, RoHS<br>MALLORY/SC628   | HRN    | 1.00   |
| 001648 | SWITCH, 22MM, CONTACT, 1-N/O, IP20<br>IDEC/HW-F10  | E-STOP | 8.00   |
| 001654 | SWITCH, 22MM, CONTACT, 1-N/C, IP20<br>IDEC/HW-F01  | PB3    | 4.00   |
| 001304 | RELAY, 24VDC COIL, 14 PIN SQ., MINI.<br>4PDT 6A, 250VAC/30VDC RES.<br>LED IND. & MECH. OP. LEVER<br>IDEC/RU4S-D24                        |        | 129.00 |
| 000402 | RELAY SOCKET, 14 PIN SQ., RAIL MNT, MINI<br>IDEC/SY4S-05U  |        | 119.00 |
| 004093 | RELAY, 24VDC COIL, 11 PIN SQ.<br>1N/O-10A,150VDC/240VAC<br>TYCO-P&B/KUEP-3D15-24   |        | 22.00  |
| 000399 | RELAY SOCKET, 11 PIN SQ., RAIL MNT<br>IDEC/SR3B-05   |        | 22.00  |
| 009310 | RELAY, 125VDC COIL, 11 PIN RND, /W DIODE<br>/W LED, CONTACT RATINGS: 10A @ 250VAC, 10A @ 30VDC, 0.5A @ 110VDC,<br>RELECO/C3-A30DX/125VDC |        | 1.00   |
| 000398 | RELAY SOCKET, 11 PIN RND, RAIL MNT<br>IDEC/SR3P-06U  |        | 1.00   |
| 003706 | CL5000, CHASSIS, 13 SLOT<br>ALLEN BRADLEY/1756-A13   |        | 1.00   |
| 013163 | CL5000, POWER SUPPLY, 24VDC<br>ALLEN BRADLEY/1756-PB75   | PLC    | 1.00   |
| 011942 | CL5000, PROCESSOR, L72<br>ALLEN BRADLEY/1756-L72   |        | 1.00   |
| 009775 | CL5000, CLX ENET/IP, 10/100 BRIDGE<br>ALLEN BRADLEY/1756-EN2T  |        | 1.00   |
| 011976 | CL5000, MODBUS TCP MODULE<br>PROSOFT/MVI56E-MNET   |        | 1.00   |
| 005784 | CL5000, ANALOG MD, 16 PT, IN<br>ALLEN BRADLEY/1756-IF16  |        | 1.00   |
| 002535 | CL5000, ANALOG MD, 8 PT, I/V - OUT<br>ALLEN BRADLEY/1756-OF8   |        | 1.00   |

|        |  |      |
|--------|--|------|
| 006743 | CL5000, INPUT MD, 32PT, 24VDC SOURCE<br>ALLEN BRADLEY/1756-IV32                      | 3.00 |
| 006744 | CL5000, OUTPUT MD, 32PT, 24VDC SOURCE<br>ALLEN BRADLEY/1756-OB32                     | 3.00 |
| 002995 | CL5000, 36-PIN SCREW CLAMP BLOCK<br>/W STD HOUSING<br>ALLEN BRADLEY/1756-TBCH        | 7.00 |
| 002994 | CL5000, 20-PIN SCREW CLAMP BLOCK<br>/W STD HOUSING<br>ALLEN BRADLEY/1756-TBNH        | 1.00 |
| 002996 | CL5000, CARD SLOT FILLER, 1-PKG<br>ALLEN BRADLEY/1756-N2                             | 2.00 |
| 006745 | CL5000, EXTENDED DEPTH HOUSING<br>ALLEN BRADLEY/1756-TBE                             | 8.00 |
| 004193 | TERM. BLK, 2-TIER W/ DIODE, WK4/U<br>MOQ = 100 FOR PRICING.<br>WIELAND/57.404.8155.9 | 4.00 |

## Bill of Materials for Work Order Number W-095113

| PART#  | DESCRIPTION  | DEV# | QTY  |
|--------|--|------|------|
| 010991 | LOAD BANK, MODEL LBO, OUTDOOR<br><br>KW: 1000KW<br>VOLTAGE: 600V<br>Q-SSPL160706<br>ESQUIMALT GRAVING DOCK<br>C-054107<br>W-095113<br>CSA LABEL<br>DRAWINGS<br><br>LBO-1000H-600V-3-C<br>LOAD BANK, MODEL LBO, OUTDOOR<br>CAPACITY: 1000KW<br>OPERATING VOLTAGE : 600V<br>TEST FREQUENCY : 60HZ<br>LOAD STEPS AT RATED VOLTAGE : 20@ 50KW<br><br>C/W<br>ALUMINIZED ENCLOSURE<br>PAINTING<br>BRANCH FUSES<br>AUTOLOAD SENSING & CONTROL<br>STAND WITH LIFT CHANEL<br>NEMA 1 REMOTE CONTROL PANEL<br>SHANGHAI SIMPSON/010991 |      | 1.00 |
| 013716 | DIG. METER, 120-300V AUX<br><br>SQUARE D/METSEPM8240   |      | 1.00 |
| 013717 | DIG. METER, ANALOG MD,<br><br>(4) 4-20MA/0-30V IN, (2) 4-20MA/0-10VOUT<br><br>SQUARE D/METSEPM89M0024  |      | 1.00 |
| 009968 | TEST BLOCK, FT-1, C-C-C-C-C P P P P<br><br>GE/FT-207   |      | 1.00 |

## Bill of Materials for Work Order Number W-095885

| PART#  | DESCRIPTION  | DEV# | QTY  |
|--------|--|------|------|
| 009743 | XFMER, METERING, 600:120V, 150VA, 60HZ<br>ACC. 0.6W, 1.2X<br>AMRAN/PT100-600 |      | 9.00 |
| 002910 | XFMER, CURRENT, 4" DIA., C50, 1000:5A<br>ITI/100-102                         |      | 9.00 |
| 004655 | XFMER, CURRENT, 4" DIA., C20, 500:5A<br>ITI/100-501                          |      | 3.00 |

End of Section

**Series 2200 / 2400**  
**Paralleling Switchgear**

***Recommended Preventative  
Maintenance Requirements***

PM083 Rev 1 14/02/17

1. Preventative Maintenance Requirements

- Visual inspection of bus and cable connections annually. Review and retorque bus and cable connections after first year of service and check once every 3 years thereafter. If loose connections are found frequency should be increased.
- Wire Tug/Tightness checks on all components after 1st year of service. This can be reduced then to every 2 years. This includes all interconnect wiring to junction boxes.
- Check wiring for chaffing or damage resulting from vibration or heat.
- Clean equipment as applicable. Remove dust/dirt, grease, etc. with dry rags, brushes or a vacuum. Do not use compressed air as this will only force dirt or metal cuttings into electrical components and may result in equipment failure or personal injury.
- Control batteries and backup batteries (i.e.: PLCs). Test per manufacturer's recommended procedures.
- Replace PLC/CPU batteries every 5 years.
- Lamp test to verify all lamps are serviceable.
- Test and record all alarm and shutdowns.
- Verify PLC operation - Proper front panel indications. Review of PLC internal fault/event summaries. Review of internal logic and settings to equal operational values as commissioned. Visual inspection of heat damage or other abnormalities.
- Verify manual operation of all breakers and manual system operation.
- Confirm all ancillary components are operational and within operating specifications.
- Verify all protection relaying trip function using relay trip test feature annually.
- Verify configuration and Protective settings per coordination study every 2 to 3 years. Review Event and Fault records and verify correct date and time.
- Verify the generator frequency and voltage are matched to the utility supply (normal expected values for the system).
- Verify analog and digital metering accuracy and recalibrate as required.



- Verify all Micro Processor programming. Compare this to commissioning values. Confirm calibration of all metering values.
- Remove LV or MV breakers from cells (where applicable) and perform visual and mechanical inspections as specified by the breakers manufacturer's O&M manual in addition to lubrication of specified rollers and cams annually.
- Remove LV or MV breakers from cells (where applicable) and verify electrical tests as specified by the breaker manufacturer's O&M manual every 3 years for LV breakers and every 2 years for MV breakers.
- Remove and inspect draw out PT drawers and perform visual and mechanical inspections in addition to lubrication of rollers annually.

# 1769 Compact Digital, Analog, and Specialty I/O Modules

**ATTENTION:**

- Before installing, configuring, operating or maintaining this product, read this document and the documents listed in the Additional Resources section for installing, configuring, or operating equipment. Users should familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.
- Installation, adjustments, putting into service, use, assembly, disassembly, and maintenance shall be carried out by suitably trained personnel in accordance with applicable code of practice. In case of malfunction or damage, no attempts at repair should be made. The module should be returned to the manufacturer for repair. Do not dismantle the module.
- This equipment is certified for use only within the surrounding air temperature range of 0...60 °C (32...140 °F). The equipment must not be used outside of this range.
- Solid state equipment has operational characteristics differing from those of electromechanical equipment. Safety Guidelines for the Application, Installation and Maintenance of Solid State Controls, publication SGI-1.1, available from your local Rockwell Automation sales office or online at <http://www.rockwellautomation.com/literature> describes some important differences between solid state equipment and hard-wired electromechanical devices.

**IMPORTANT** Any illustrations, charts, sample programs, and layout examples shown in this publication are intended solely for the purposes of example. Since there are many variables and requirements associated with any particular installation, Rockwell Automation does not assume responsibility or liability for actual use based upon the examples shown in this publication.

## North American Hazardous Location Approval

The following information applies when operating this equipment in hazardous locations: Products marked "CL I, DIV 2, GP A, B, C, D" are suitable for use in Class I Division 2 Groups A, B, C, D, Hazardous Locations and nonhazardous locations only. Each product is supplied with markings on the rating nameplate indicating the hazardous location temperature code. When combining products within a system, the most adverse temperature code (lowest "T" number) may be used to help determine the overall temperature code of the system. Combinations of equipment in your system are subject to investigation by the local authority having jurisdiction at the time of installation.

**WARNING: EXPLOSION HAZARD**

- Do not disconnect equipment unless power has been removed or the area is known to be nonhazardous.
- Do not disconnect connections to this equipment unless power has been removed or the area is known to be nonhazardous. Secure any external connections that mate to this equipment by using screws, sliding latches, threaded connectors, or other means provided with this product.
- Substitution of components may impair suitability for Class I, Division 2.
- If this product contains batteries, they must be changed only in an area known to be nonhazardous.

Informations sur l'utilisation de cet équipement en environnements dangereux:

Les produits marqués "CL I, DIV 2, GP A, B, C, D" ne conviennent qu'à une utilisation en environnements de Classe I Division 2 Groupes A, B, C, D dangereux et non dangereux. Chaque produit est livré avec des marquages sur sa plaque d'identification qui indiquent le code de température pour les environnements dangereux. Lorsque plusieurs produits sont combinés dans un système, le code de température le plus défavorable (code de température le plus faible) peut être utilisé pour déterminer le code de température global du système. Les combinaisons d'équipements dans le système sont sujettes à inspection par les autorités locales qualifiées au moment de l'installation.

**AVERTISSEMENT: RISQUE D'EXPLOSION**

- Couper le courant ou s'assurer que l'environnement est classé non dangereux avant de débrancher l'équipement.
- Couper le courant ou s'assurer que l'environnement est classé non dangereux avant de débrancher les connecteurs. Fixer tous les connecteurs externes reliés à cet équipement à l'aide de vis, loquets coulissants, connecteurs filetés ou autres moyens fournis avec ce produit.
- La substitution de composants peut rendre cet équipement inadapté à une utilisation en environnement de Classe I, Division 2.
- S'assurer que l'environnement est classé non dangereux avant de changer les piles.

## Environment and Enclosure




**ATTENTION:** This equipment is intended for use in a Pollution Degree 2 industrial environment, in overvoltage Category II applications (as defined in IEC 60664-1), at altitudes up to 2000 m (6562 ft) without derating.

This equipment is considered Group 1, Class A industrial equipment according to IEC/CISPR 11. Without appropriate precautions, there may be difficulties with electromagnetic compatibility in residential and other environments due to conducted and radiated disturbances.

This equipment is supplied as open-type equipment. It must be mounted within an enclosure that is suitably designed for those specific environmental conditions that will be present and appropriately designed to prevent personal injury resulting from accessibility to live parts. The enclosure must have suitable flame-retardant properties to prevent or minimize the spread of flame, complying with a flame spread rating of 5VA, V2, V1, V0 (or equivalent) if non-metallic. The interior of the enclosure must be accessible only by the use of a tool. Subsequent sections of this publication may contain additional information regarding specific enclosure type ratings that are required to comply with certain product safety certifications. In addition to this publication, see Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1, for additional installation requirements. See NEMA 250 and IEC publication 60529, as applicable, for explanations of the degrees of protection provided by different types of enclosure.

## European Hazardous Location Approval

The following applies to products marked  II 3 G: Such modules:

- are Equipment Group II, Equipment Category 3, and comply with the Essential Health and Safety Requirements relating to the design and construction of such equipment given in Annex II to Directive 94/9/EC. See the EC Declaration of Conformity at <http://www.rockwellautomation.com> for details. The type of protection used is "Ex nA IIC T- or Ex nC IIC T-" according to EN 60079-15. The specific temperature code is documented in the Additional Resources section and must be verified by the installer by comparing it with the temperature code marked on the product.
- are intended for use in areas in which explosive atmospheres caused by gases, vapors, mists, or air or dust mixtures are unlikely to occur, or are likely to occur only infrequently and for short periods. Such locations correspond to Zone 2 classification according to ATEX directive 1999/92/EC.

**WARNING: Special Conditions for Safe Use:**

- This equipment must be installed in an enclosure providing at least IP54 protection when applied in Zone 2 environments.
- This equipment shall be used within its specified ratings defined by Rockwell Automation.
- Provision shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 40% when applied in Zone 2 environments.
- This equipment must be used only with ATEX certified Rockwell Automation backplanes.
- Secure any external connections that mate to this equipment by using screws, sliding latches, threaded connectors, or other means provided with this product.
- Do not disconnect equipment unless power has been removed or the area is known to be nonhazardous.



**ATTENTION:** Do not install this product until you read the documentation in your local language. Go to <http://www.rockwellautomation.com/literature> or contact your local sales office or Rockwell Automation representative.

**ATENÇÃO:** Não instale este produto antes de ler os documentos em sua língua. Clique <http://www.rockwellautomation.com/literature> ou entre em contato com o escritório ou representante da Rockwell Automation regional.

**ATTENTION:** N'installez pas ce produit tant que vous n'avez pas lu la documentation dans votre langue locale. Rendez-vous sur le site <http://www.rockwellautomation.com/literature> ou contactez votre agence commerciale ou votre représentant Rockwell Automation local.

**ATTENZIONE:** Non installare questo prodotto senza prima avere letto la documentazione nella propria lingua. Consultare la pagina web <http://www.rockwellautomation.com/literature> oppure contattare l'ufficio commerciale o il rappresentante Rockwell Automation di zona.

**ACHTUNG:** Bitte installieren Sie dieses Produkt erst, nachdem Sie sich die Produktdokumentation in Ihrer jeweiligen Sprache durchgelesen haben. Gehen Sie zu <http://www.rockwellautomation.com/literature> oder nehmen Sie Kontakt mit Ihrem lokalen Vertriebsbüro bzw.

**ATENCIÓN:** No instale este producto antes de leer los documentos en su idioma. Para hacerlo, haga clic en <http://www.rockwellautomation.com/literature> o póngase en contacto con su oficina o representante de Rockwell Automation regional.

## 1756 EtherNet/IP Communication Modules

Catalog Numbers 1756-EN2T, 1756-EN2TR, 1756-EN2TSC, 1756-EN3TR, 1756-EN2TXT, 1756-EN2TRXT



**ATTENTION:** Read this document and the documents listed in the Additional Resources section about installation, configuration and operation of this equipment before you install, configure, operate or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

注意：在安装、配置、操作和维护本产品前，请阅读本文档以及“其他资源”部分列出的有关设备安装、配置和操作的相应文档。除了所有适用规范、法律和标准的相关要求之外，用户还必须熟悉安装和接线说明。

安装、调整、投运、使用、组装、拆卸和维护等各项操作必须由经过适当训练的专业人员按照适用的操作规范实施。

如果未按照制造商指定的方式使用该设备，则可能会损害设备提供的保护。

**ATENCIÓN:** Antes de instalar, configurar, poner en funcionamiento o realizar el mantenimiento de este producto, lea este documento y los documentos listados en la sección Recursos adicionales acerca de la instalación, configuración y operación de este equipo. Los usuarios deben familiarizarse con las instrucciones de instalación y cableado y con los requisitos de todos los códigos, leyes y estándares vigentes.

El personal debidamente capacitado debe realizar las actividades relacionadas a la instalación, ajustes, puesta en servicio, uso, ensamblaje, desensamblaje y mantenimiento de conformidad con el código de práctica aplicable.

Si este equipo se usa de una manera no especificada por el fabricante, la protección provista por el equipo puede resultar afectada.

**ATENÇÃO:** Leia este e os demais documentos sobre instalação, configuração e operação do equipamento que estão na seção Recursos adicionais antes de instalar, configurar, operar ou manter este produto. Os usuários devem se familiarizar com as instruções de instalação e fiação além das especificações para todos os códigos, leis e normas aplicáveis.

É necessário que as atividades, incluindo instalação, ajustes, colocação em serviço, utilização, montagem, desmontagem e manutenção sejam realizadas por pessoal qualificado e especializado, de acordo com o código de prática aplicável.

Caso este equipamento seja utilizado de maneira não estabelecida pelo fabricante, a proteção fornecida pelo equipamento pode ficar prejudicada.

**ВНИМАНИЕ:** Перед тем как устанавливать, настраивать, эксплуатировать или обслуживать данное оборудование, прочитайте этот документ и документы, перечисленные в разделе «Дополнительные ресурсы». В этих документах изложены сведения об установке, настройке и эксплуатации данного оборудования. Пользователи обязаны ознакомиться с инструкциями по установке и прокладке соединений, а также с требованиями всех применимых норм, законов и стандартов.

Все действия, включая установку, наладку, ввод в эксплуатацию, использование, сборку, разборку и техническое обслуживание, должны выполняться обученным персоналом в соответствии с применимыми нормами и правилами.

Если оборудование используется не предусмотренным производителем образом, защита оборудования может быть нарушена.

注意：本製品を設置、構成、稼働または保守する前に、本書および本機器の設置、設定、操作についての参考資料の該当箇所に記載されている文書に目を通してください。ユーザは、すべての該当する条例、法律、規格の要件に加えて、設置および配線の手順に習熟している必要があります。

設置調整、運転の開始、使用、組立て、解体、保守を含む諸作業は、該当する実施規則に従って訓練を受けた適切な作業員が実行する必要があります。

本機器が製造メーカーにより指定されていない方法で使用されている場合、機器により提供されている保護が損なわれる恐れがあります。

**ACHTUNG:** Lesen Sie dieses Dokument und die im Abschnitt „Literaturverweise“ genannten Dokumente zur Installation, Konfiguration und Bedienung dieser Ausrüstung sorgfältig durch, bevor Sie dieses Produkt installieren, konfigurieren, bedienen oder instandsetzen. Benutzer müssen sich mit den Anweisungen zur Installation und Verdrahtung vertraut machen und müssen die Anforderungen aller geltenden Vorschriften, Gesetze und Normen kennen.

Aktivitäten wie Installation, Einstellung, Inbetriebnahme, Verwendung, Montage, Demontage und Instandsetzung müssen durch ausreichend geschultes Personal in Übereinstimmung mit den geltenden Durchführungsvorschriften ausgeführt werden.

Wenn diese Ausrüstung in einer Weise verwendet wird, die nicht vom Hersteller angegeben wurde, kann der von der Ausrüstung bereitgestellte Schutz beeinträchtigt sein.

**ATTENTION :** Lisez ce document et les documents listés dans la section Ressources complémentaires relatifs à l'installation, la configuration et le fonctionnement de cet équipement avant d'installer, configurer, utiliser ou entretenir ce produit. Les utilisateurs doivent se familiariser avec les instructions d'installation et de câblage en plus des exigences relatives aux codes, lois et normes en vigueur.

Les activités relatives à l'installation, le réglage, la mise en service, l'utilisation, l'assemblage, le démontage et l'entretien doivent être réalisées par des personnes formées selon le code de pratique en vigueur.

Si cet équipement est utilisé d'une façon qui n'a pas été définie par le fabricant, la protection fournie par l'équipement peut être compromise.

주의: 본 제품 설치, 설정, 작동 또는 유지 보수하기 전에 본 문서를 포함하여 설치, 설정 및 작동에 관한 참고 자료 섹션의 문서들을 반드시 읽고 숙지하십시오. 사용자는 모든 관련 규정, 법규 및 표준에서 요구하는 사항에 대해 반드시 설치 및 배선 지침을 숙지해야 합니다.

설치, 조정, 가동, 사용, 조립, 분해, 유지보수 등 모든 작업은 관련 규정에 따라 적절한 교육을 받은 사용자를 통해서만 수행해야 합니다.

본 장비를 제조사가 명시하지 않은 방법으로 사용하면 장비의 보호 기능이 손상될 수 있습니다.

**ATTENZIONE** Prima di installare, configurare ed utilizzare il prodotto, o effettuare interventi di manutenzione su di esso, leggere il presente documento ed i documenti elencati nella sezione "Altre risorse", riguardanti l'installazione, la configurazione ed il funzionamento dell'apparecchiatura. Gli utenti devono leggere e comprendere le istruzioni di installazione e cablaggio, oltre ai requisiti previsti dalle leggi, codici e standard applicabili.

Le attività come installazione, regolazioni, utilizzo, assemblaggio, disassemblaggio e manutenzione devono essere svolte da personale adeguatamente addestrato, nel rispetto delle procedure previste.

Qualora l'apparecchio venga utilizzato con modalità diverse da quanto previsto dal produttore, la sua funzione di protezione potrebbe venire compromessa.

**DIKKAT:** Bu ürünün kurulumu, yapılandırılması, işletilmesi veya bakımı öncesinde bu dokümanı ve bu ekipmanın kurulumu, yapılandırılması ve işletimi ile ilgili ilave Kaynaklar bölümünde yer listelenmiş dokümanları okuyun. Kullanıcılar yürürlükte tüm yönetmelikler, yasalar ve standartların gereksinimlerine ek olarak kurulum ve kablolama talimatlarını da öğrenmek zorundadır.

Kurulum, ayarlama, hizmete alma, kullanma, parçaları birleştirme, parçaları sökme ve bakım gibi aktiviteler sadece uygun eğitimleri almış kişiler tarafından yürürlükte uygulama yönetmeliklerine uygun şekilde yapılabilir.

Bu ekipman üretici tarafından belirlenmiş amaç dışında kullanılırsa, ekipman tarafından sağlanan koruma bozulabilir.

注意事項：在安装、設定、操作或維護本产品前，請先閱讀此文件以及列於「其他資源」章節中有關安裝、設定與操作此設備的文件。使用者必須熟悉安裝和配線指示，並符合所有法規、法律和標準要求。

包括安裝、調整、交付使用、使用、組裝、拆卸和維護等動作都必須交由已經過適當訓練的人員進行，以符合適用的實作法規。

如果將設備用於非製造商指定的用途時，可能會造成設備所提供的保護功能受損。

**POZOR:** Než začnete instalovat, konfigurovat či provozovat tento výrobek nebo provádět jeho údržbu, přečtěte si tento dokument a dokumenty uvedené v části Dodatečné zdroje ohledně instalace, konfigurace a provozu tohoto zařízení. Uživatelé se musejí vedle požadavků všech relevantních vyhlášek, zákonů a norem nutně seznámit také s pokyny pro instalaci a elektrické zapojení.

Činnosti zahrnující instalaci, nastavení, uvedení do provozu, užívání, montáž, demontáž a údržbu musí vykonávat vhodně proškolený personál v souladu s příslušnými prováděcími předpisy.

Pokud se toto zařízení používá způsobem neodpovídajícím specifikaci výrobce, může být narušena ochrana, kterou toto zařízení poskytuje.

**UWAGA:** Przed instalacją, konfiguracją, użytkowaniem lub konserwacją tego produktu należy przeczytać niniejszy dokument oraz wszystkie dokumenty wymienione w sekcji Dodatkowe źródła omawiające instalację, konfigurację i procedury użytkowania tego urządzenia. Użytkownicy mają obowiązek zapoznać się z instrukcjami dotyczącymi instalacji oraz oprzewodowania, jak również z obowiązującymi kodeksami, prawem i normami.

Działania obejmujące instalację, regulację, przekazanie do użytkowania, użytkowanie, montaż, demontaż oraz konserwację muszą być wykonywane przez odpowiednio przeszkolony personel zgodnie z obowiązującym kodeksem postępowania.

Jeśli urządzenie jest używane w sposób inny niż określony przez producenta, zabezpieczenie zapewniane przez urządzenie może zostać ograniczone.

**OB!** Läs detta dokument samt dokumentet, som står listat i avsnittet Övriga resurser, om installation, konfiguration och drift av denna utrustning innan du installerar, konfigurerar eller börjar använda eller utföra underhållsarbete på produkten. Användare måste bekanta sig med instruktioner för installation och kabeldragning, förutom krav enligt gällande koder, lagar och standarder.

Åtgärder som installation, justering, service, användning, montering, demontering och underhållsarbete måste utföras av personal med lämplig utbildning enligt lämpligt bruk.

Om denna utrustning används på ett sätt som inte anges av tillverkaren kan det hända att utrustningens skyddsanordningar försärrs ur funktion.

**LET OP:** Lees dit document en de documenten die genoemd worden in de paragraaf Aanvullende informatie over de installatie, configuratie en bediening van deze apparatuur voordat u dit product installeert, configureert, bedient of onderhoudt. Gebruikers moeten zich vertrouwd maken met de installatie en de bedringsinstructies, naast de vereisten van alle toepasselijke regels, wetten en normen.

Activiteiten zoals het installeren, afstellen, in gebruik stellen, gebruiken, monteren, demonteren en het uitvoeren van onderhoud mogen uitsluitend worden uitgevoerd door hiervoor opgeleid personeel en in overeenstemming met de geldende praktijkregels.

Indien de apparatuur wordt gebruikt op een wijze die niet is gespecificeerd door de fabrikant, dan bestaat het gevaar dat de beveiliging van de apparatuur niet goed werkt.

### Install the Module

You can install or remove a module while chassis power is applied.



**WARNING:** When you insert or remove the module while backplane power is on, an electrical arc can occur. This could cause an explosion in hazardous location installations.

Be sure that power is removed or the area is nonhazardous before proceeding. Repeated electrical arcing causes excessive wear to contacts on both the module and its mating connector. Worn contacts may create electrical resistance that can affect module operation.

For equipment with multi-point network communication connections.



**WARNING:** If you connect or disconnect the communication cable with power applied to this module or any device on the network, an electrical arc can occur. This could cause an explosion in hazardous location installations.

Be sure that power is removed or the area is nonhazardous before proceeding.

Follow these steps to install the module.

1. Set the network IP address on a module.

For more information about configuring an EtherNet/IP network, see EtherNet/IP Network Configuration User Manual, publication ENET-UM001.

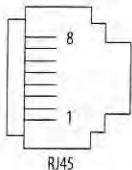
Depending on the 1756 EtherNet/IP communication module, you can use some or all of these tools to set the network Internet Protocol (IP) address:

- Rotary switches
- Bootstrap Protocol (BOOTP)/Dynamic Host Configuration Protocol (DHCP) server
- RSLinx® Classic software
- the Studio 5000® environment

The module uses these tools sequentially to set the IP address.

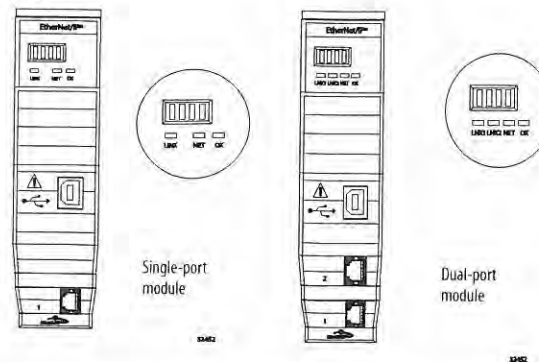
2. Determine module slot location.
3. Install the module.
  - a. Align the circuit board with top and bottom guides in the chassis.
  - b. Slide the module into the chassis, making sure the module backplane connector properly connects to the chassis backplane and noting that the module is properly installed when it is flush with the power supply or other installed modules.
4. Connect the module to an EtherNet/IP network via an RJ45 connection.

- 8 ----- NC
- 7 ----- NC
- 6 ----- RD-
- 5 ----- NC
- 4 ----- NC
- 3 ----- RD+
- 2 ----- TD-
- 1 ----- TD+



### Status Indicators

These 1756 EtherNet/IP communication modules use the same status indicators. This graphic shows the front of the module for these modules (Extended-temperature versions [catalog numbers 1756-EN2TXT and 1756-EN2TRXT] not shown).



For more information on the status indicators, refer to the EtherNet/IP Modules Installation Instructions, publication ENET-IN002.

### Network Connectors and Cable

This product may contain a USB port.

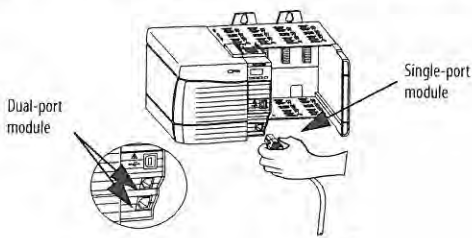


**WARNING:** Local programming ports, network access ports (NAP), and USB ports are intended only for temporary use and must not be connected or disconnected unless the area is nonhazardous. Do not use the USB port in hazardous locations.

| Modules     | Ports           | Requirements  |
|-------------|-----------------|---|
| EtherNet/IP | Copper Ethernet | Connector/cable: RJ45 connector according to IEC 60603-7, 2 or 4 pair Category 5e minimum cable according to TIA 568-B.1 or Category 5 cable according to ISO/IEC 24702 |

5. Attach the cable with the RJ45 connector to the Ethernet port on the module as shown.

**IMPORTANT** Your module will resemble one of the modules shown in the illustration.



6. Download the Add-on Profile from the Product Compatibility and Download website at <http://www.ab.com>.
7. Connect to the module via the USB port (if the module is equipped with a USB port).
8. Download the firmware from the Product Compatibility and Download website at <http://www.ab.com>.
9. Apply chassis power and check status indicators.





## INSTALLATION

**CAUTION:** Before installing in a nuclear application, determine that the product is intended for such use.

4555K10-001K  
Supersedes 4555K10-001J

### TYPES AB-16, -40, DB-16, -40, AMMETERS AND VOLTMETERS [TAUT-BAND SUSPENSION]

The Types AB-16, -40 and Types DB-16 and -40 are switchboard instruments whose moving systems are supported by thin metallic bands which practically eliminate friction and make the instrument resistant to shock.

#### PANEL MOUNTING

All drilling and wiring should be completed before mounting the instruments. The instruments must be mounted in a level position. If the panels are over 3/8" thick, use adapter mounting studs as shown in Fig. 4.

It is advisable to keep wires carrying heavy current as far as possible from all indicating instruments. When the instrument is mounted in a level position, any deviation from zero should be corrected by means of the zero adjustment.

Connect the instrument as shown in the appropriate diagram.

#### **WARNING**

DO NOT REMOVE COVER WHILE THE INSTRUMENT IS ENERGIZED. SCALE PLATE, POINTER AND ELEMENT ASSEMBLY MAY BE AT HAZARDOUS VOLTAGE LEVELS.

#### GROUNDING CASES OF A-C INSTRUMENTS

If transformers are used on circuits of over 150 volts, connect the grounded side of the secondary circuits to the instrument case. Use No. 12 Awg copper wire. Ground connections in accordance with the National Electric Code.

#### A-C AMMETERS (TYPE AB)

When the circuit exceeds 30 amperes or 650 volts, a current transformer of the ratio indicated on the nameplate must be used, and instrument scale will be marked in primary amperes.

#### D-C AMMETERS (TYPE DB)

D-C ammeters for current measurement above 30 amperes must be shunted externally. Shunt leads can be provided. When leads are supplied by the purchaser, their resistance should agree with the value stamped on the instrument nameplate, otherwise an error in the reading will result.

#### **WARNING**

ALL SHUNTS SHOULD BE CONNECTED IN THE GROUNDED SIDE OF THE LINE WHEN POSSIBLE. WHEN THIS IS NOT POSSIBLE, OR THE CIRCUIT CAN NOT BE GROUNDED, AVOID REMOVING THE COVER SINCE THE INSTRUMENT WINDINGS, AS WELL AS THE SCALE AND POINTER, ARE AT LINE POTENTIAL. USE CAUTION TO AVOID CONTACTING THIS POTENTIAL.

*These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the Yokogawa Corporation of America.*

YOKOGAWA 

YOKOGAWA CORPORATION OF AMERICA

## RHEOSTAT ADJUSTMENT

As the resistance of the shunt reads used in certain applications can not be predetermined at the factory, it has been found desirable to furnish some D-C ammeters with an internal rheostat to adjust for non-standard lead resistances.

The nameplate on the instrument has an INSTRUMENT + LEAD RESIS. value stamped on it. Connect a resistance bridge across the shunt end of the leads (shunt disconnected) and the instrument across the opposite end. Set the resistance bridge for the INSTRUMENT + LEAD RESIS. value stamped on the nameplate. Remove protective label located on base of instrument, and adjust rheostat until a zero deflection is indicated by the bridge galvanometer. Replace protective label after completing adjustment.

If a resistance bridge is not available, connect a standard millivoltmeter across the shunt end of the leads (shunt disconnected) and the instrument across the opposite end. Apply a low, adjustable D-C voltage across the shunt end of the leads and adjust this voltage until the indication on the standard millivoltmeter agrees with the fullscale millivolts (marked FULL SCALE MV) on the instrument nameplate. Remove protective label located on base of instrument and adjust rheostat until the instrument reads full scale. Replace protective label after completing adjustment.

## A-C VOLTMETERS (TYPE AB)

When the circuit exceeds 600 volts, a potential transformer of the ratio indicated on the instrument nameplate must be used, and the instrument scale will be marked in primary volts.

## D-C VOLTMETERS (TYPE DB)

D-C voltmeters designed for use on circuits above 600 volts, and D-C ground detectors for voltages up to and including 600 volts, are furnished with external resistors and are connected directly to the circuit to be measured.

## EXTERNAL RESISTORS

"Res. Ext. No." designation on the nameplate indicates an external resistor is required, where "No." is the resistor part number. Dimensions of the external resistors are given in Fig. 11, and circuit connections are given in Fig. 7, 8, 9 and 10.

## UNCALIBRATED SCALES

Check for accuracy of full scale, stickiness, etc. Failure to do so will place warranty in jeopardy. Do not touch the pointer or any other moving parts while removing cover and scale because of the possibility of unbalancing the element.

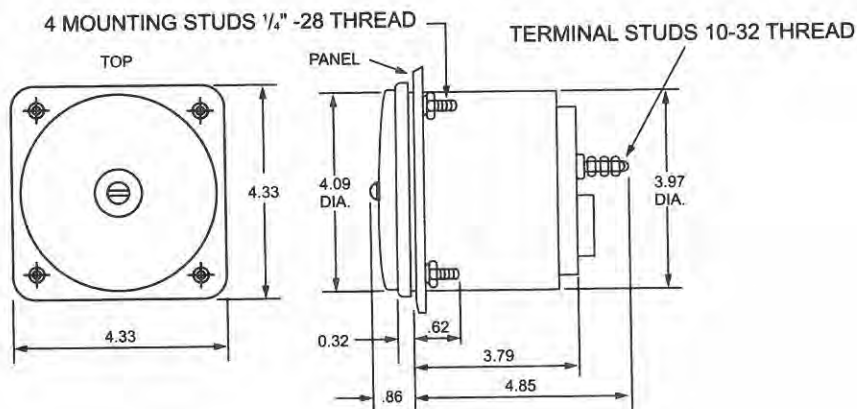


Fig. 1 . Dimensions, Types DB-40 and AB-40 Ammeters and Voltmeters.

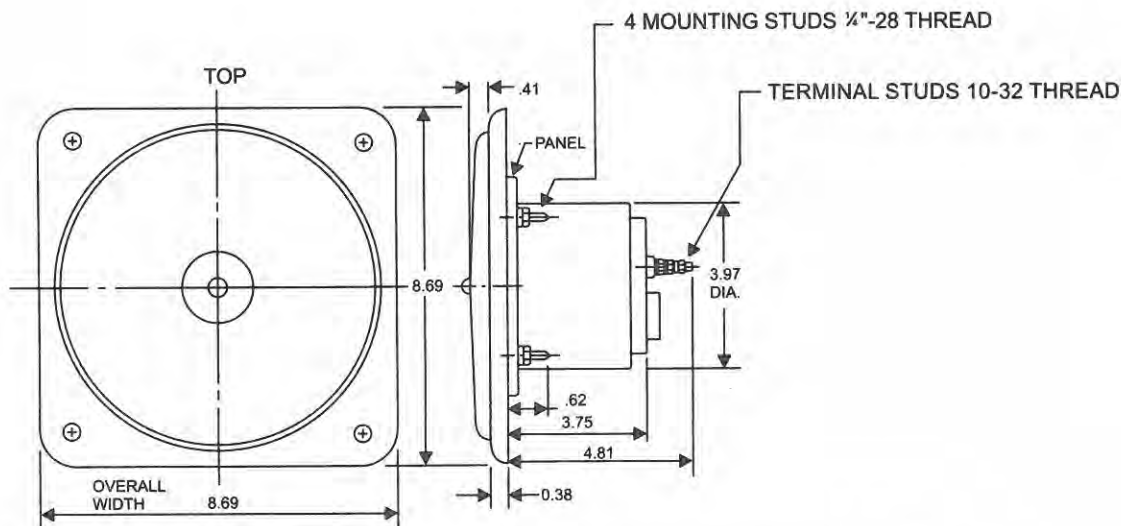


Fig. 2. Dimensions of Types DB-16, AB-16 Ammeters and Voltmeters.

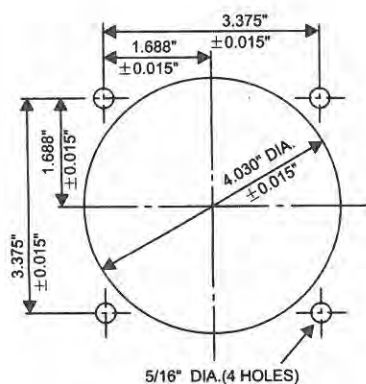


Fig. 3. Cut-out and panel drilling dimensions.

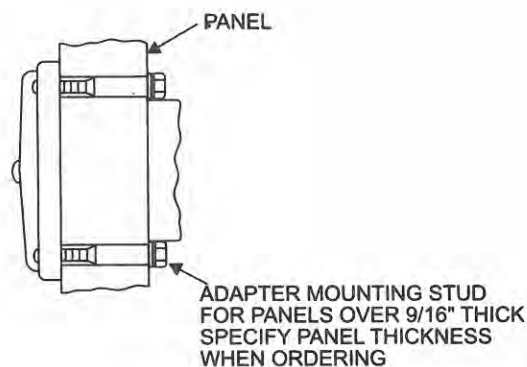


Fig. 4. Adapter mounting stud.

**WARNING**

SINCE DANGEROUS VOLTAGE WILL DEVELOP IN THE OPEN-CIRCUIT SECONDARY WINDINGS OF ENERGIZED CURRENT TRANSFORMERS. DE-ENERGIZE THE TRANSFORMERS BY SHORT-CIRCUITING THE SECONDARY WINDINGS BEFORE DISCONNECTING OR CONNECTING INSTRUMENT TO TRANSFORMERS.

**Maintenance:** To clean Type AB-16, -40 and Type DB-16 and -40 plastic windows, wash with soap and water, not chemical cleaners.

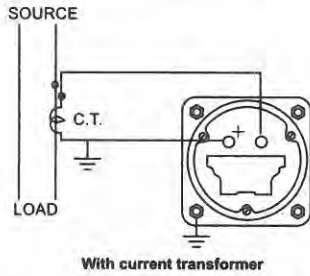
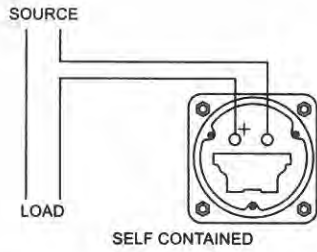


Fig. 5. External connections of A-C ammeters.

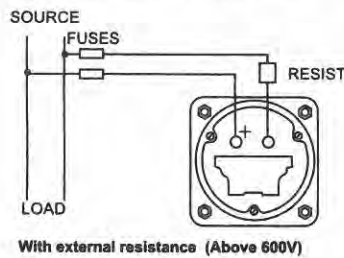
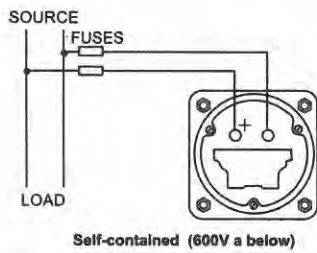


Fig. 7. External connections, A-C voltmeters.

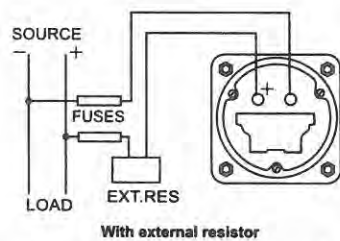
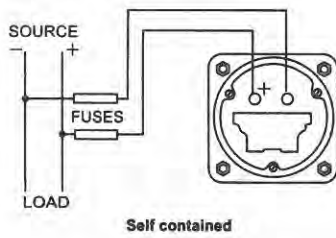


Fig. 9. External connections of D-C voltmeters.

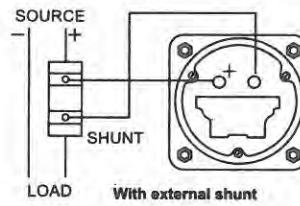
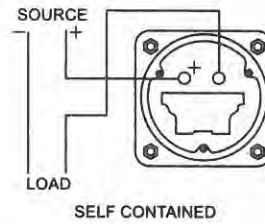


Fig. 6. External connections of D-C ammeters.

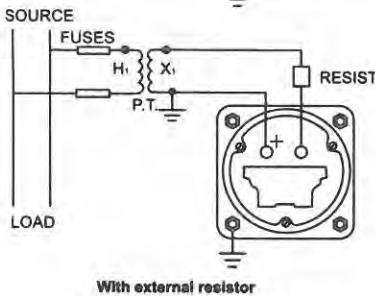
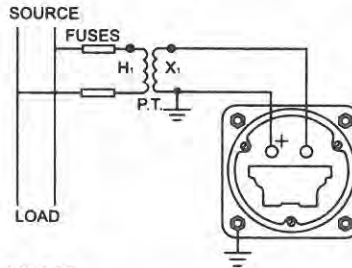


Fig. 8. External connections, A-C voltmeters with potential transformer.

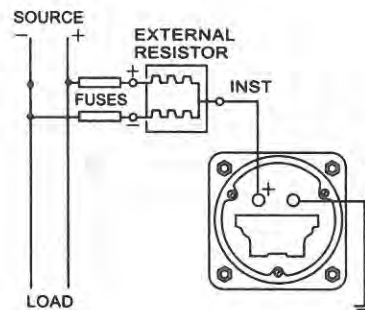


Fig. 10. External connections of D-C ground detectors.



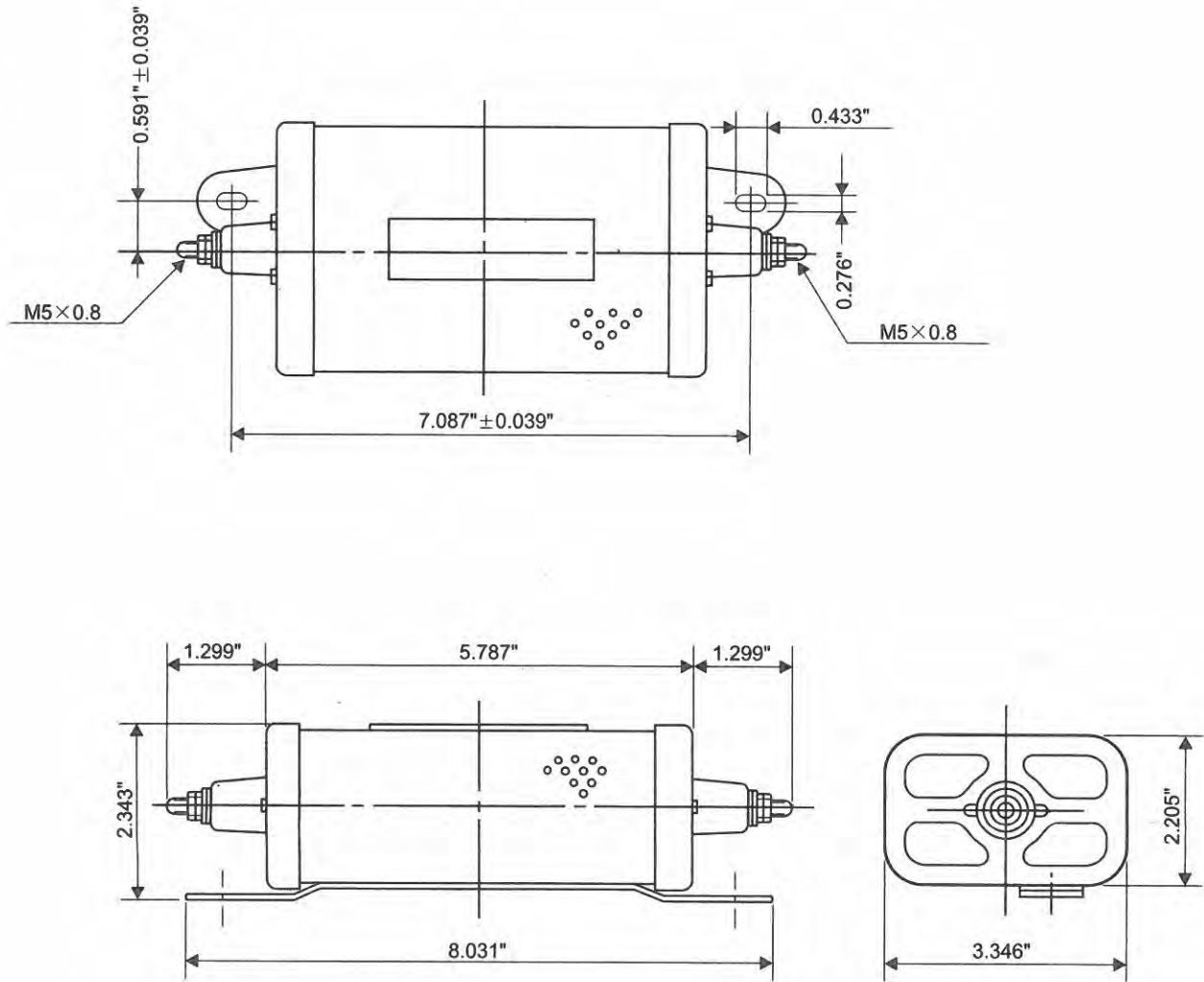


Fig. 11. External resistor

End of Section

**marathon**<sup>™</sup>  
Thomson Power Systems

# **LOADBANK**

**TLB & LBO**

**STORAGE & MAINTENANCE**

PM088 Rev 1 14/01/31



## **LOAD BANK STORAGE AND MAINTENANCE**

- Before storing, unpack sufficiently to check for concealed damage. If concealed damage is found, notify Thomson Power Systems and the carrier immediately.
- Repack with the original, or equivalent packing materials. Protect from physical damage.
- Do not stack.
- Store indoors in a clean, dry, and well-ventilated area that is free of corrosive agents, including fumes, salt, and concrete/cement dust. Apply heat as necessary to prevent condensation.
- Failure to store equipment as specified may cause damage and void warranty.

### **Daily/Weekly:**

- If the elements are wet in a non-operational state it is recommended to operate the fan for approximately 5 minutes prior to applying load to minimize element stress, which will extend the life of the elements.
- Perform a visual inspection of load bank noting any physical damage or unusual conditions.
- Confirm that the air inlet and outlet of the load bank are not blocked.
- Inspect power cables and note insulation deterioration or physical damage.
- Check for signs of water entry to controls section
- Check for signs of water entry in the element and fan motor sections.

### ***Every 6 months or 15 hours of operation do the following:***

- Do a complete visual inspection of the load bank.
- Look for any kind of chafing.
- Replace any affected wiring if necessary.
- If there is any visible scorching, then there is a dead short that will need to be repaired by a qualified technician.
- Check the load bank resistive elements for sag. If the lower side of any element at the peak of the sag arc is more than 1" below level, then the element should be replaced.
- Check all of the terminals for tightness including element terminal connections and load contactors in the controls section.

***Annually perform the following:***

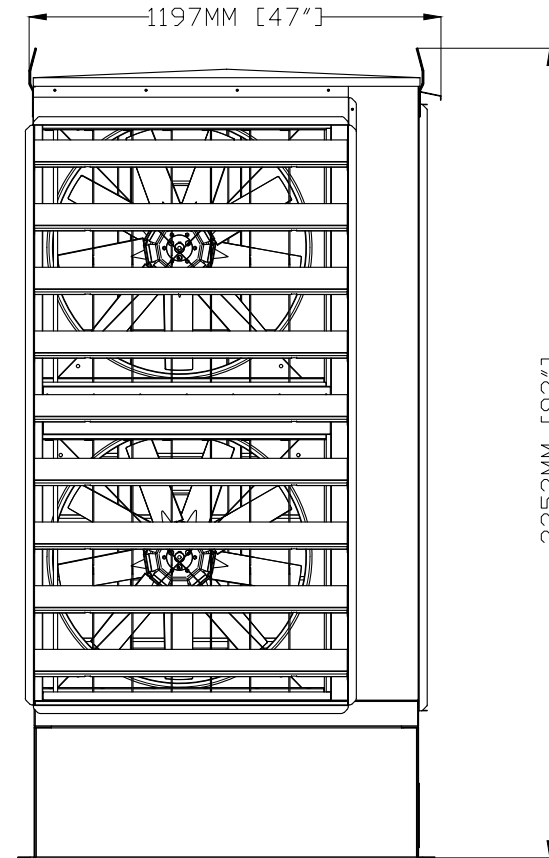
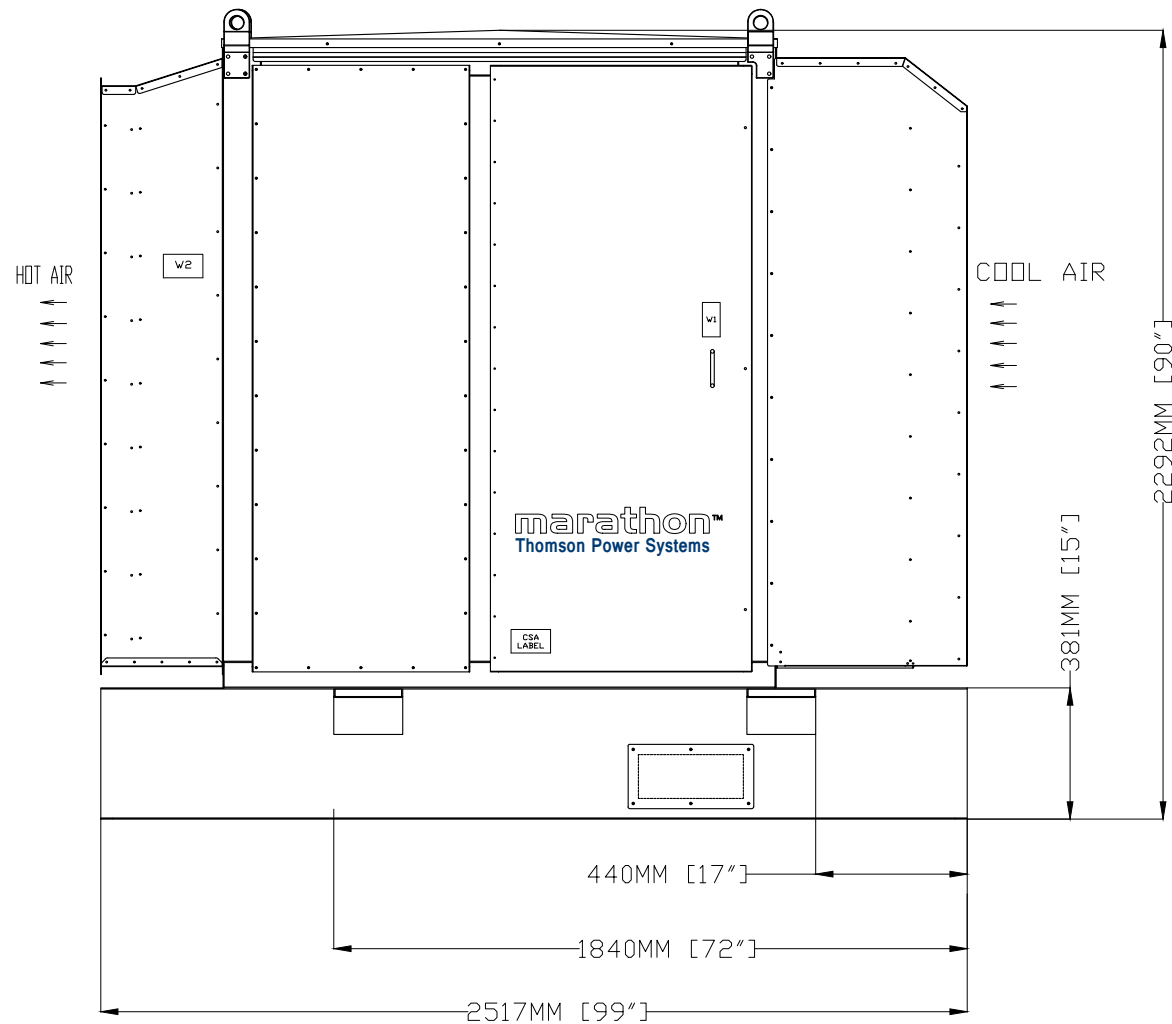
- Inspect the fan motor mounting, noting loose or damaged hardware, or cracking in the load bank frame. Repair or replace as required.
- Inspect fan motor bearings for wear and lubricate where applicable
- Inspect load element support insulators noting cracked or broken supports. Broken or cracked insulators must be replaced before operating the load bank; catastrophic failures may occur if failed components are not replaced.
- Operate the load bank selecting one step at a time and note loading balance per phase on each step. Unbalanced steps are indicators of loose wire connections or failed elements.

**Spare parts**

A customer may elect to carry a selection of spare components for maintenance purposes. These would typically include the following:

- Relays
- LED/Incandescent Bulbs
- Switches (or Switch Contacts)
- Fuses
- Contactors

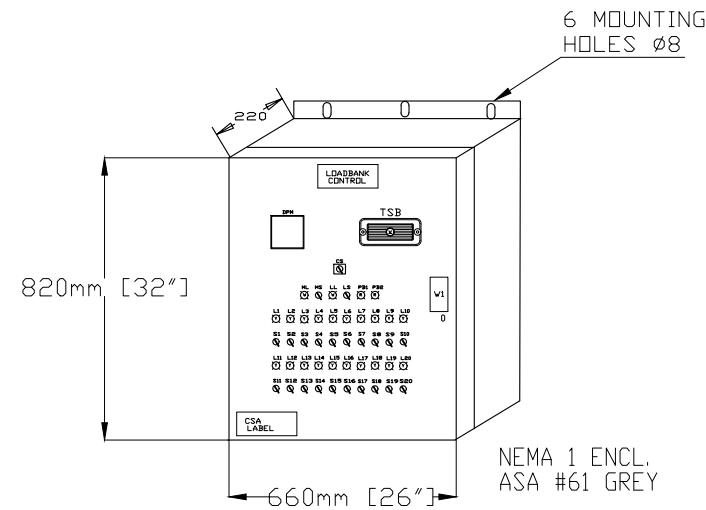
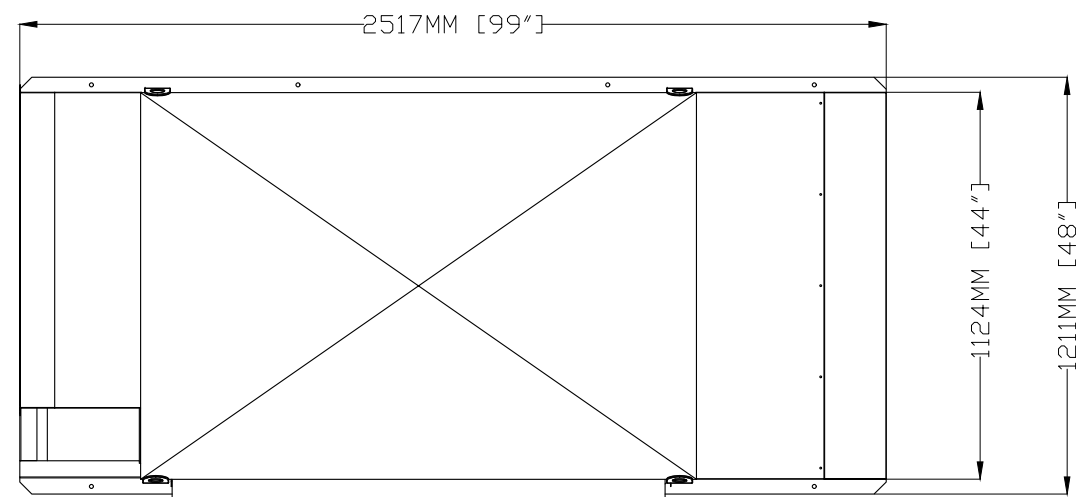
For a recommended list of spare components that is specific to your load bank, contact the Thomson Power Systems sales department at 604.888.0110.



| NOTES |  |
|-------|--|
| 1     | LOAD BANK ENCLOSURE, 16GA AULMINIZED STEEL, BOTTOM, 13GA ALUMINIZED STEEL                                  |
| 2     | ENCLOSURE TYPE NEMA 3R   |
| 3     | AIR INTAKE/DISCHARGE VENTS ARE COVERED WITH 12x12 mm SCREEN  |
| 4     | DIMENSIONS: MILLIMETER(mm)   |
| 5     | APPROX WEIGHT: 950KG EXCLUSIVE OF THE STAND & CONTROL PANEL  |
| 6     | COAT PAINTING COLOR ASA #61 GREY<br>4C #4/0-500MCM LUGS PER PHASE<br>4@1C #6-250MCM LUGS GDRUND CONNECTION |

**CAUTION**

DISCHARGE AIR TEMPERATURE MAY RISE TO 200°C, ENSURE THE DISCHARGE AIR PASSAGE IS UNOBSTRUCTED. FOR PERSONNEL SAFETY REMAIN 16FT.(5m) MINIMUM FROM DISCHARGE SIDE OF LOAD BANK. TO PREVENT HOT AIR RECIRCULATION, OBSTRUCTIONS AT THE DISCHARGE SIDE MUST BE KEPT TO A MINIMUM. TO ALLOW GENERAL ACCESSIBILITY, ETC., IT IS RECOMMENDED THAT A MINIMUM OF 3FT.(1m) CLEARANCE BE MAINTAINED AROUND THE OTHER 3 SIDES.



AS BUILT

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| 3           |                    |     | AS BUILT              | MS | XJ   | 2016-11-3  |
| 2           |                    |     | REVIEW                | MS | XJ   | 2016/8/22  |
| 1           |                    |     | APPROVED              | LU | XJ   | 2016/7/6   |



1000KW 600V OUTDOOR LOAD BANK  
 MODEL LBO-1000H-600V-3-C  
 ENCLOSURE DETAILS  
 ESQUIMALT GRAVING DOCK

|   |            |                         |       |
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| CUSTOMER WESTERN PACIFIC ENTERPRISES GP   |            | WORK ORDER No. W-095113 |       |
| CUSTOMER ORDER No. C-054107   | AUTH BY XJ | DATE 2016/7/6           | REV 4 |
| DRAWING/FILE No. SSPL160706   | SHEET 1    |                         |       |



100 x 152 (TYPICAL)  
BLACK LETTERS ON SILVER BACKGROUND

### OPERATING INSTRUCTIONS

- OBSERVE THAT THE AIR PASSAGE IS CLEAR. THERE MUST BE AT LEAST 16 FEET OF CLEARANCE FOR THE AIR DISCHARGE DUE TO THE EXTREMELY HOT DISCHARGE AIR. ENSURE THAT LOAD BANK AIR DOES NOT RECIRCULATE.
- OBSERVE VOLTAGE OUTPUT OF GENERATOR TO BE TESTED.

#### MANUAL OPERATION

- MOVE THE MASTER CONTROL SWITCH TO "MANUAL" AND OBSERVE THE AIRFLOW. SHOULD THE AIR DISCHARGE AT INTAKE, THE PHASE SEQUENCE IS WRONG. CORRECT PHASE ROTATION IS A-B-C.
- MOVE THE LOAD ENABLE SWITCH TO "ON" (THE AIR FLOW MUST BE SUFFICIENT BEFORE THE LOAD ENABLE CIRCUIT BECOMES OPERATIONAL).
- APPLY LOAD AS REQUIRED.

#### AUTO OPERATION

- MOVE THE CONTROL MODE SWITCH TO "AUTO". WHEN PERMISSION OF START SIGNAL IS GIVEN, MASTER CONTROL ON LIGHT WILL INDICATE. WHEN THE AIR DISCHARGE AT THE OUTLET, LOAD AVAILABLE LIGHT WILL INDICATE.
- THE CONTROLLER WILL MAINTAIN A CONSTANT LOAD (KW SETPOINT) ON THE GENERATOR SET. THE CONTROLLER MONITORS THE CONNECTED DOWNSTREAM LOADS AND WILL AUTOMATICALLY ADD OR SUBTRACT LOAD STEPS IN RESPONSE TO BUILDING LOAD CHANGES TO MAINTAIN PRESET LOAD LEVEL ON THE GENERATOR SET.
- REFER TO LOAD BANK "SEQUENCE OF OPERATIONS".

NOTE—NO OVERLOAD OR OVERCURRENT PROTECTION PROVIDED IN THE LOAD BANK.

NOTE—DON'T OPERATE THE LOAD BANK WITHOUT A GROUND WIRE.

50 x 152 (TYPICAL)  
BLACK LETTERS ON  
WHITE BACKGROUND

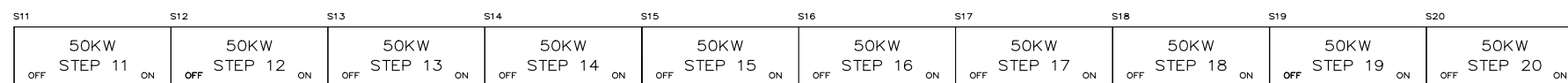
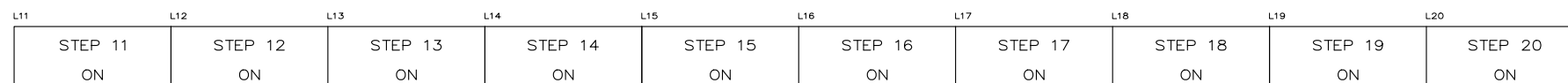
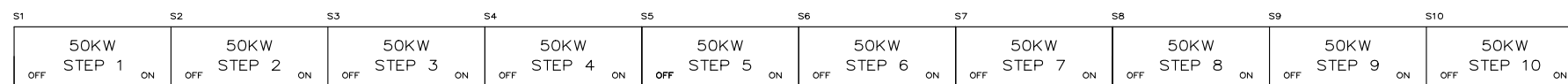
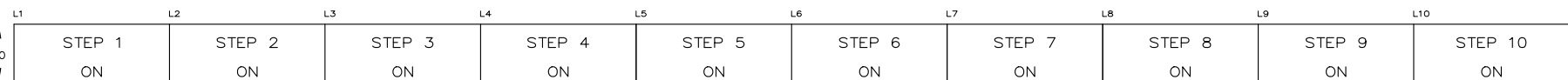
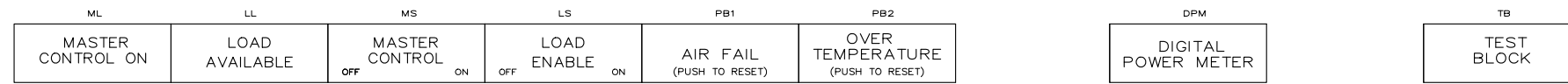
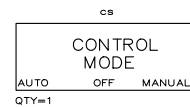
## LOAD BANK CONTROL

50 x 152 (TYPICAL)  
WHITE LETTERS ON  
RED BACKGROUND

### WARNING AVERTISSEMENT

DURING OPERATION THE DISCHARGE  
TEMPERATURE MAY RISE TO 200° C.

LA TEMPERATURE DE DECHARGE DE CE  
MATERIEL PEUT ATTEINDRA 200° C EN SERVICE.



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|             |                    | 1   | APPROVED              | MS | XJ   | 2016-07-28 |

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| 1 | APPROVED              | MS | XJ | 2016-07-28 |



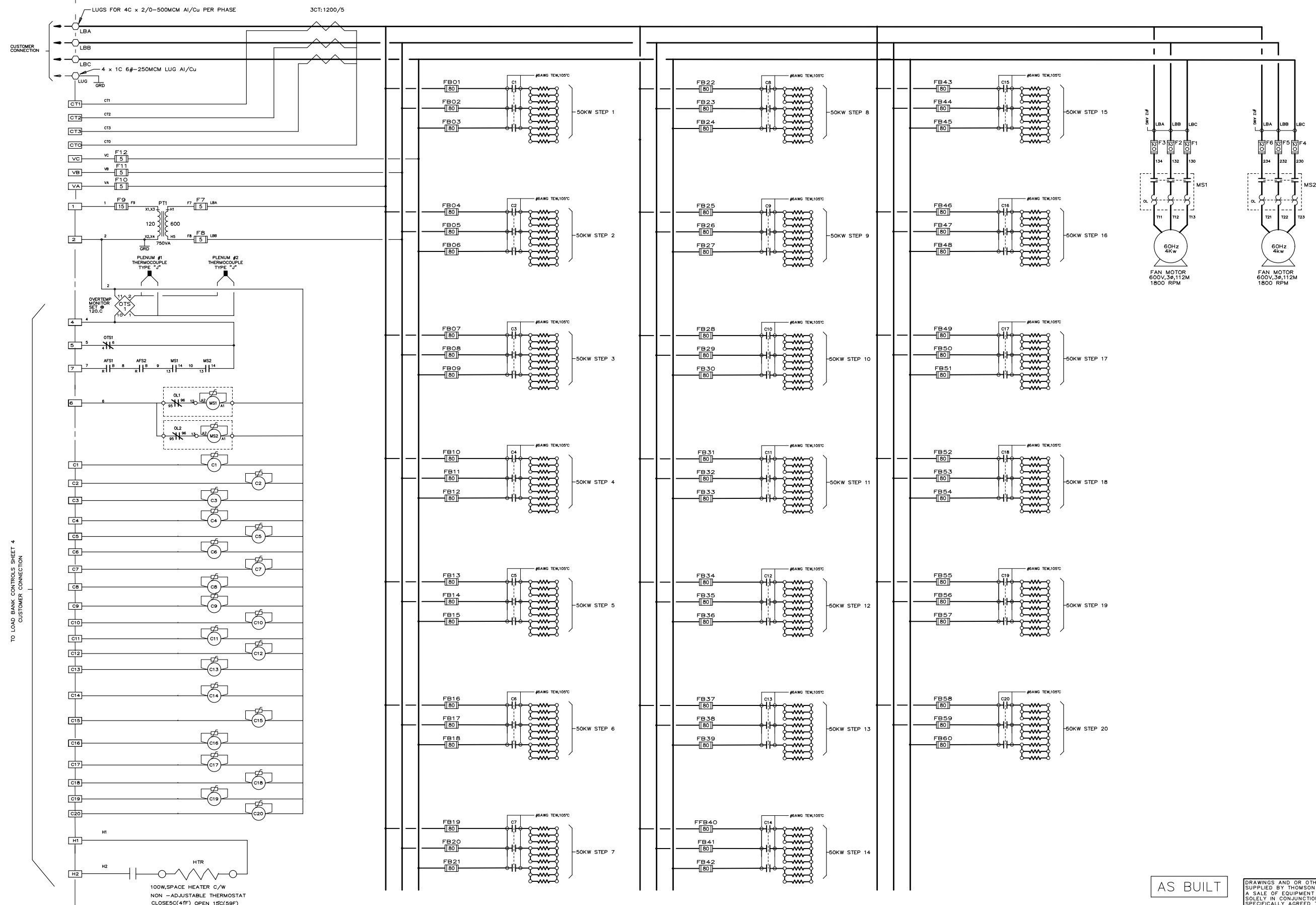
1000kW 600V 60Hz OUTDOOR LOAD BANK  
MODEL LBO-1000H-600V-3-C  
NAMEPLATE DETAILS  
ESQUIMALT GRAVING DOCK

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| DRAWN BY<br>MS                          | AUTH BY<br>XJ              |
| DATE<br>16-07-28                        | REV<br>4                   |
| DRAWING/FILE No.<br>SSPL160706          | SHEET<br>2                 |





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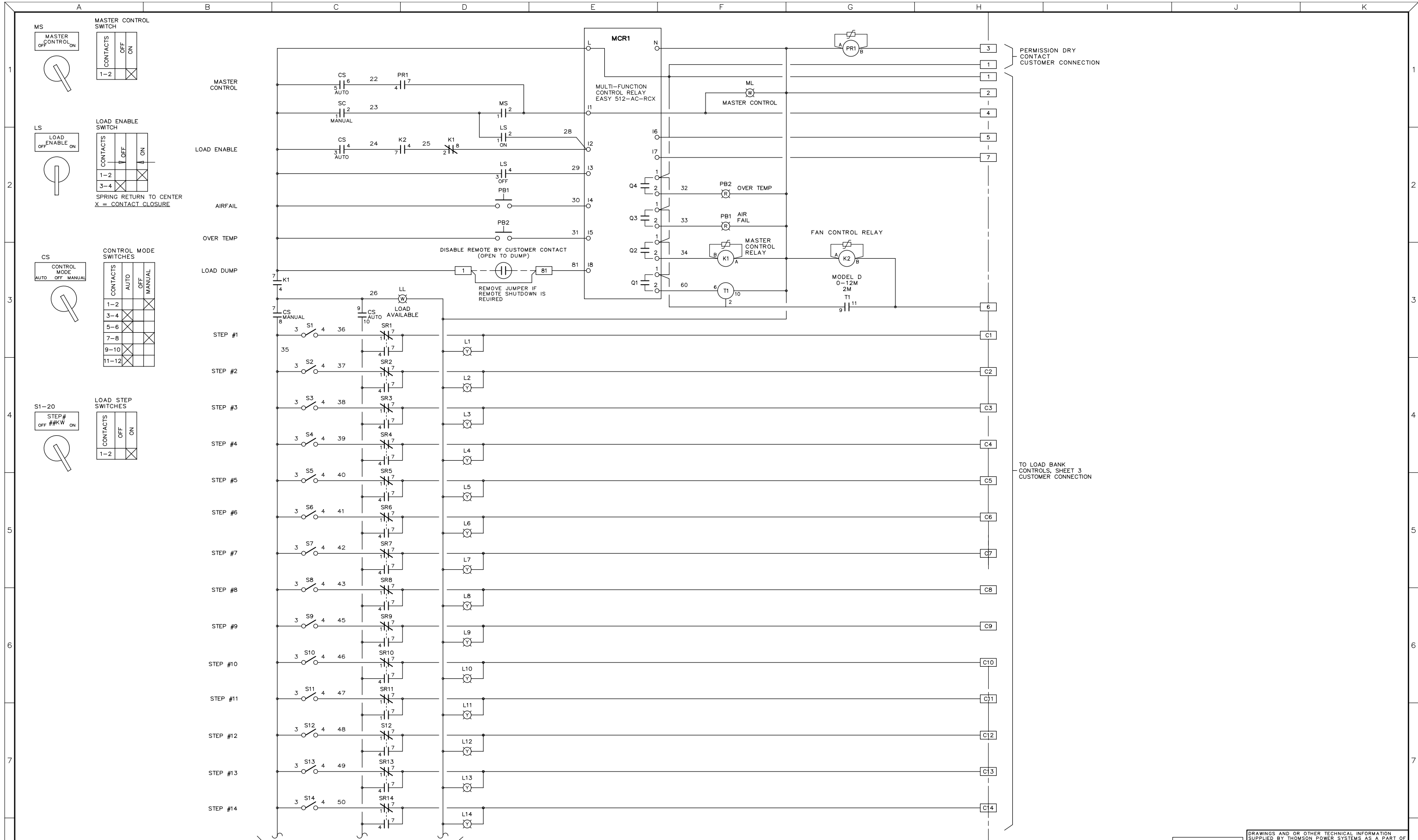
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 No. \_\_\_\_\_

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|-----|-----------------------|----|------|------------|
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| 3   | AS BUILT              | MS | XJ   | 2016-11-3  |
| 2   | REVIEW                | MS | XJ   | 2016/8/22  |
| 1   | APPROVED              | MS | XJ   | 2016/7/28  |

**marathon™**  
 Thomson Power Systems

1000kW 600V 60Hz OUTDOOR LOAD BANK  
 MODEL LBO-1000H-600V-3-C  
 LOAD BANK SCHEMATIC DIAGRAM  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
|---|-------------------------|
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095113 |
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| DRAWING/FILE No. SSPL160706             | SHEET 3                 |



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|             |                    | 2   | REVIEW                | MS | XJ   | 2016/8/22  |
|             |                    | 1   | APPROVED              | MS | XJ   | 16-07-28   |

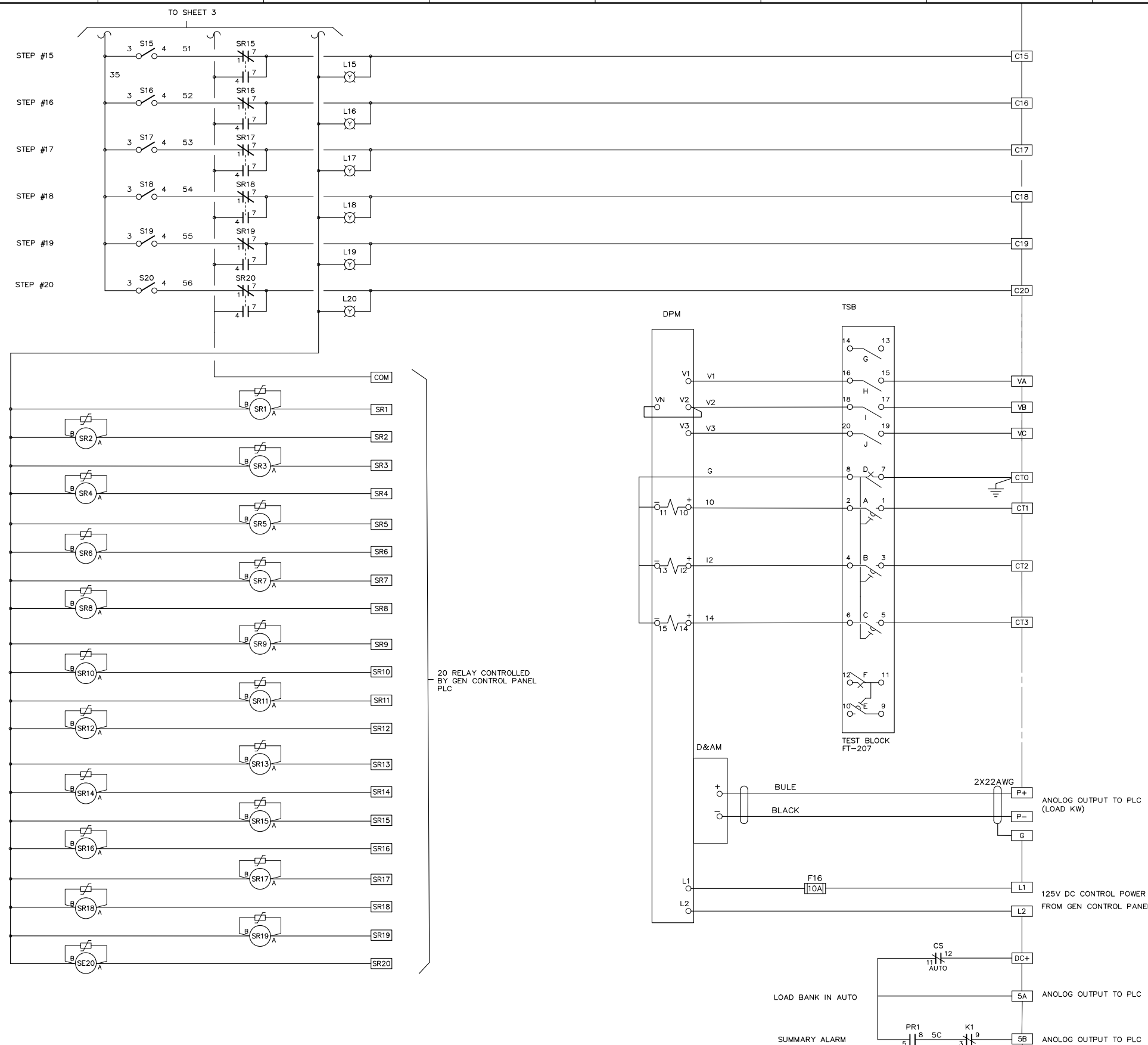


1000kW 600V OUTDOOR LOAD BANK  
 MODEL LBO-1000H-600V-3-C  
 LOAD BANK SCHEMATIC DIAGRAM  
 ESQUIMALT GRAVING DOCK

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| DRAWN BY<br>MS                          | AUTH BY<br>XJ              | DATE<br>16-07-28 | REV<br>4   |
| DRAWING/FILE No.<br>SSPL160706          |                            |                  | SHEET<br>4 |



TO LOAD BANK  
CONTROLS, SHEET 3  
CUSTOMER CONNECTION

20 RELAY CONTROLLED  
BY GEN CONTROL PANEL  
PLC

20 RELAY CONTROLLED  
BY GEN CONTROL PANEL  
PLC

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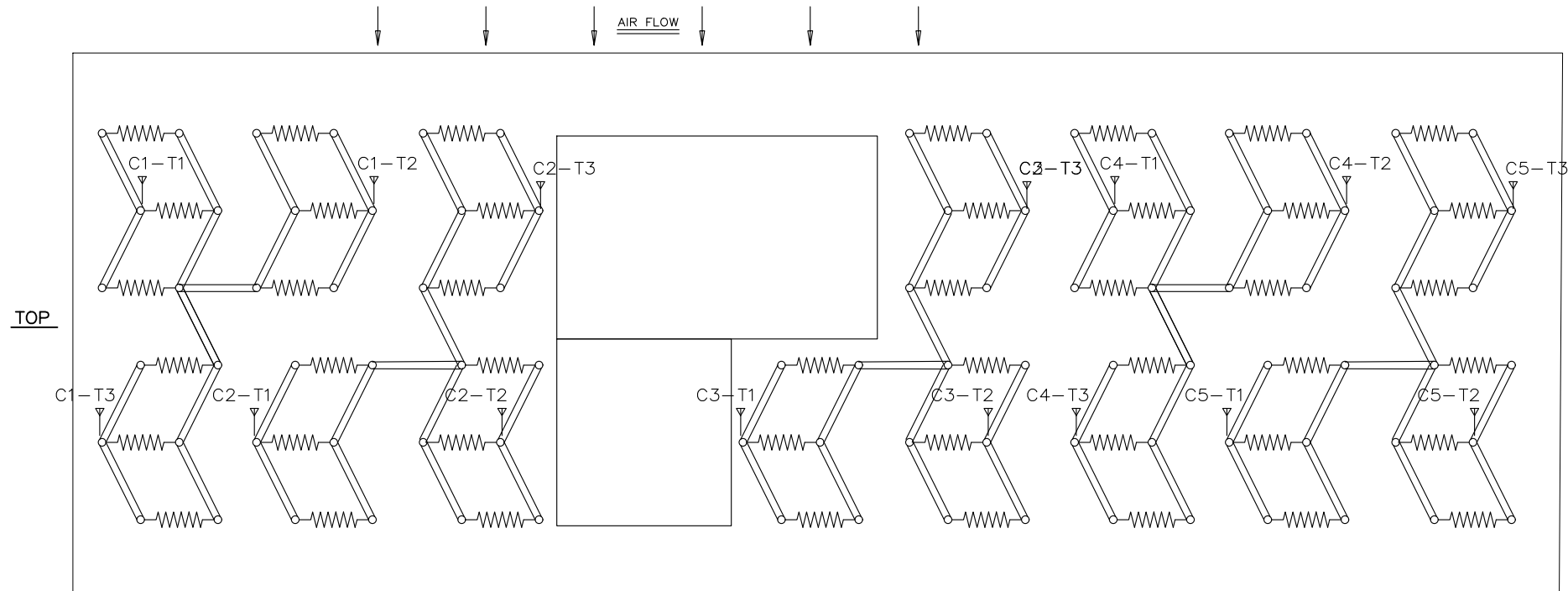
| DRAWING No. | REFERENCE DRAWINGS    | No. | REVISIONS | BY | AUTH | DATE       |
|-------------|-----------------------|-----|-----------|----|------|------------|
| 4           | AS BUILT [TPS UPDATE] |     |           | RR | RR   | 2017-01-10 |
| 3           | AS BUILT              |     |           | MS | XJ   | 2016-11-3  |
| 2           | REVIEW                |     |           | MS | XJ   | 2016/8/22  |
| 1           | APPROVED              |     |           | MS | XJ   | 2016/7/28  |



1000kW 600V OUTDOOR LOAD BANK  
 MODEL LBO-1000H-600V-3-C  
 LOAD BANK SCHEMATIC DIAGRAM  
 ESQUIMALT GRAVING DOCK

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

|   |                         |
|---|-------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095113 |
| DRAWN BY MS                             | AUTH BY XJ              |
| DATE 16-07-28                           | REV 4                   |
| DRAWING/FILE No. SSPL160706             | SHEET 4A                |



| ELEMENT IDENTIFICATION | QTY. | COLD RES.           | WIRE # | KW   | VOLTAGE | AMPS | TIGHT COIL LENGTH | STRETCHED COIL LENGTH |
|------------------------|------|---------------------|--------|------|---------|------|-------------------|-----------------------|
| C1-C5                  | 45   | 22.2 Ω              | # 17   | 5.56 | 346     | 16.1 | APPROX. 23.2      | 66"                   |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        | 45   | TOTAL # OF ELEMENTS |        |      |         |      |                   |                       |

- 90 TERMINAL CERAMICS
- 630 SUPPORT CERAMICS
- 70 JUMPER LINKS

AS BUILT

APPROVED FOR CONSTRUCTION  
 MASTER COPY  REFERENCE COPY OF \_\_\_\_\_  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

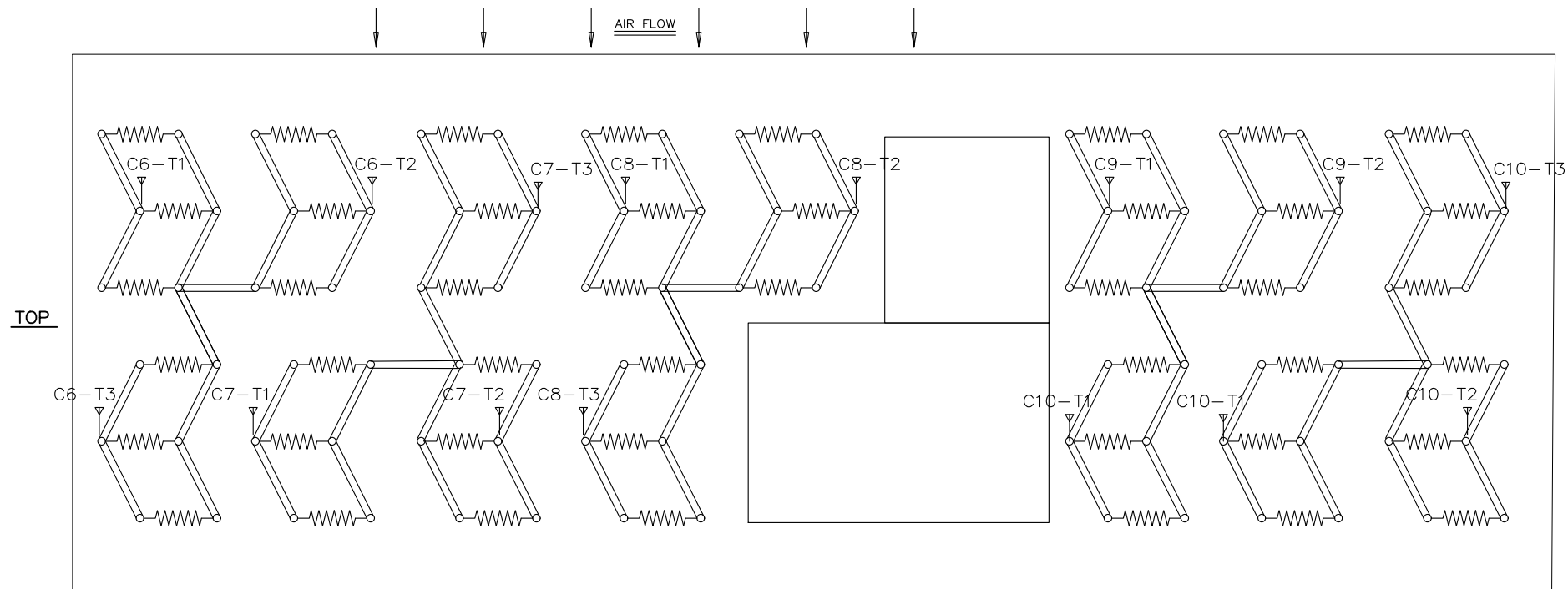
| DRAWING No. | REFERENCE DRAWINGS | No. | REVISIONS             | BY | AUTH | DATE       |
|-------------|--------------------|-----|-----------------------|----|------|------------|
|             |                    | 3   | AS BUILT [TPS UPDATE] | RR | RR   | 2017-01-10 |
|             |                    | 2   | AS BUILT              | MS | XJ   | 2016-11-3  |
|             |                    | 1   | APPROVED              | MS | XJ   | 16-07-28   |



1000kW 600V 60Hz OUTDOOR LOAD BANK  
 MODEL LBO-1000H-600V-3-C  
 ELEMENT FRAME LB29L-1  
 ESQUIMALT GRAVING DOCK

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

|   |                         |
|---|-------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095113 |
| DRAWN BY MS                             | AUTH BY XJ              |
| DATE 16-07-28                           | REV 3                   |
| DRAWING/FILE No. SSPL160706             | SHEET 5                 |



| ELEMENT IDENTIFICATION | QTY. | COLD RES.           | WIRE # | KW   | VOLTAGE | AMPS | TIGHT COIL LENGTH | STRETCHED COIL LENGTH |
|------------------------|------|---------------------|--------|------|---------|------|-------------------|-----------------------|
| C6-C10                 | 45   | 22.2 Ω              | # 17   | 5.56 | 346     | 16.1 | APPROX. 24.2      | 66"                   |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        |      | Ω                   | #      |      |         |      | APPROX.           |                       |
|                        | 45   | TOTAL # OF ELEMENTS |        |      |         |      |                   |                       |

90 TERMINAL CERAMICS  
 630 SUPPORT CERAMICS  
 70 JUMPER LINKS

AS BUILT

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 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

| DRAWING No. | REFERENCE DRAWINGS | No. | REVISIONS             | BY | AUTH | DATE       |
|-------------|--------------------|-----|-----------------------|----|------|------------|
|             |                    | 3   | AS BUILT [TPS UPDATE] | RR | RR   | 2017-01-10 |
|             |                    | 2   | AS BUILT              | MS | XJ   | 2016-11-3  |
|             |                    | 1   | APPROVED              | MS | XJ   | 16-07-28   |



1000kW 600V 60Hz OUTDOOR LOAD BANK  
 MODEL LBO-1000H-600V-3-C  
 ELEMENT FRAME LB29L-2  
 ESQUIMALT GRAVING DOCK

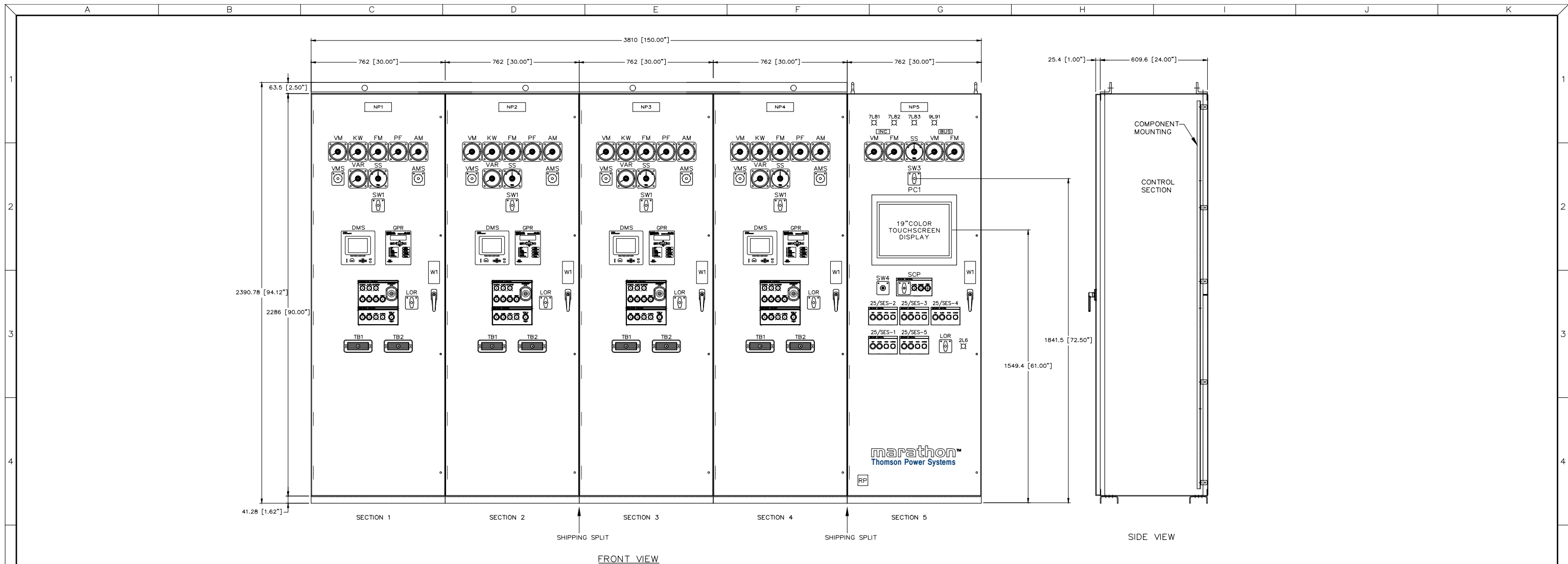
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|   |                            |
|---|----------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095113 |
| DRAWN BY<br>MS                          | AUTH BY<br>XJ              |
| DATE<br>16-07-28                        | REV<br>3                   |
| DRAWING/FILE No.<br>SSPL160706          | SHEET<br>6                 |









FRONT VIEW

SIDE VIEW

| DEVICE LEGEND    |                                       |
|------------------|---------------------------------------|
| AM               | AC AMMETER                            |
| AMS              | AMMETER SELECTOR SWITCH               |
| DMS              | DIGITAL METERING SYSTEM (ION-7650)    |
| FM               | FREQUENCY METER                       |
| GPR              | GENERATOR PROTECTION RELAY (SEL-700G) |
| HRN              | HORN                                  |
| KW               | KILOWATT METER                        |
| L1               | BREAKER OPEN LIGHT                    |
| L2               | BREAKER CLOSED LIGHT                  |
| L3               | GENERATOR RUNNING LIGHT               |
| L4               | GENERATOR COMMON ALARM LIGHT          |
| L5               | GENERATOR COMMON SHUTDOWN LIGHT       |
| L6               | BREAKER TRIPPED LIGHT                 |
| L7               | GENERATOR IN AUTO LIGHT               |
| 7L81, 7L82, 7L83 | UTILITY AVAILABLE LIGHT               |
| 9L91             | EMERGENCY AVAILABLE LIGHT             |
| 8L10             | SYSTEM COMMON ALARM LIGHT             |
| LOR              | LOCKOUT RELAY                         |
| OIT              | OPERATOR INTERFACE TERMINAL DISPLAY   |
| PB1              | GENERATOR BREAKER TRIP PUSHBUTTON     |
| PB2              | GENERATOR BREAKER CLOSE PUSHBUTTON    |
| PB3              | ENGINE STOP PUSHBUTTON                |
| PB4              | ENGINE START PUSHBUTTON               |
| PB5              | EMERGENCY STOP PUSHBUTTON             |

| DEVICE LEGEND |   |
|---------------|---|
| PB6           | BREAKER SYNC & CLOSE PUSHBUTTON                       |
| PB7           | ALARM SILENCE PUSHBUTTON                              |
| PF            | POWER FACTOR METER                                    |
| RP            | RATING PLATE  |
| SS            | SYNCHROSCOPE  |
| SW1           | SYNC SWITCH (ON-OFF)                                  |
| SW2           | SYSTEM MODE (MAN-AUTO-START-TEST)                     |
| SW3           | SYNC SELECTOR SWITCH (OFF-GENMAIN, DND, BCH-1, BCH-2) |
| SW4           | TRANSITION MODE SWITCH (OPEN-CLOSED)                  |
| TB1, TB2      | TEST BLOCK  |
| VAR           | VAR METER   |
| VM            | AC VOLTMETER  |
| VMS           | VOLTMETER SELECTOR SWITCH                             |
| W1,W3         | WARNING LABELS  |

| DRAWING LEGEND |                                     |
|----------------|-------------------------------------|
| 10A            | PHYSICAL LAYOUT                     |
| 10B            | SECTIONAL LAYOUT                    |
| 20A            | NAME PLATE DETAILS                  |
| 30A            | OVERALL SINGLE LINE DIAGRAM         |
| 30B            | SINGLE LINE DIAGRAM                 |
| 30C            | SINGLE LINE DIAGRAM                 |
| 30D            | FIELD COMMUNICATION BLOCK DIAGRAM   |
| 30E            | FIELD CONNECTION BLOCK DIAGRAM      |
| 40A            | COMMON 24VDC SUPPLY SCHEMATIC       |
| 50A            | COMMON PLC SCHEMATIC                |
| 50B            | COMMON PLC SCHEMATIC                |
| 50C            | COMMON PLC SCHEMATIC                |
| 50D            | COMMON PLC SCHEMATIC                |
| 50E            | COMMON PLC SCHEMATIC                |
| 50F            | COMMON PLC SCHEMATIC                |
| 50G            | COMMON PLC SCHEMATIC                |
| 61A            | DND UTILITY 1 AC SCHEMATIC          |
| 61B            | DND UTILITY 1 DC CONTROL SCHEMATIC  |
| 62A            | BCH1 UTILITY 2 AC SCHEMATIC         |
| 62B            | BCH1 UTILITY 2 DC CONTROL SCHEMATIC |
| 63A            | BCH2 UTILITY 3 AC SCHEMATIC         |
| 63B            | BCH2 UTILITY 3 DC CONTROL SCHEMATIC |
| 70A            | TIE BREAKER AC & DC SCHEMATIC       |
| 80A            | SYNC SCHEMATIC                      |
| 91A            | GENERATOR 1 AC SCHEMATIC            |
| 91B            | GENERATOR 1 DC SCHEMATIC            |
| 91C            | GENERATOR 1 DC SCHEMATIC            |
| 91D            | GENERATOR 1 DC SCHEMATIC            |
| 91E            | GENERATOR 1 DC SCHEMATIC            |

| DRAWING LEGEND |                                       |
|----------------|---------------------------------------|
| 92A            | GENERATOR 2 AC SCHEMATIC              |
| 92B            | GENERATOR 2 DC SCHEMATIC              |
| 92C            | GENERATOR 2 DC SCHEMATIC              |
| 92D            | GENERATOR 2 DC SCHEMATIC              |
| 92E            | GENERATOR 2 DC SCHEMATIC              |
| 93A            | GENERATOR 3 AC SCHEMATIC              |
| 93B            | GENERATOR 3 DC SCHEMATIC              |
| 93C            | GENERATOR 3 DC SCHEMATIC              |
| 93D            | GENERATOR 3 DC SCHEMATIC              |
| 93E            | GENERATOR 3 DC SCHEMATIC              |
| 94A            | GENERATOR 4 AC SCHEMATIC              |
| 94B            | GENERATOR 4 DC SCHEMATIC              |
| 94C            | GENERATOR 4 DC SCHEMATIC              |
| 94D            | GENERATOR 4 DC SCHEMATIC              |
| 94E            | GENERATOR 4 DC SCHEMATIC              |
| 100A           | GENERATOR MAIN AC SCHEMATIC           |
| 100B           | GENERATOR MAIN DC CONTROL SCHEMATIC   |
| 110A           | OUTDOOR TRANSFORMER AC & DC SCHEMATIC |

| NOTES |   |
|-------|---|
| 1     | FREE STANDING ENCLOSURE : METAL ENCLOSED, NEMA 1.   |
| 2     | CERTIFIED TO : CSA 22.2 NO. 14.   |
| 3     | FRONT & REAR ACCESS REQUIRED.   |
| 4     | ENCLOSURE COLOUR : ASA #61 GREY. INTERIOR MOUNTING PANS PAINTED WHITE.  |
| 5     | COLOR CODE:<br>BLUE - DC CONTROL,<br>RED - AC CONTROL,<br>BLACK - PT SECONDARY,<br>ORANGE - CT SECONDARY,<br>GREEN - GROUND.  |
| 6     | WIRE TYPE : ALL CONNECTIONS TO BE #14AWG TEW. CT SECONDARY #10 AWG TEW. WIRING THAT IS TO BE PROVIDED AS A PART OF OR IN AN INTEGRAL PART OF SUPERVISORY CONTROL EQUIPMENT SHALL BE #14 AWG TEW. EXCEPT, PLC DIGITAL & ANALOG I/O WIRING #18 AWG TEW. |
| 7     | WIRE MARKERS : HEAT SHRINK TYPE C/W INDELIBLE INK MARKING.  |
| 8     | WIRE NUMBERS TO MATCH TERMINAL NUMBERS, UNLESS NOTED.   |
| 9     | ASSEMBLY FOR INDOOR USE.  |
| 10    | SWITCHBOARD SUITABLE FOR MOUNTING ON NON-COMBUSTIBLE SURFACE ONLY.  |
| 11    | ALL DIMENSIONS ARE TYPICAL AND SHOWN IN MM[INCHES].   |

AS BUILT

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 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

CROSS REFERENCE LEGEND  
 SOC-C-1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

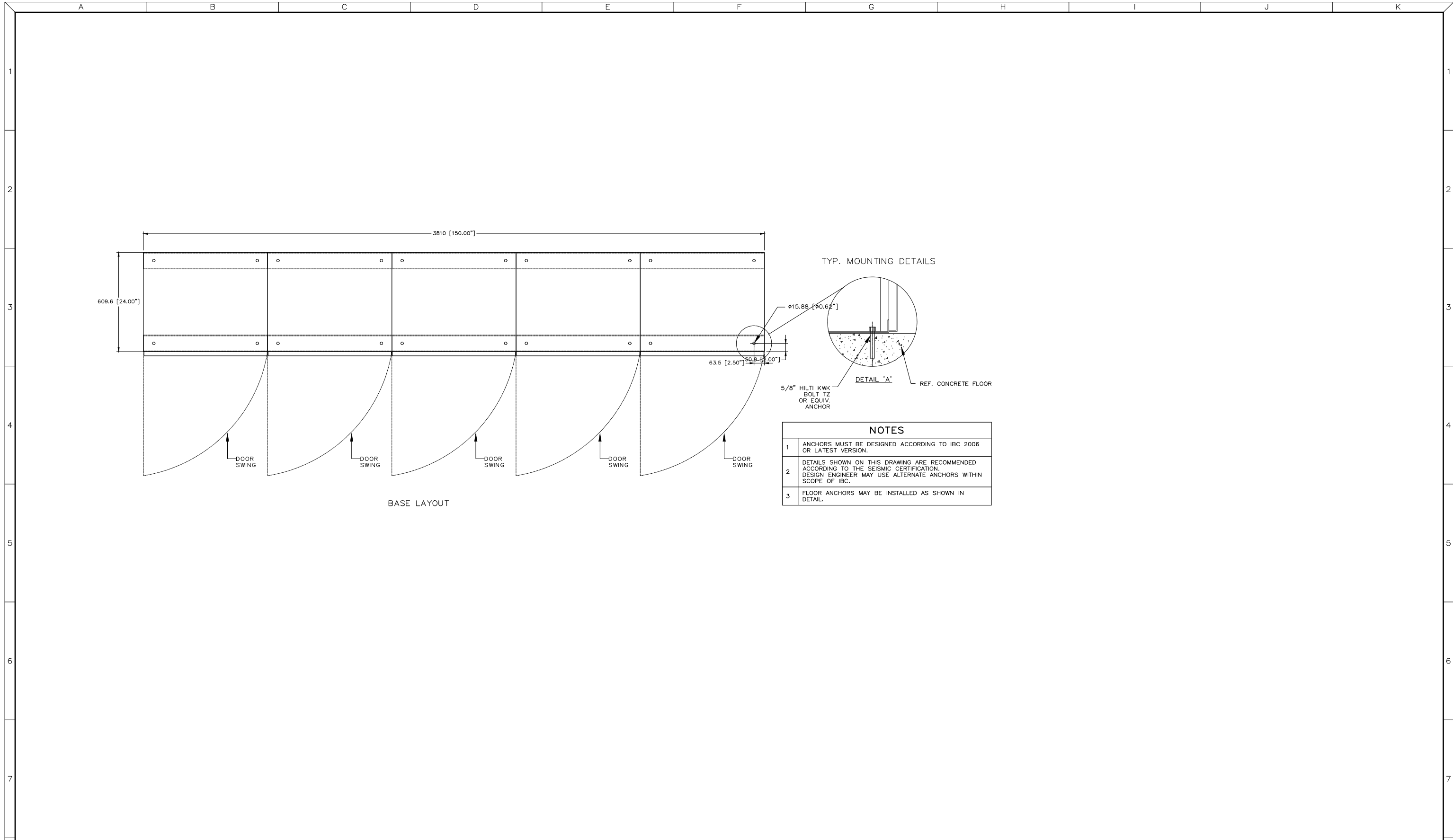
| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY/AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|---------|----------|
| 3           | AS BUILT                       |     |           | SD SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 PHYSICAL LAYOUT  
 ESQUIMALT GRAVING DOCK

|   |                         |
|---|-------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-010A          | SHEET                   |





| NOTES |  |
|-------|--|
| 1     | ANCHORS MUST BE DESIGNED ACCORDING TO IBC 2006 OR LATEST VERSION.  |
| 2     | DETAILS SHOWN ON THIS DRAWING ARE RECOMMENDED ACCORDING TO THE SEISMIC CERTIFICATION. DESIGN ENGINEER MAY USE ALTERNATE ANCHORS WITHIN SCOPE OF IBC. |
| 3     | FLOOR ANCHORS MAY BE INSTALLED AS SHOWN IN DETAIL.   |

AS BUILT

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 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

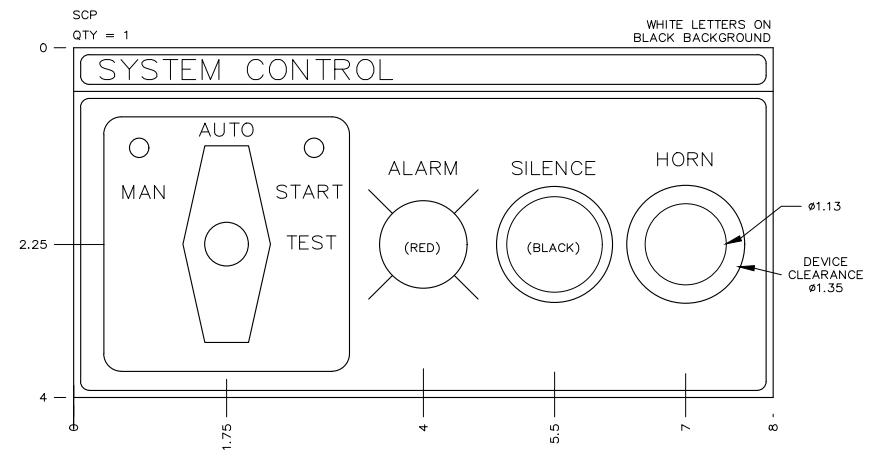
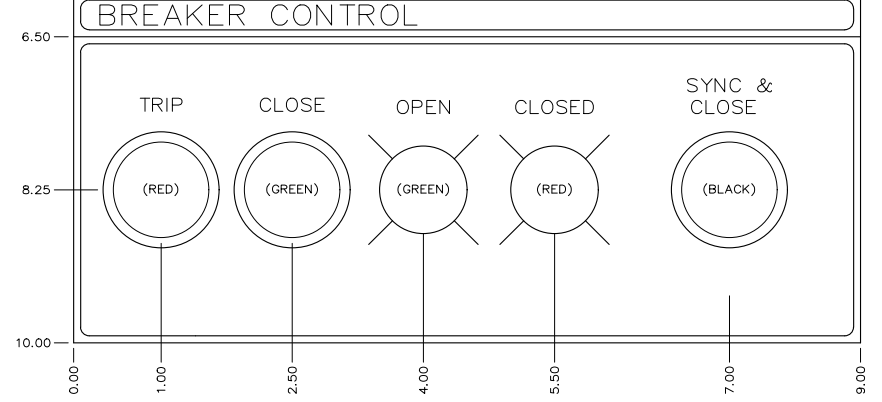
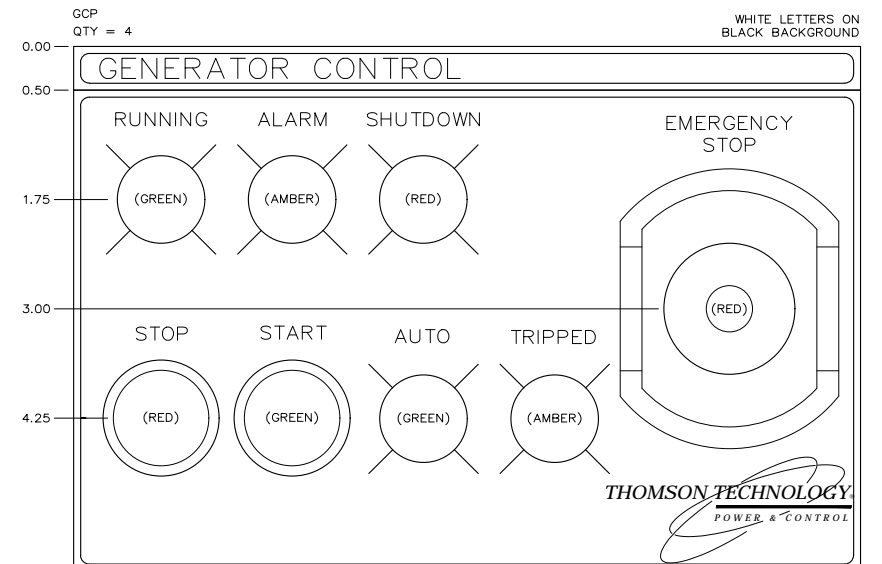
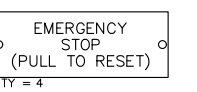
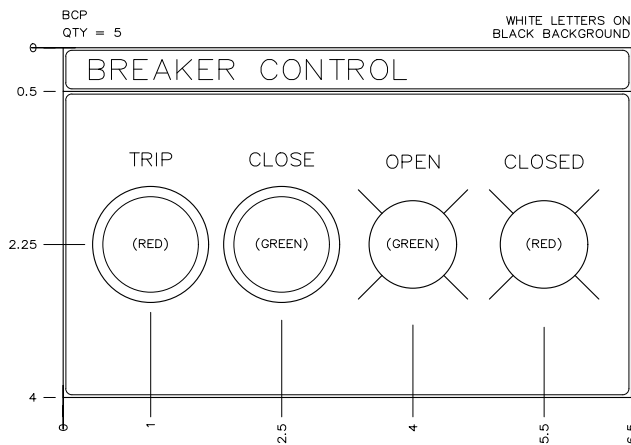
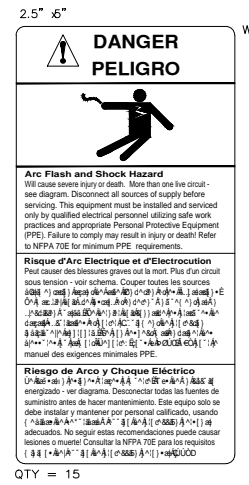
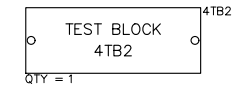
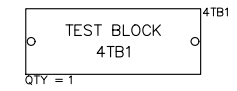
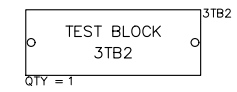
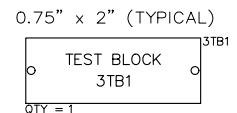
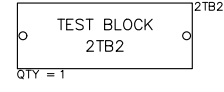
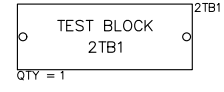
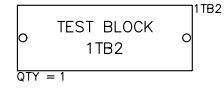
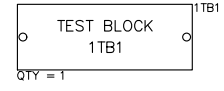
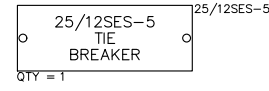
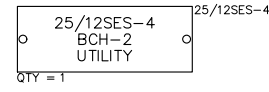
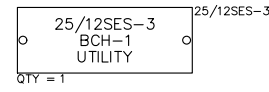
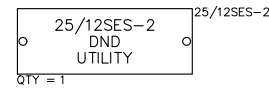
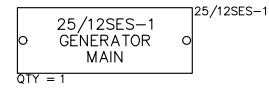
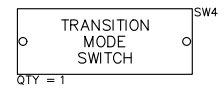
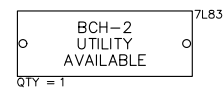
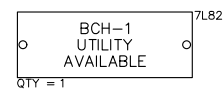
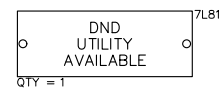
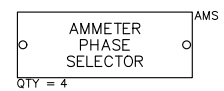
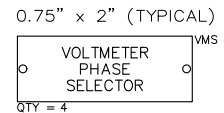
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 SOC - C - 1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

| No. | REVISIONS                      | BY | AUTH | DATE     |
|-----|--------------------------------|----|------|----------|
| 3   | AS BUILT                       | SD | SS   | 17-01-18 |
| 2   | CUSTOMER COMMENTS INCORPORATED | SD | SS   | 16-10-19 |
| 1   | ADDED SCHEMATIC DRAWINGS       | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 SECTIONAL LAYOUT  
 ESQUIMALT GRAVING DOCK

|   |                            |
|---|----------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-010B       | SHEET<br>10B               |



- NOTES**
- ALL LAMICOIDS ARE BLACK WITH WHITE LETTERING UNLESS SPECIFIED OTHERWISE.
  - LAMICOIDS ARE MECHANICALLY ATTACHED.
  - INTERNAL LABELS : PAPER ADHESIVE.

AS BUILT

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CROSS REFERENCE LEGEND

SOC - C - 1

GRID COORDINATE

SHEET No. \_\_\_\_\_

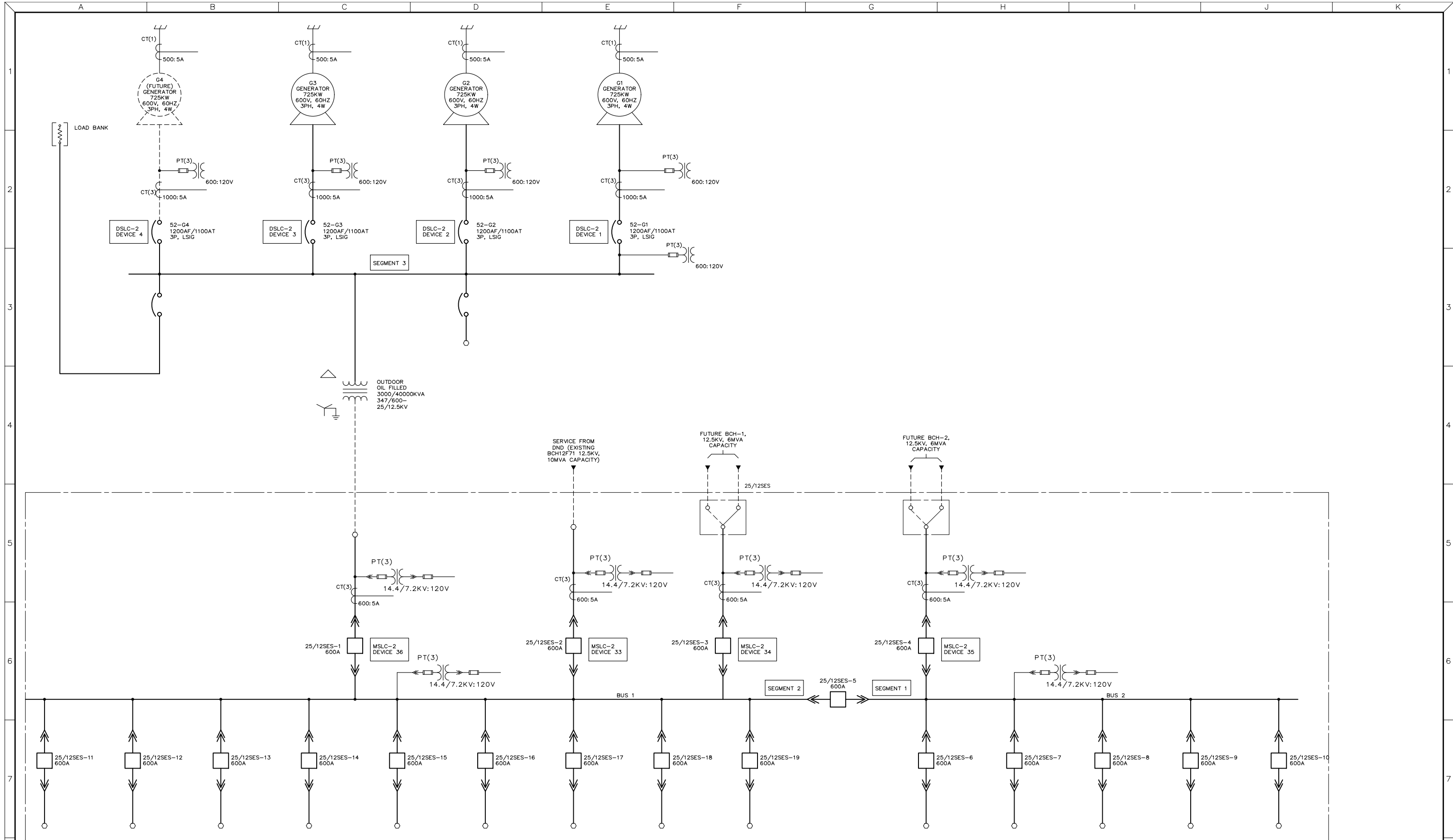
| DRAWING No. | REFERENCE DRAWINGS | No. |
|-------------|--------------------|-----|
|             |                    |     |

|   |                                |    |    |          |
|---|--------------------------------|----|----|----------|
| 3 | AS BUILT                       | SD | SS | 17-01-18 |
| 2 | CUSTOMER COMMENTS INCORPORATED | SD | SS | 16-10-19 |
| 1 | ADDED SCHEMATIC DRAWINGS       | SD | SS | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 NAME PLATE DETAILS  
 ESQUIMALT GRAVING DOCK

|   |                            |                  |          |
|---|----------------------------|------------------|----------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |                  |          |
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 | DATE<br>16-08-11 | REV<br>3 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              | DATE<br>16-08-11 | REV<br>3 |
| DRAWING/FILE No.<br>W-095112-020A       | SHEET<br>20A               |                  |          |



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 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

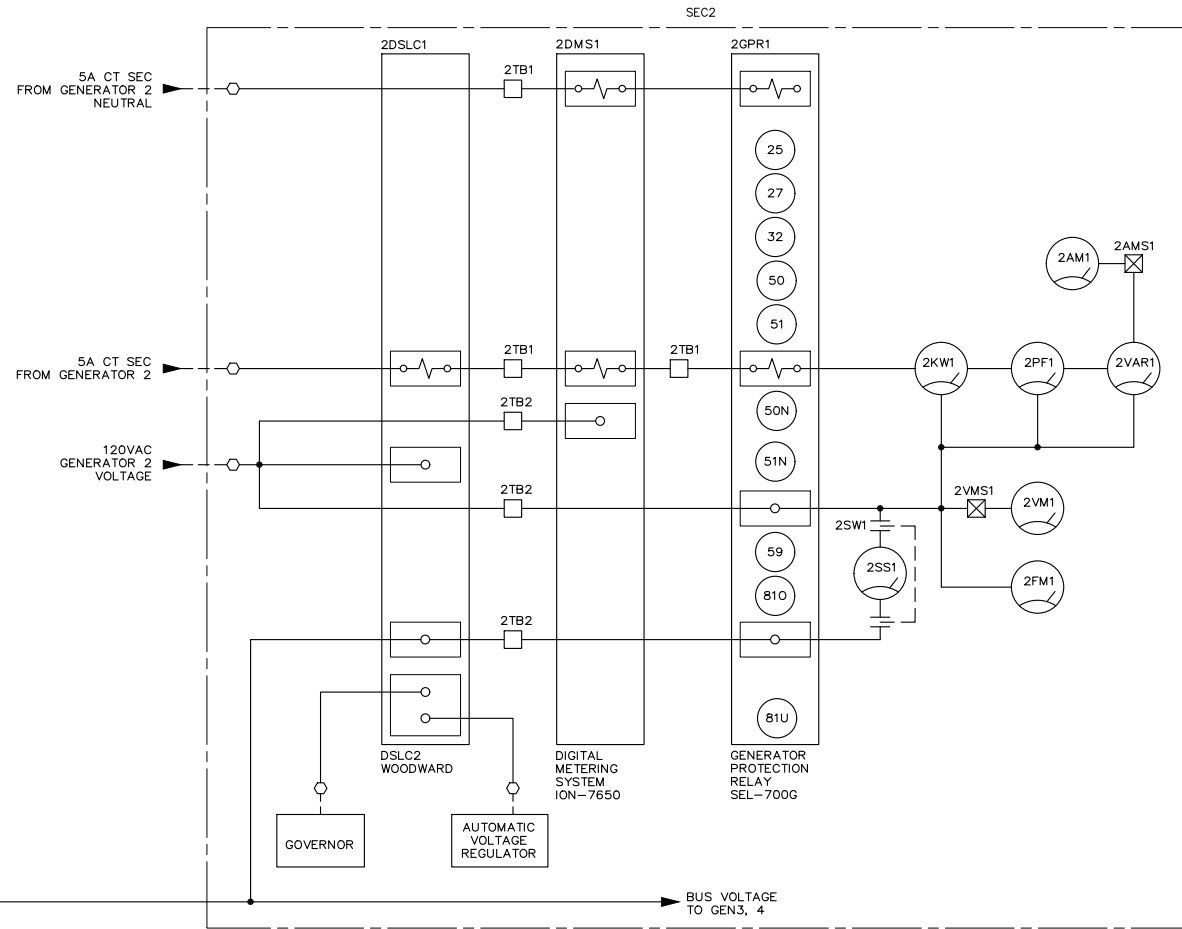
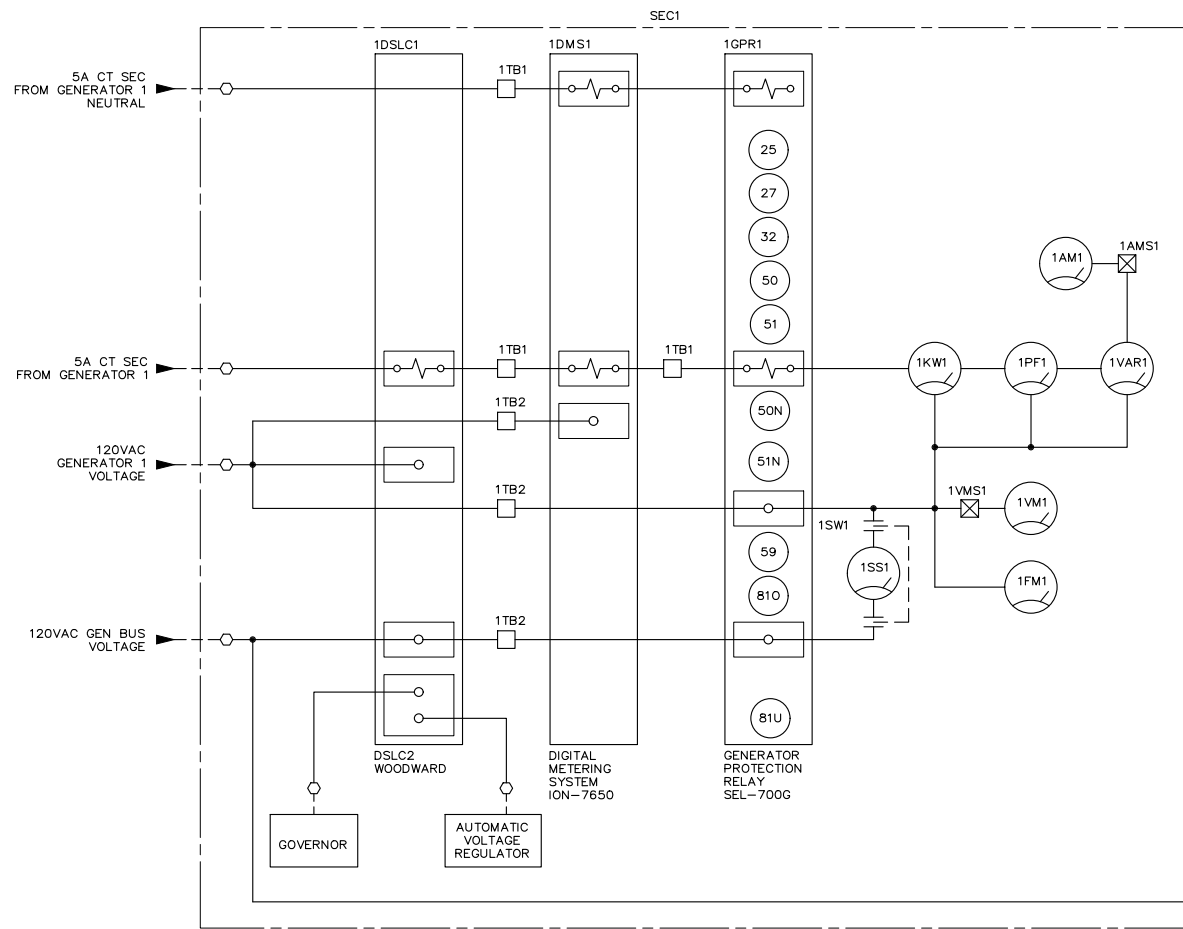
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 SOC - C - 1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 OVERALL SINGLE LINE DIAGRAM  
 ESQUIMALT GRAVING DOCK

|   |                         |
|---|-------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-030A          | SHEET 30A               |



| IEEE FUNCTION |                           |
|---------------|---------------------------|
| 25            | SYNC CHECK                |
| 27            | UNDER VOLTAGE             |
| 32            | REVERSE POWER             |
| 50            | INSTANTANEOUS OVERCURRENT |
| 51            | TIMED OVERCURRENT         |
| 59            | OVER VOLTAGE              |
| 81O           | OVER FREQUENCY            |
| 81U           | UNDER FREQUENCY           |

| NOTES |   |
|-------|---|
| 1     | DSLC2 GENERATOR CONTROLLER : WOODWARD, 8440-1878, 12-24VDC. |
| 2     | MSLC2 MASTER CONTROLLER : WOODWARD, 8440-1877, 12-24VDC.    |
| 3     | GENERATOR PROTECTION RELAY : SEL, SEL-700G, 125VDC AUX.     |
| 4     | DIGITAL METERING SYSTEM : SQUARE D, ION-7650, 125VDC AUX.   |

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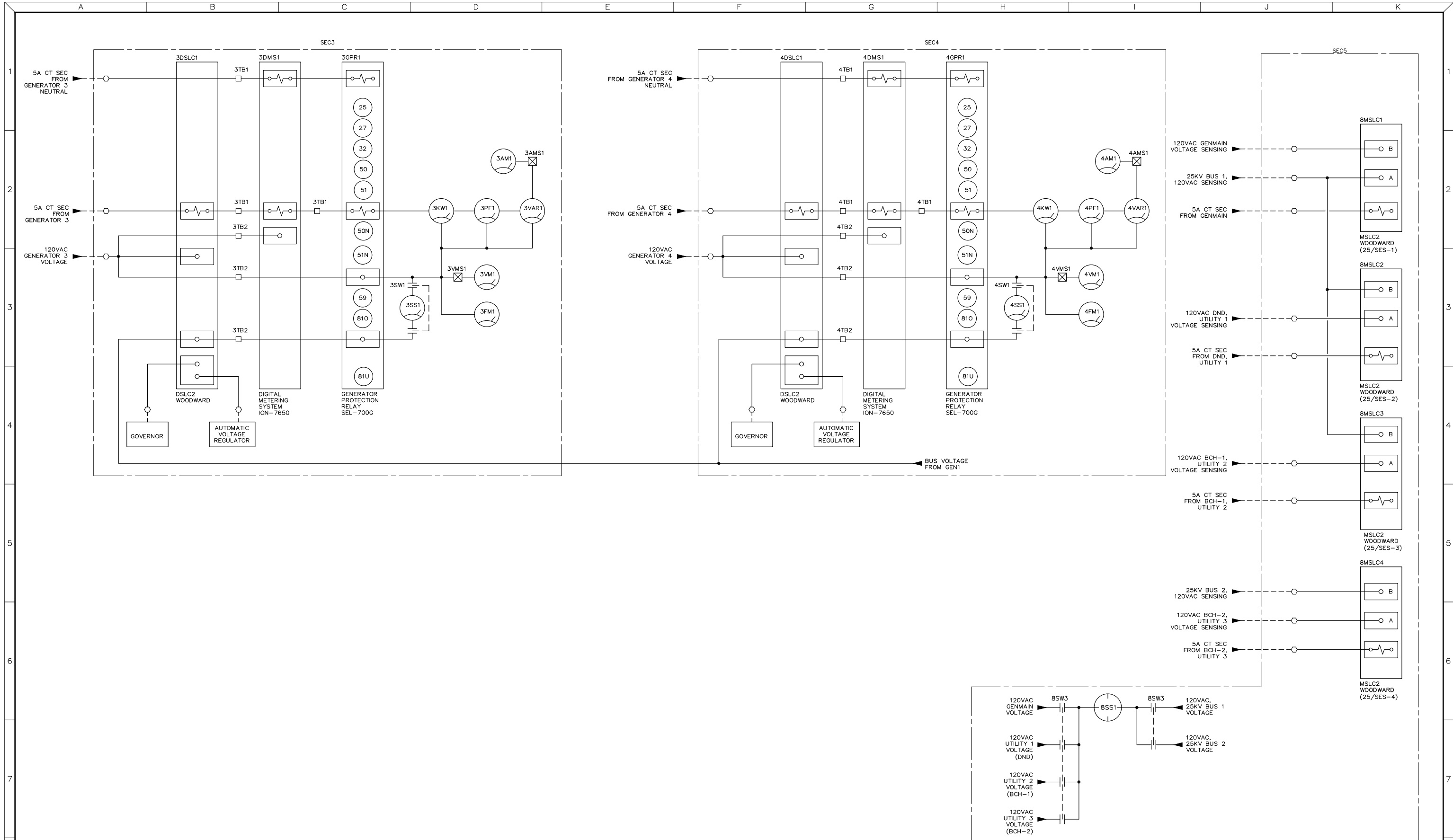
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 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

| CROSS REFERENCE LEGEND |                        |
|------------------------|------------------------|
| 50C-C-1                | GRID COORDINATE        |
|                        | SHEET No.              |
|                        | DRAWING No.            |
|                        | REFERENCE DRAWINGS No. |
|                        | REVISIONS              |
|                        | BY/AUTH                |
|                        | DATE                   |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 SINGLE LINE DIAGRAM  
 ESQUIMALT GRAVING DOCK

|   |                         |
|---|-------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-030B          | SHEET 30B               |



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 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

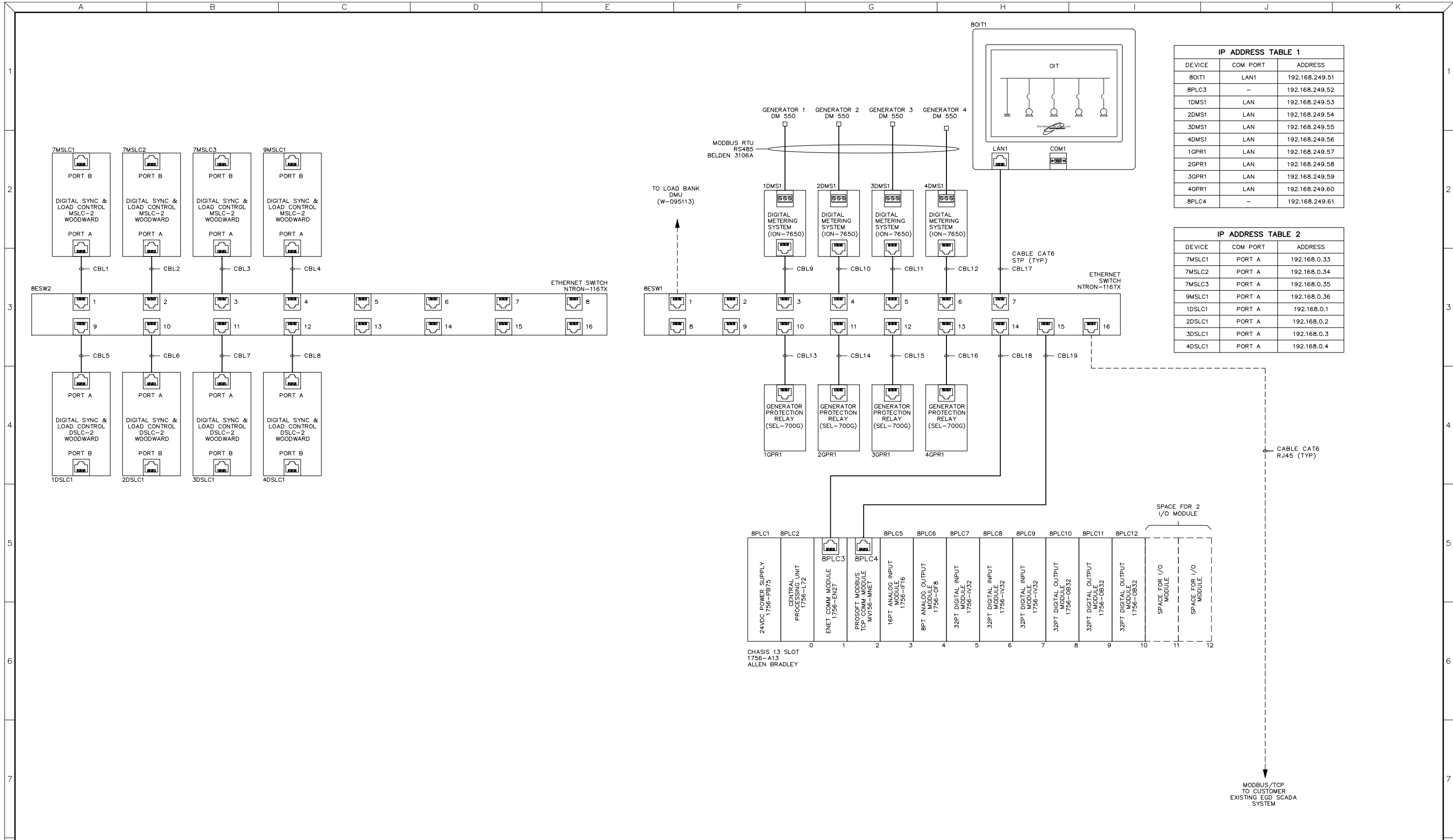
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 50C-C-1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

| NO. | REVISIONS                      | BY | AUTH | DATE     |
|-----|--------------------------------|----|------|----------|
| 3   | AS BUILT                       | SD | SS   | 17-01-18 |
| 2   | CUSTOMER COMMENTS INCORPORATED | SD | SS   | 16-10-19 |
| 1   | ADDED SCHEMATIC DRAWINGS       | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 SINGLE LINE DIAGRAM  
 ESQUIMALT GRAVING DOCK

|   |                         |
|---|-------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-030C          | SHEET 30C               |



**IP ADDRESS TABLE 1**

| DEVICE | COM PORT | ADDRESS        |
|--------|----------|----------------|
| 80IT1  | LAN1     | 192.168.249.51 |
| 8PLC3  | -        | 192.168.249.52 |
| 1DMS1  | LAN      | 192.168.249.53 |
| 2DMS1  | LAN      | 192.168.249.54 |
| 3DMS1  | LAN      | 192.168.249.55 |
| 4DMS1  | LAN      | 192.168.249.56 |
| 1GPR1  | LAN      | 192.168.249.57 |
| 2GPR1  | LAN      | 192.168.249.58 |
| 3GPR1  | LAN      | 192.168.249.59 |
| 4GPR1  | LAN      | 192.168.249.60 |
| 8PLC4  | -        | 192.168.249.61 |

**IP ADDRESS TABLE 2**

| DEVICE | COM PORT | ADDRESS      |
|--------|----------|--------------|
| 7MSLC1 | PORT A   | 192.168.0.33 |
| 7MSLC2 | PORT A   | 192.168.0.34 |
| 7MSLC3 | PORT A   | 192.168.0.35 |
| 9MSLC1 | PORT A   | 192.168.0.36 |
| 1DSLC1 | PORT A   | 192.168.0.1  |
| 2DSLC1 | PORT A   | 192.168.0.2  |
| 3DSLC1 | PORT A   | 192.168.0.3  |
| 4DSLC1 | PORT A   | 192.168.0.4  |

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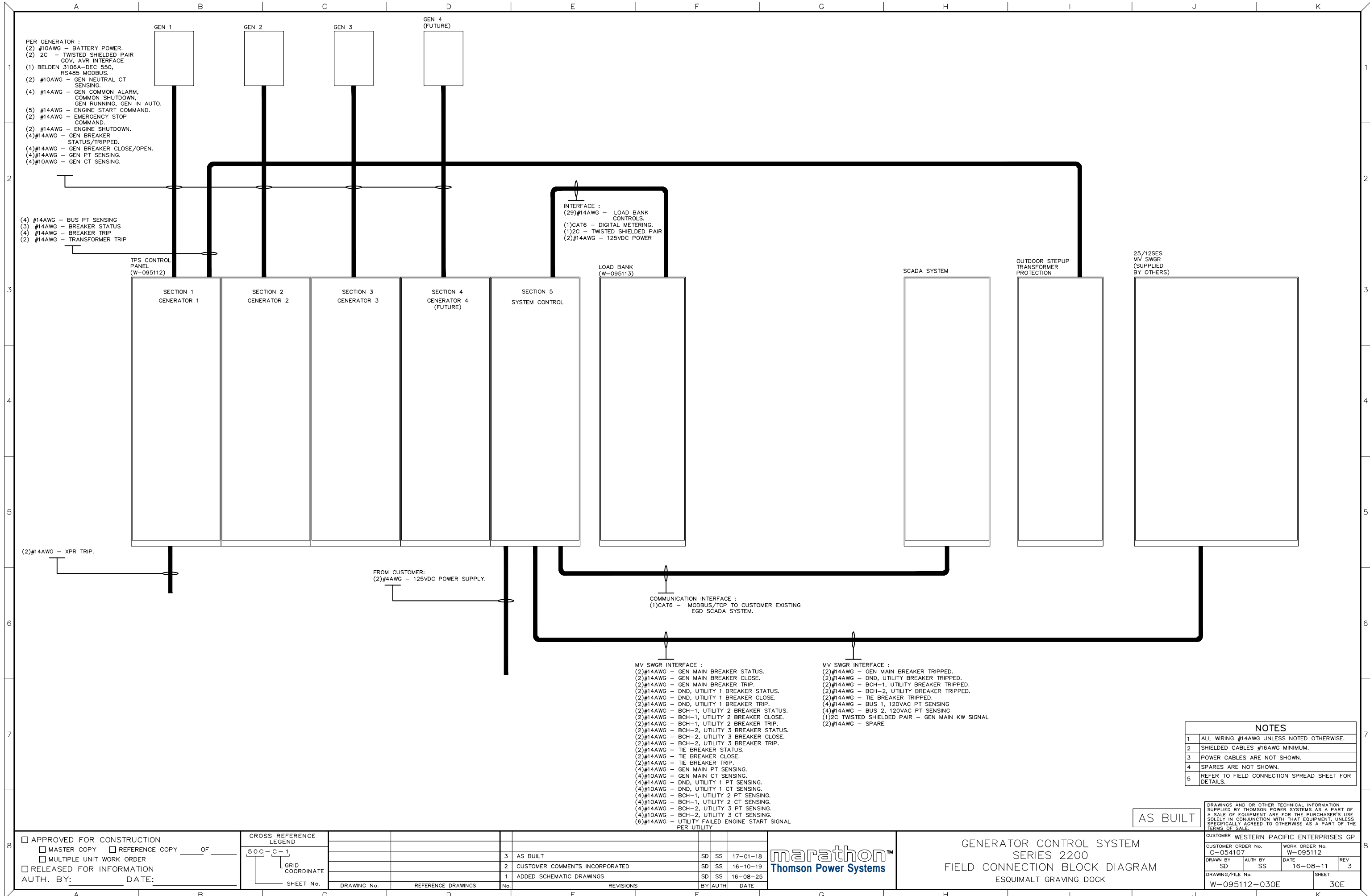
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 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

| CROSS REFERENCE LEGEND |                    | REVISIONS |                                |
|------------------------|--------------------|-----------|--------------------------------|
| SOC-C-1                | GRID COORDINATE    | 3         | AS BUILT                       |
|                        | SHEET No.          | 2         | CUSTOMER COMMENTS INCORPORATED |
|                        | DRAWING No.        | 1         | ADDED SCHEMATIC DRAWINGS       |
|                        | REFERENCE DRAWINGS |           |                                |
|                        | No.                |           |                                |
|                        | BY/AUTH            |           |                                |
|                        | DATE               |           |                                |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 COMMUNICATION BLOCK DIAGRAM  
 ESQUIMALT GRAVING DOCK

|   |                         |
|---|-------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-030D          | SHEET 30D               |



| NOTES |   |
|-------|---|
| 1     | ALL WIRING #14AWG UNLESS NOTED OTHERWISE.           |
| 2     | SHIELDED CABLES #16AWG MINIMUM.                     |
| 3     | POWER CABLES ARE NOT SHOWN.                         |
| 4     | SPARES ARE NOT SHOWN.                               |
| 5     | REFER TO FIELD CONNECTION SPREAD SHEET FOR DETAILS. |

AS BUILT

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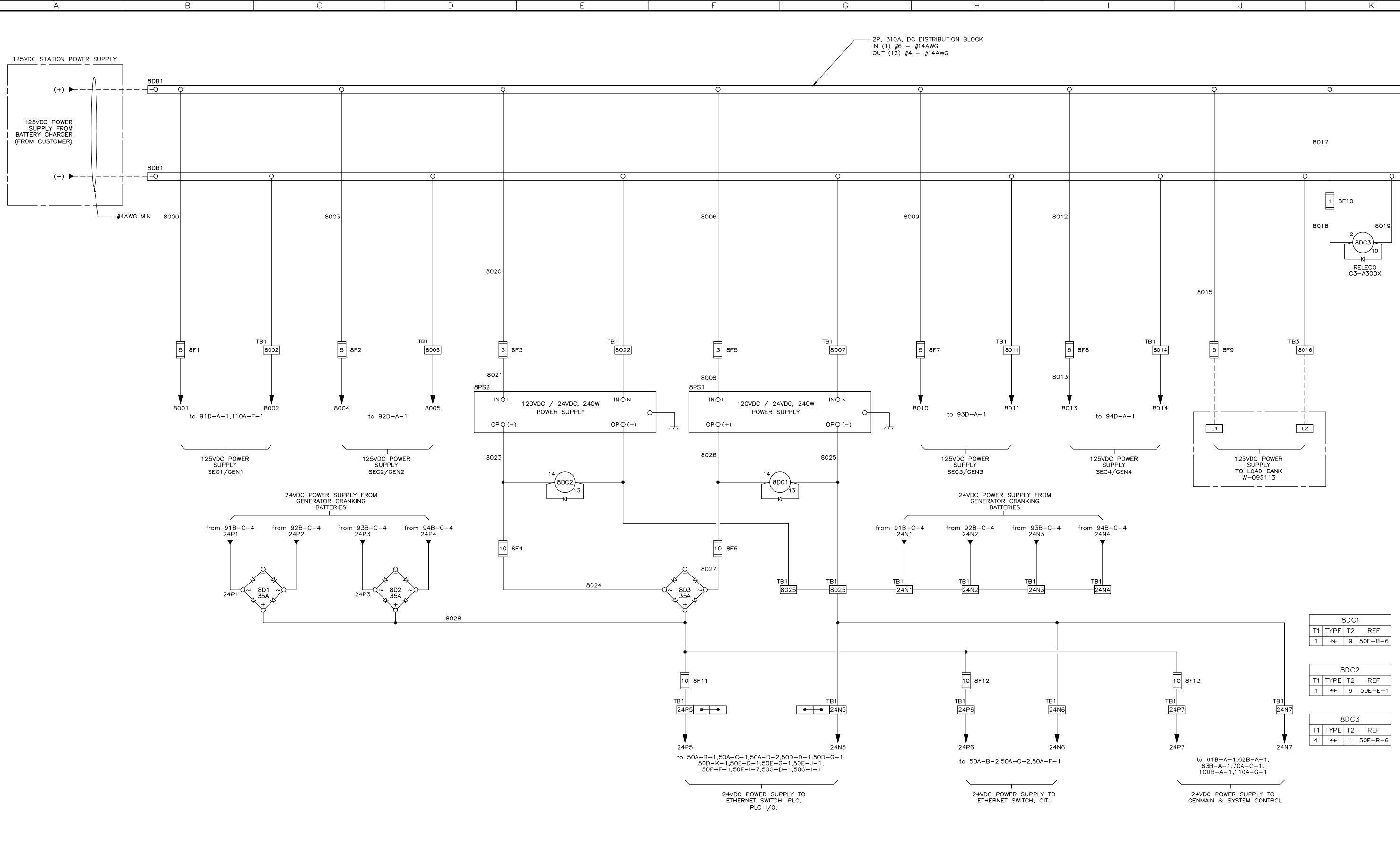
| CROSS REFERENCE LEGEND |                    |
|------------------------|--------------------|
| SOC - C - 1            | GRID COORDINATE    |
| SHEET No.              | DRAWING No.        |
|                        | REFERENCE DRAWINGS |
|                        | No.                |

| NO. | REVISIONS                      | BY | AUTH | DATE     |
|-----|--------------------------------|----|------|----------|
| 3   | AS BUILT                       | SD | SS   | 17-01-18 |
| 2   | CUSTOMER COMMENTS INCORPORATED | SD | SS   | 16-10-19 |
| 1   | ADDED SCHEMATIC DRAWINGS       | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 FIELD CONNECTION BLOCK DIAGRAM  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
|---|----------------------------|
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-030E       | SHEET<br>30E               |



2P, 310A, DC DISTRIBUTION BLOCK  
 IN (1) #6 - #14AWG  
 OUT (12) #4 - #14AWG

125VDC POWER SUPPLY SEC1/GEN1

125VDC POWER SUPPLY SEC2/GEN2

125VDC POWER SUPPLY SEC3/GEN3

125VDC POWER SUPPLY SEC4/GEN4

24VDC POWER SUPPLY FROM GENERATOR CRANKING BATTERIES

24VDC POWER SUPPLY FROM GENERATOR CRANKING BATTERIES

24VDC POWER SUPPLY TO ETHERNET SWITCH, PLC I/O.

24VDC POWER SUPPLY TO ETHERNET SWITCH, OIT.

24VDC POWER SUPPLY TO GENMAIN & SYSTEM CONTROL

| 8DC1 |      |    |         |
|------|------|----|---------|
| T1   | TYPE | T2 | REF     |
| 1    | ↔    | 9  | 50E-B-6 |

| 8DC2 |      |    |         |
|------|------|----|---------|
| T1   | TYPE | T2 | REF     |
| 1    | ↔    | 9  | 50E-E-1 |

| 8DC3 |      |    |         |
|------|------|----|---------|
| T1   | TYPE | T2 | REF     |
| 4    | ↔    | 1  | 50E-B-6 |

SECTION# 5

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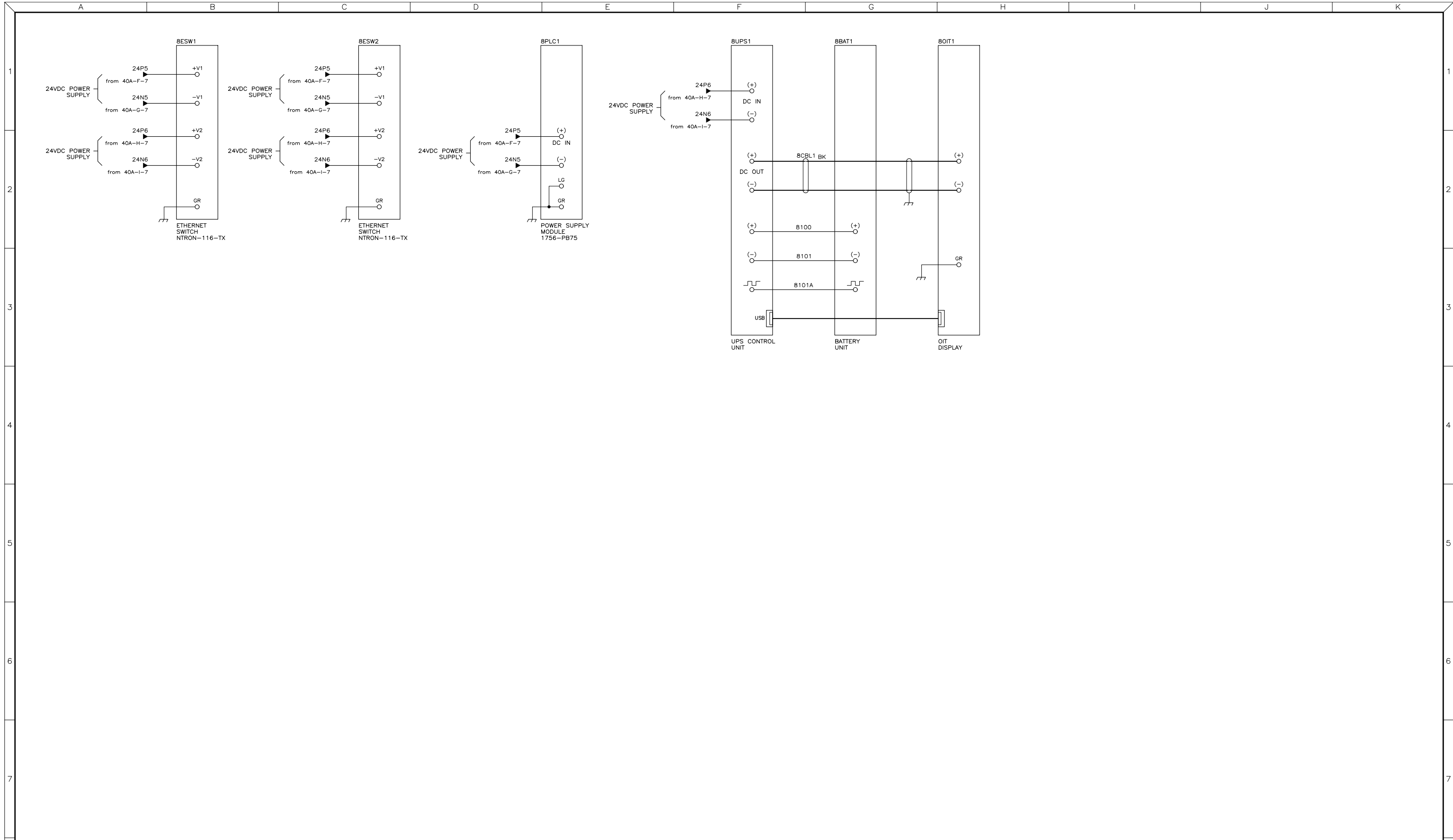
| CROSS REFERENCE LEGEND |                 | DRAWING No. |  | REFERENCE DRAWINGS |  | No. |  | REVISIONS |  | BY/AUTH |  | DATE |  |
|------------------------|-----------------|-------------|--|--------------------|--|-----|--|-----------|--|---------|--|------|--|
| 50C-C-1                | GRID COORDINATE |             |  |                    |  |     |  |           |  |         |  |      |  |
|                        | SHEET No.       |             |  |                    |  |     |  |           |  |         |  |      |  |
|                        |                 |             |  |                    |  |     |  |           |  |         |  |      |  |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 COMMON 24VDC SUPPLY SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |            |                         |       |
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| CUSTOMER WESTERN PACIFIC ENTERPRISES GP   |            | WORK ORDER No. W-095112 |       |
| CUSTOMER ORDER No. C-054107   | AUTH BY SS | DATE 16-08-11           | REV 3 |
| DRAWN BY SD   | AUTH BY SS | DATE 16-08-11           | REV 3 |
| DRAWING/FILE No. W-095112-040A  | SHEET 40A  |                         |       |





SECTION# 5

AS BUILT

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 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

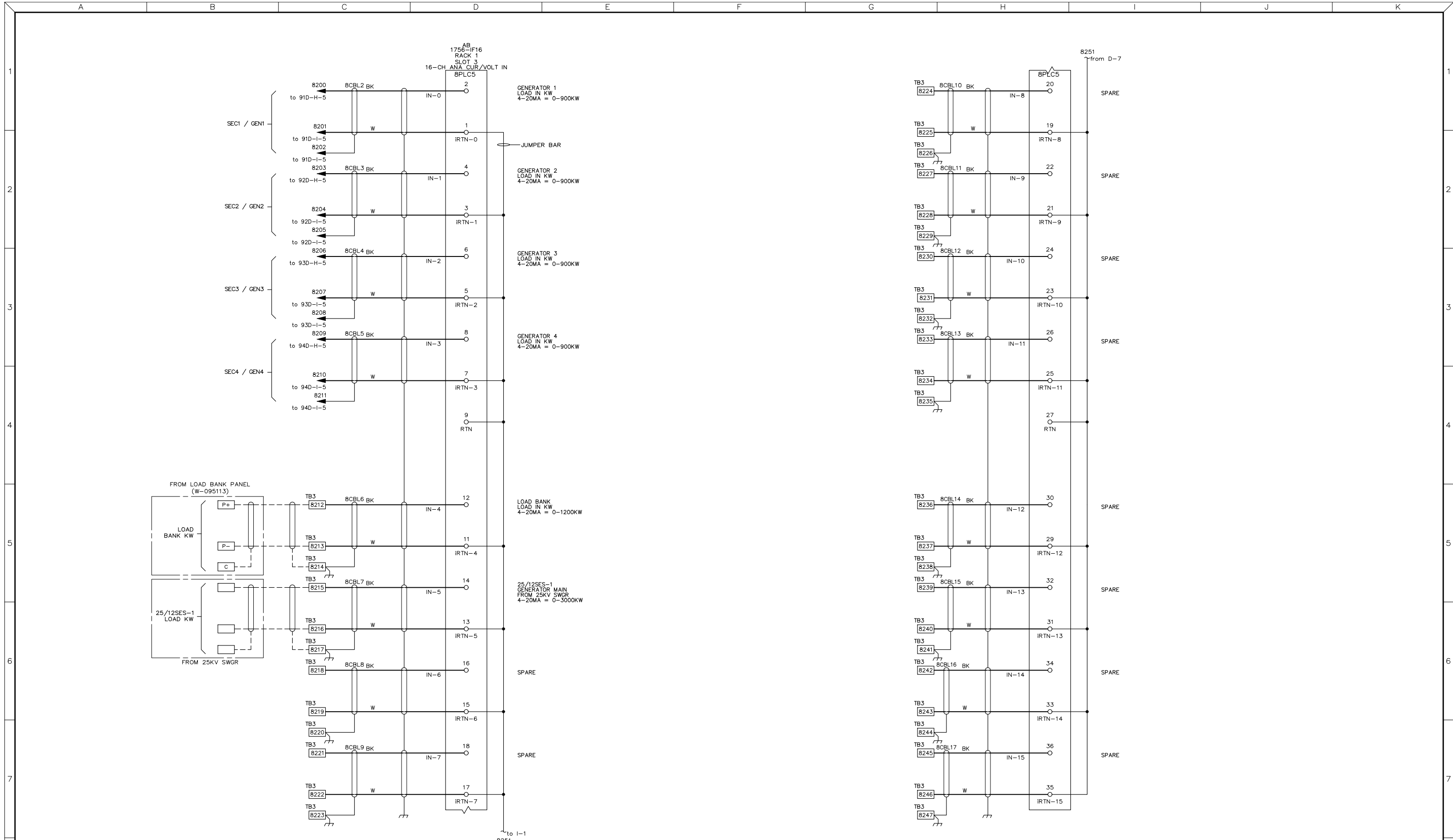
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 50C-C-1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 COMMON PLC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |                            |
|---|----------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-050A       | SHEET<br>50A               |



SECTION# 5

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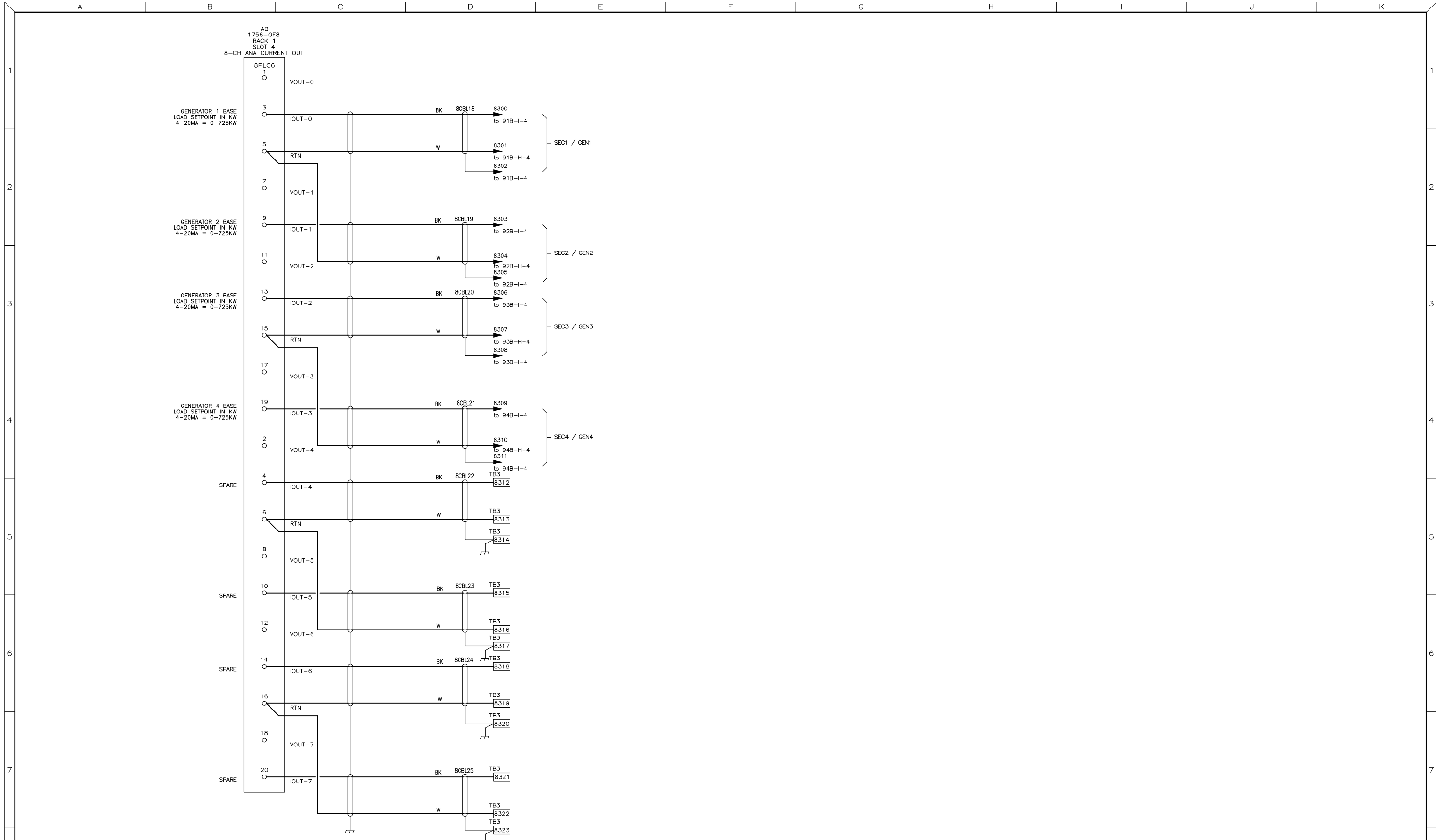
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|------------------------|-----------------|
| 50C-C-1                | GRID COORDINATE |
|                        | SHEET No.       |

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 COMMON PLC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |                  |          |
|---|----------------------------|------------------|----------|
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 | DATE<br>16-08-11 | REV<br>3 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              | DATE<br>16-08-25 | REV<br>3 |
| DRAWING/FILE No.<br>W-095112-050B       | SHEET<br>50B               |                  |          |



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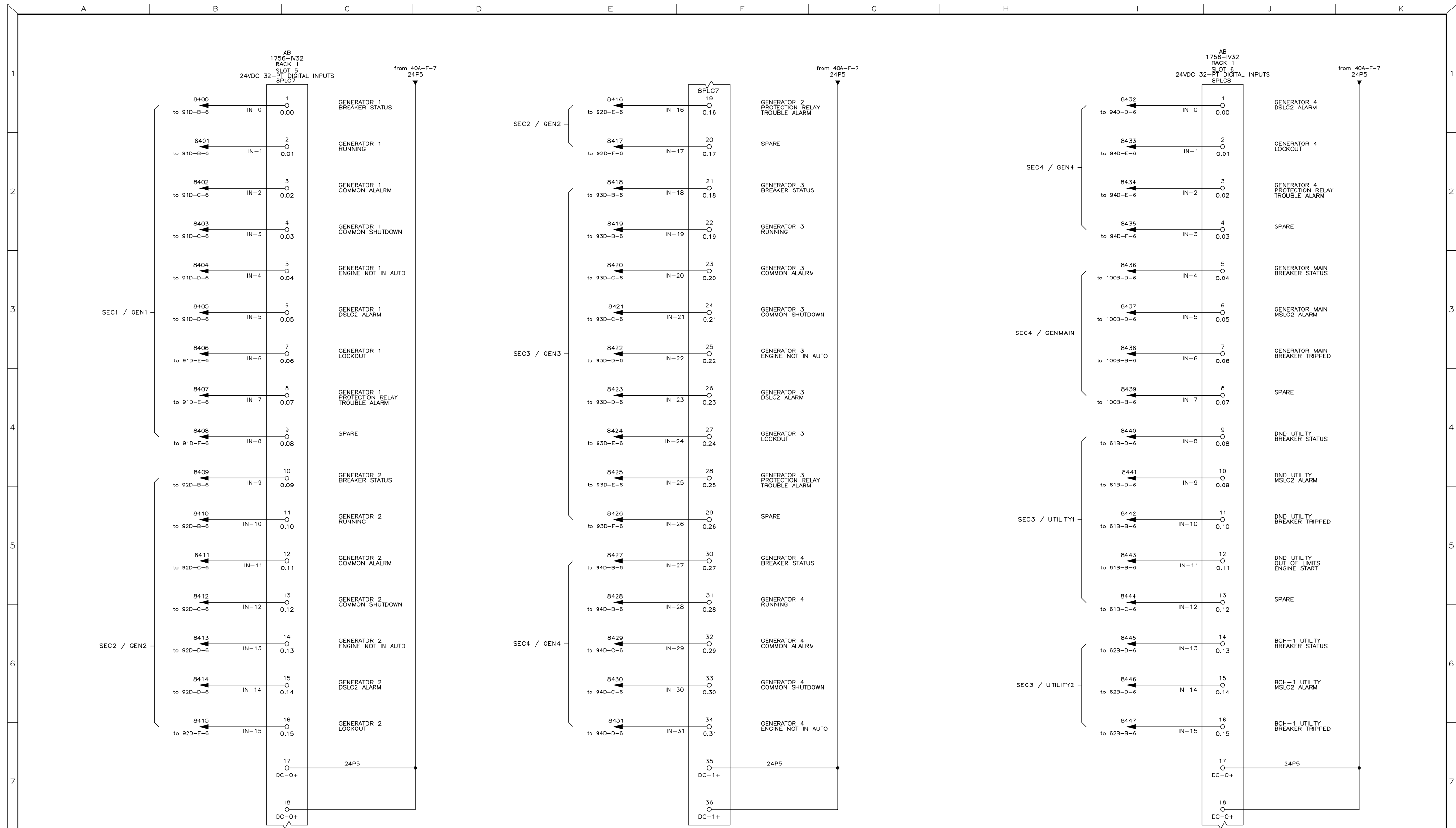
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 SHEET No. \_\_\_\_\_

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 COMMON PLC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |                            |
|---|----------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-050C       | SHEET<br>50C               |



SECTION# 5

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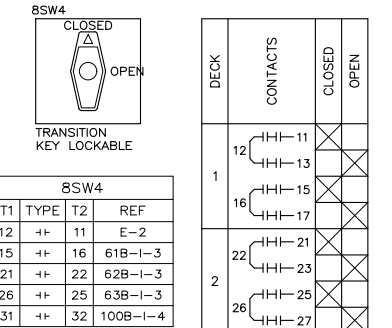
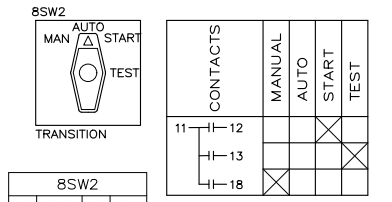
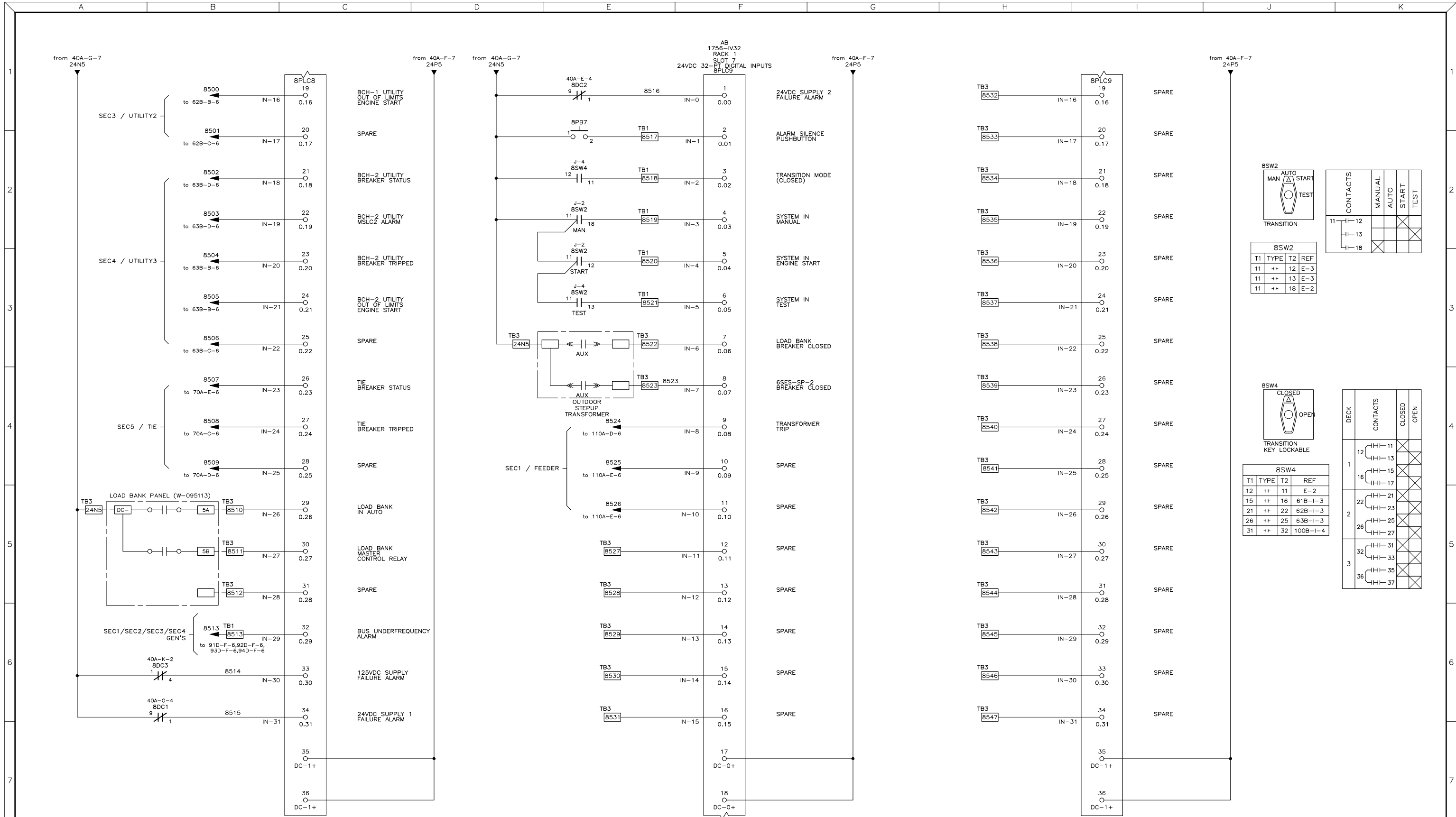
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 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 COMMON PLC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |                            |
|---|----------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-050D       | SHEET<br>50D               |



SECTION# 5

AS BUILT

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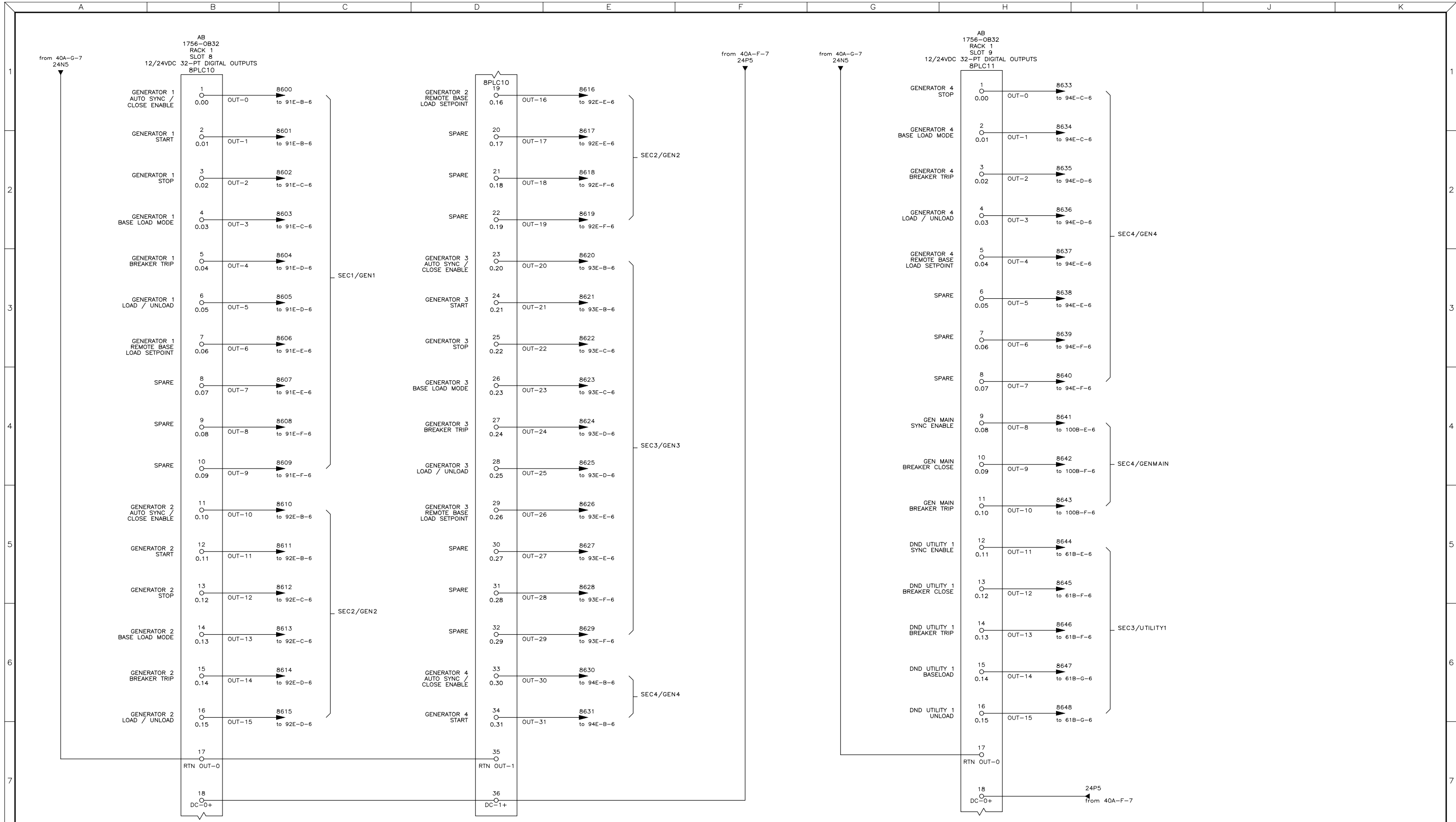
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 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
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| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 COMMON PLC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |         |                |       |
|---|---------|----------------|-------|
| CUSTOMER ORDER No.                      |         | WORK ORDER No. |       |
| C-054107                                |         | W-095112       |       |
| DRAWN BY                                | AUTH BY | DATE           | REV   |
| SD                                      | SS      | 16-08-11       | 3     |
| DRAWING/FILE No.                        |         |                | SHEET |
| W-095112-050E                           |         |                | 50E   |



SECTION# 5

AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

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 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

| CROSS REFERENCE LEGEND |                    |
|------------------------|--------------------|
| 50C-C-1                | GRID COORDINATE    |
| _____                  | SHEET No.          |
| _____                  | DRAWING No.        |
| _____                  | REFERENCE DRAWINGS |
| _____                  | No.                |

| NO. | REVISIONS                      | BY | AUTH | DATE     |
|-----|--------------------------------|----|------|----------|
| 3   | AS BUILT                       | SD | SS   | 17-01-18 |
| 2   | CUSTOMER COMMENTS INCORPORATED | SD | SS   | 16-10-19 |
| 1   | ADDED SCHEMATIC DRAWINGS       | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 COMMON PLC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |                            |
|---|----------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-050F       | SHEET<br>50F               |



| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 1  | +    | 9  | C-7 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-1 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-7 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-2 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-2 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-2 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-2 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-3 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-3 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-3 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-4 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-4 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-4 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-4 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-5 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-5 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-5 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-6 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-6 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-6 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-6 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-7 |

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-7 |

DRY CONTACTS  
RATED 5A,  
250VAC/30VDC  
RESISTIVE

SECTION# 5

AS BUILT

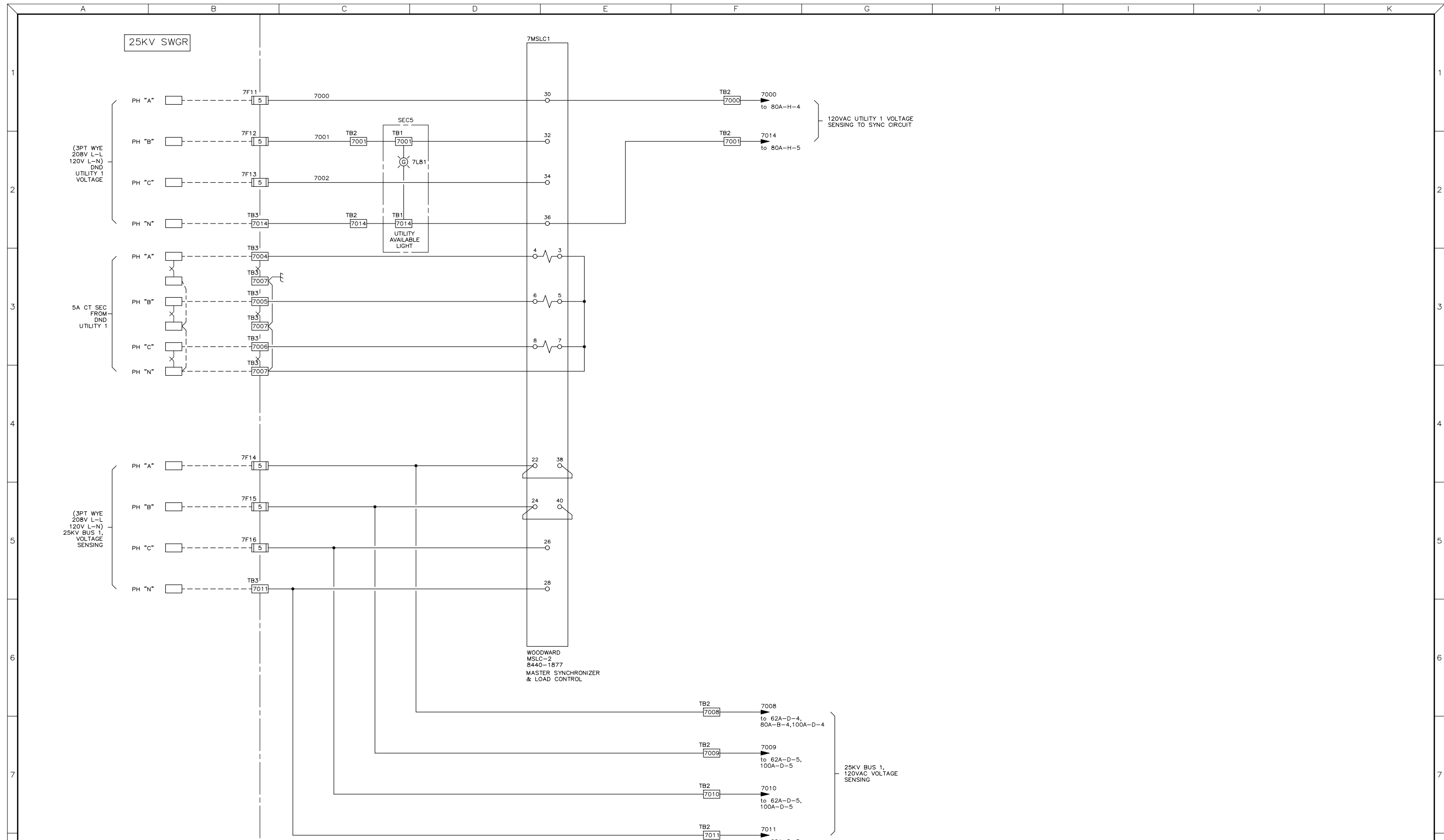
APPROVED FOR CONSTRUCTION  
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 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

| CROSS REFERENCE LEGEND |  |
|------------------------|--|
| SOC - C-1              |  |
| GRID COORDINATE        |  |
| SHEET No.              |  |
| DRAWING No.            |  |
| REFERENCE DRAWINGS     |  |
| No.                    |  |
| REVISIONS              |  |
| BY/AUTH                |  |
| DATE                   |  |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 COMMON PLC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |                                   |              |
|---|----------------------------|-----------------------------------|--------------|
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 | DATE<br>16-08-11                  | REV<br>3     |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              | DRAWING/FILE No.<br>W-095112-050G | SHEET<br>50G |



SECTION# 3

AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

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 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

CROSS REFERENCE LEGEND  
 50C-C-1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |

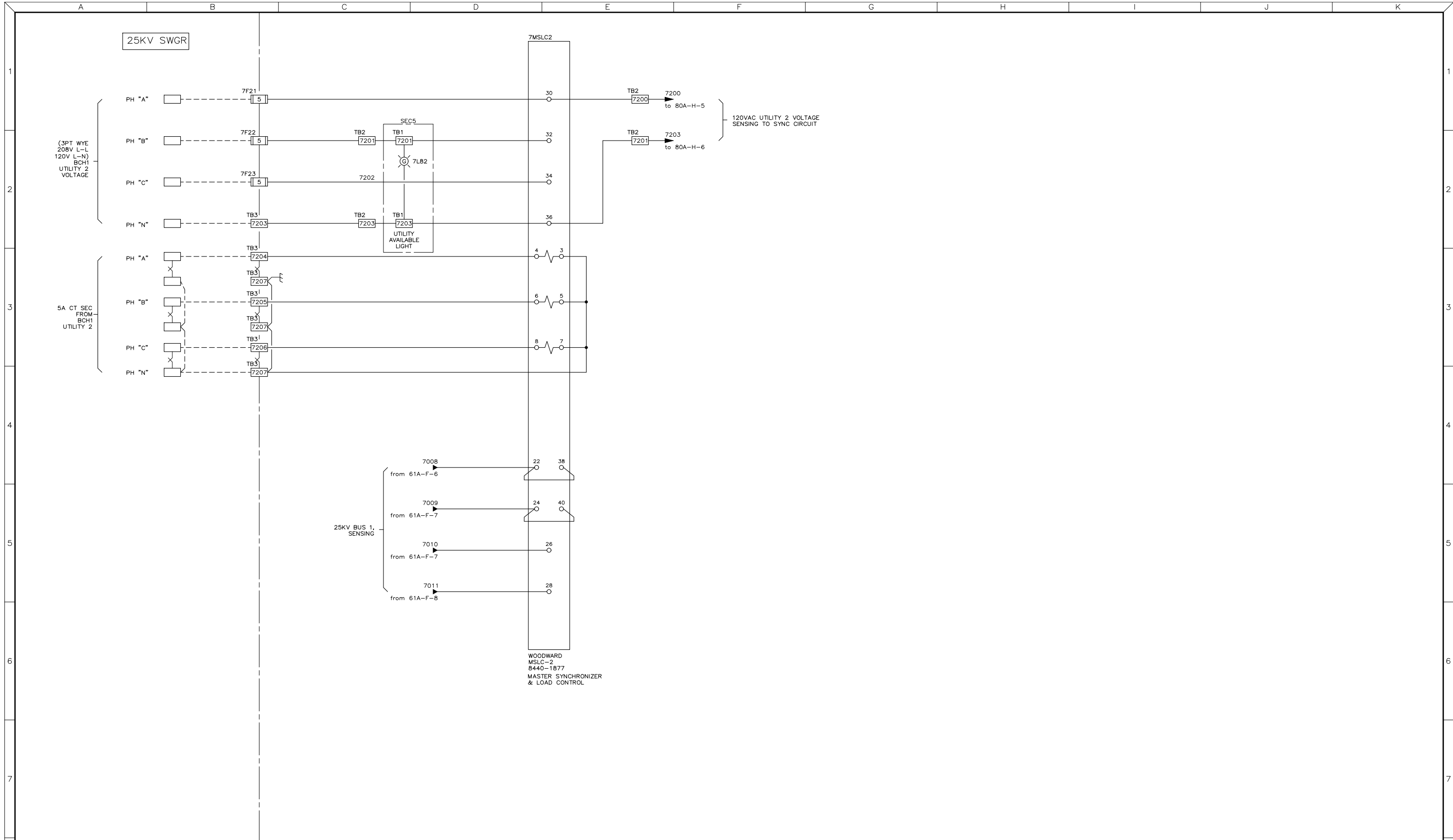


GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 DND UTILITY 1 AC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |                            |
|---|----------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-061A       | SHEET<br>61A               |







SECTION# 3

AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

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 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

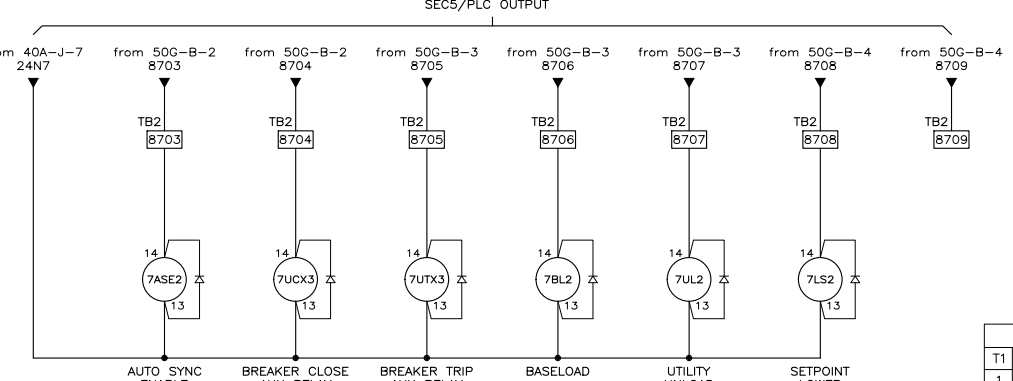
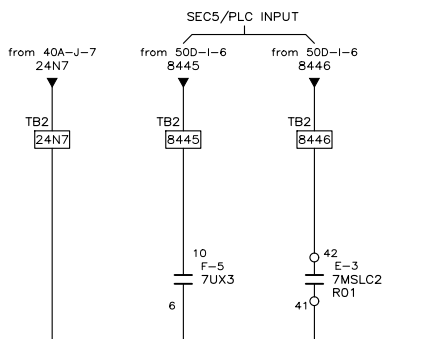
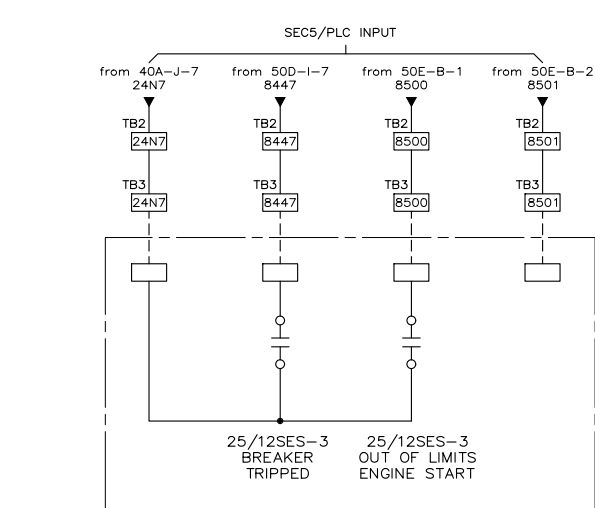
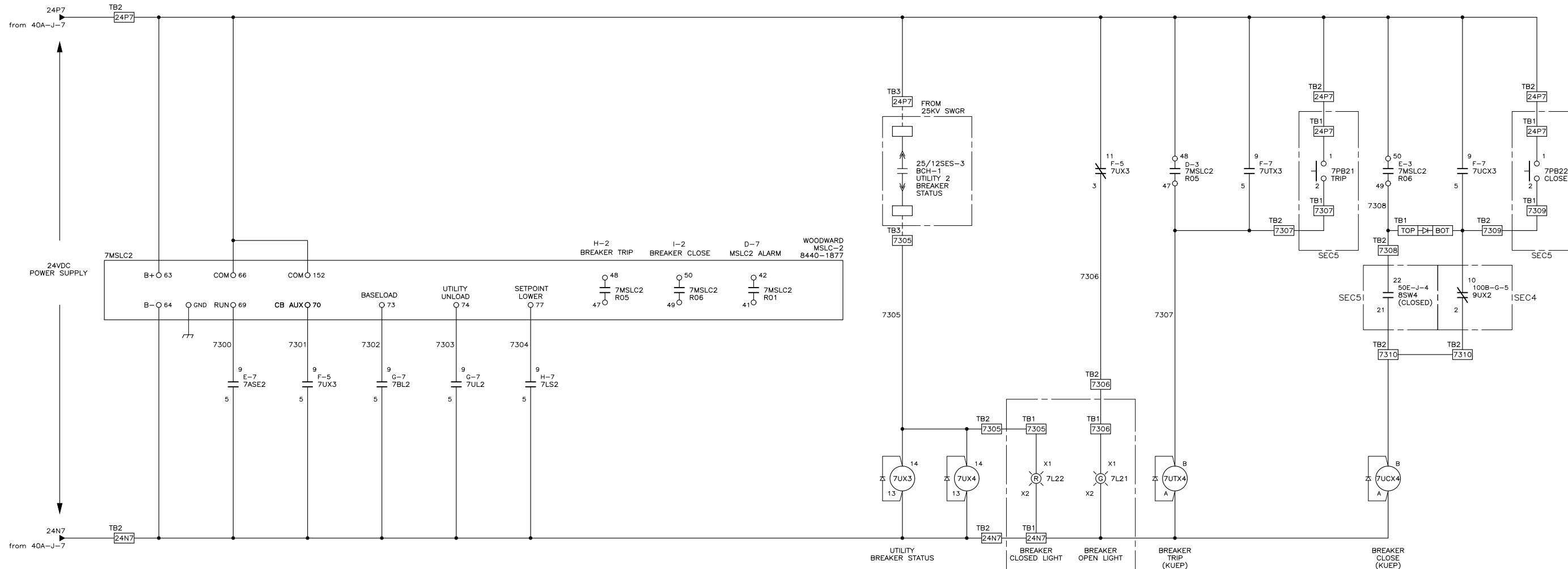
CROSS REFERENCE LEGEND  
 50C-C-1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY/AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|---------|----------|
| 3           | AS BUILT                       |     |           | SD SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 BCH-1 UTILITY 1 AC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |                            |
|---|----------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-062A       | SHEET<br>62A               |



| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | C-4 |

7BL2

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | D-4 |

7UL2

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | B-4 |

7ASE2

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-2 |

7UCX3

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | I-2 |

7UTX3

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | J-6 |

7UTX4

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 6  | +    | 4  | J-6 |

7UCX4

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 6  | +    | 4  | J-7 |

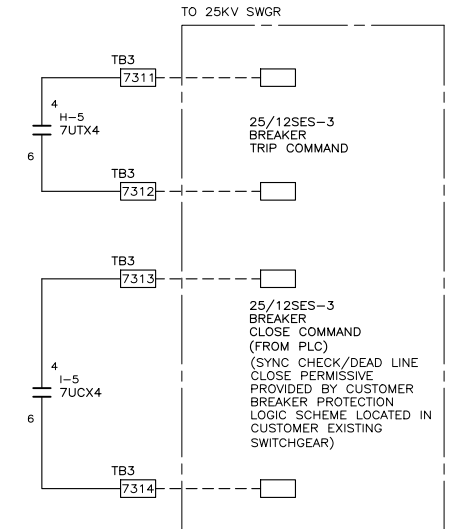
7UCX4

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 5  | +    | 9  | D-4 |

7LS2

| T1 | TYPE | T2 | REF      |
|----|------|----|----------|
| 1  | +    | 9  | 100B-J-4 |
| 6  | +    | 10 | 91D-G-4  |

7UX4



SECTION# 3 AS BUILT

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50C-C-1

GRID COORDINATE

SHEET No.

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY       | AUTH | DATE |
|-------------|--------------------------------|-----|-----------|----------|------|------|
| 3           | AS BUILT                       | SD  | SS        | 17-01-18 |      |      |
| 2           | CUSTOMER COMMENTS INCORPORATED | SD  | SS        | 16-10-19 |      |      |
| 1           | ADDED SCHEMATIC DRAWINGS       | SD  | SS        | 16-08-25 |      |      |



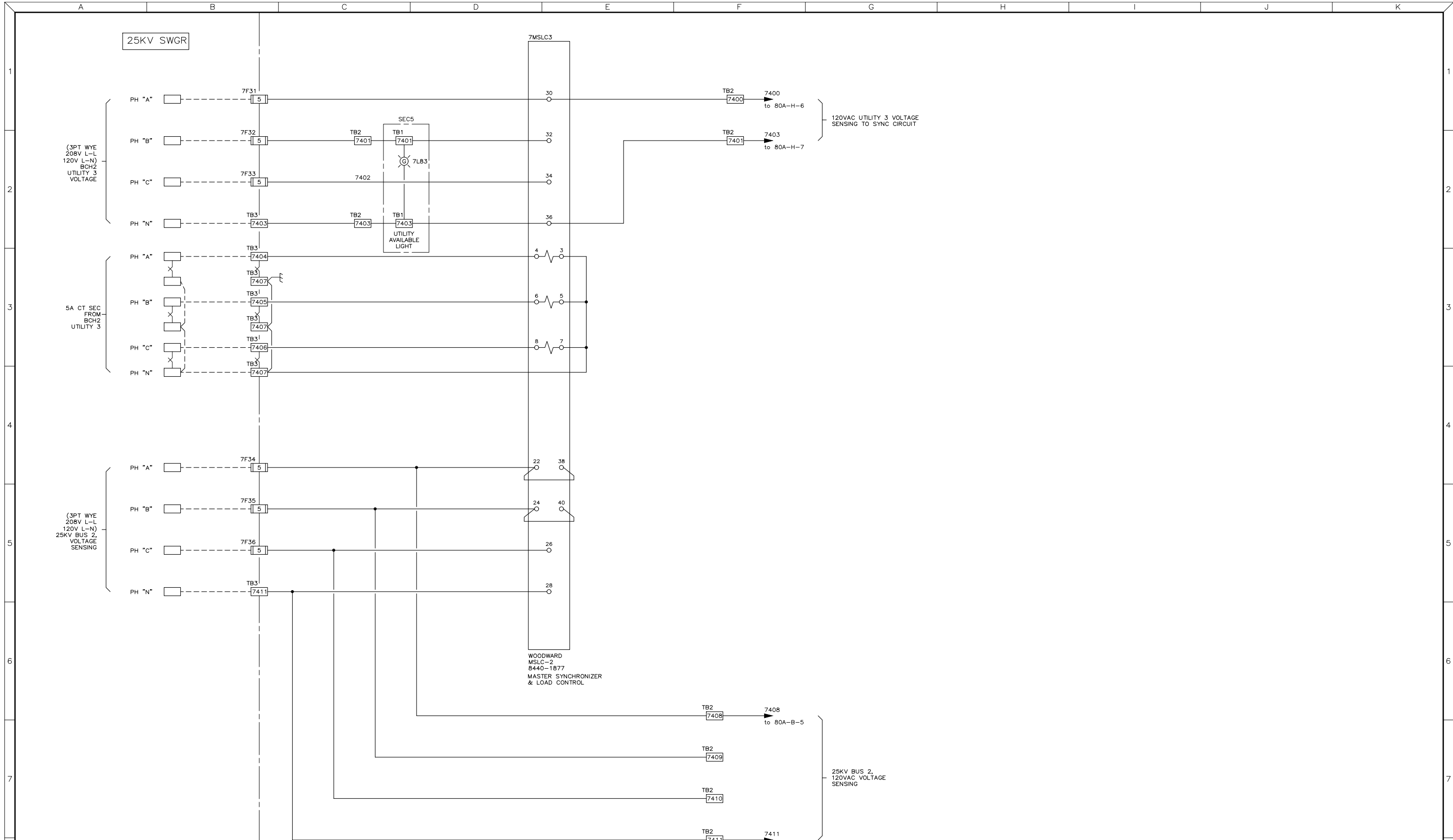
GENERATOR CONTROL SYSTEM

SERIES 2200

BCH-1 UTILITY 1 DC CONTROL SCHEMATIC

ESQUIMALT GRAVING DOCK

| CUSTOMER           | WESTERN PACIFIC ENTERPRISES GP |
|--------------------|--------------------------------|
| CUSTOMER ORDER No. | WORK ORDER No.                 |
| C-054107           | W-095112                       |
| DRAWN BY           | AUTH BY                        |
| SD                 | SS                             |
| DATE               | DATE                           |
| 16-08-11           | 16-08-11                       |
| REV                | REV                            |
| 3                  | 3                              |
| DRAWING/FILE No.   | SHEET                          |
| W-095112-062B      | 62B                            |



SECTION# 4

AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

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 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

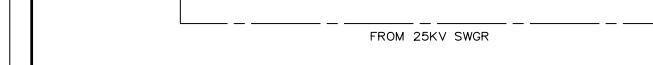
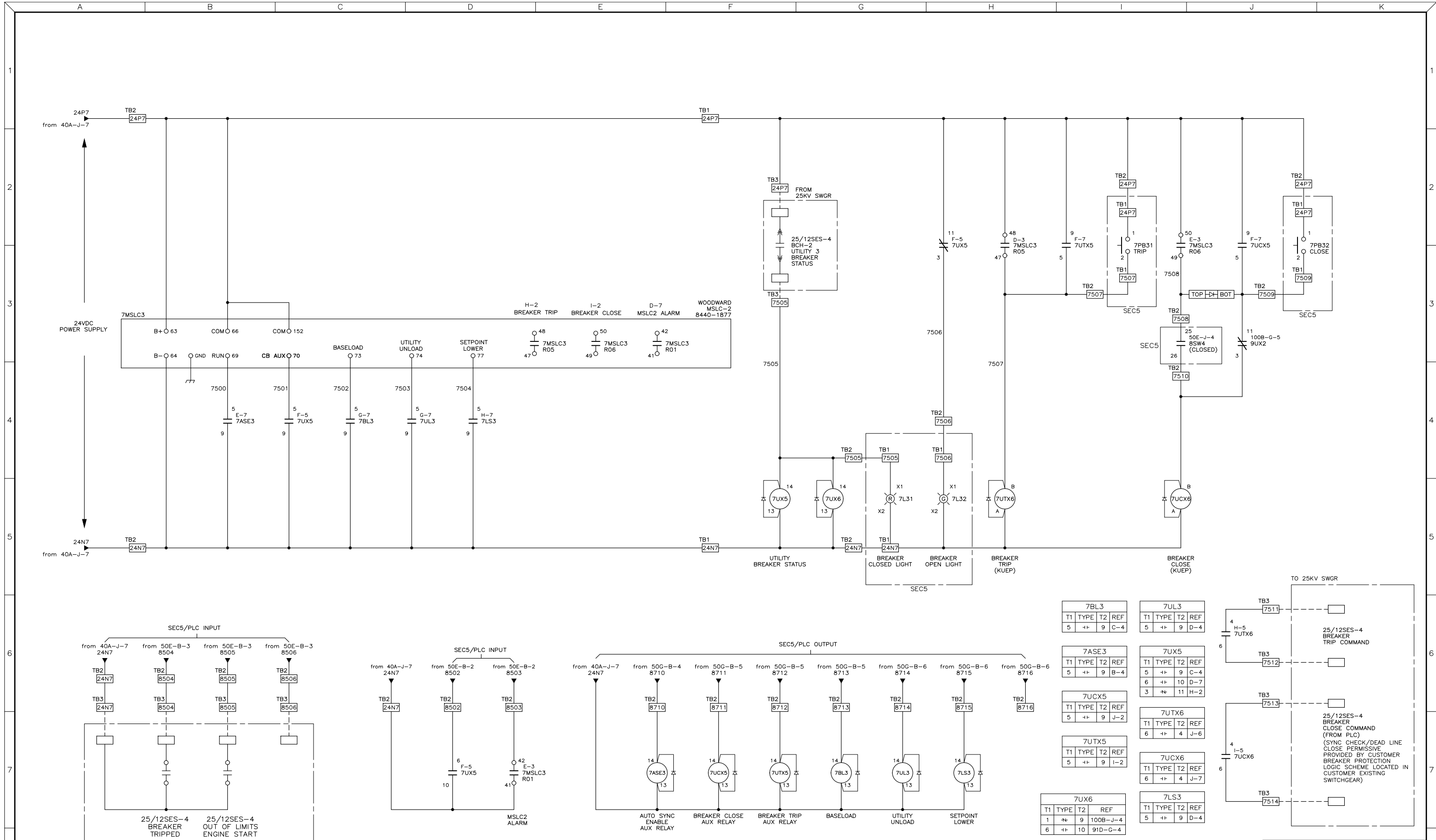
CROSS REFERENCE LEGEND  
 50C-C-1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 BCH-2 UTILITY 1 AC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |                            |
|---|----------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-063A       | SHEET<br>63A               |



| T1    | TYPE | T2 | REF   |
|-------|------|----|-------|
| 7BLS3 | 5    | +  | 9 C-4 |
| 7UL3  | 5    | +  | 9 D-4 |
| 7ASE3 | 5    | +  | 9 B-4 |
| 7UCX5 | 5    | +  | 9 J-2 |
| 7UTX5 | 5    | +  | 9 I-2 |
| 7UCX6 | 6    | +  | 4 J-6 |
| 7UTX6 | 6    | +  | 4 J-6 |
| 7UCX6 | 6    | +  | 4 J-7 |
| 7LS3  | 5    | +  | 9 D-4 |

SECTION# 4

AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

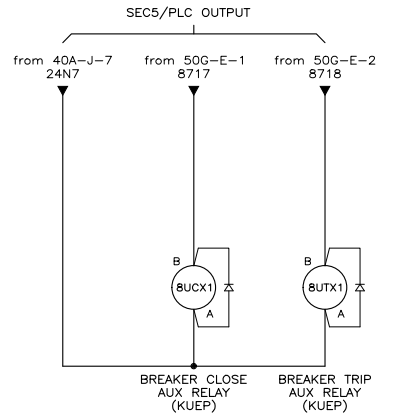
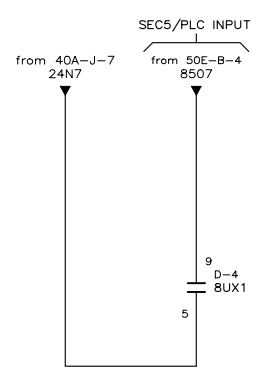
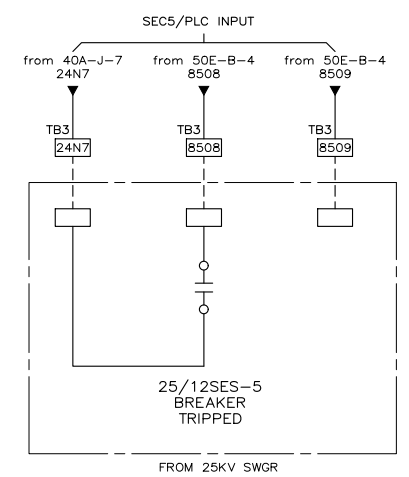
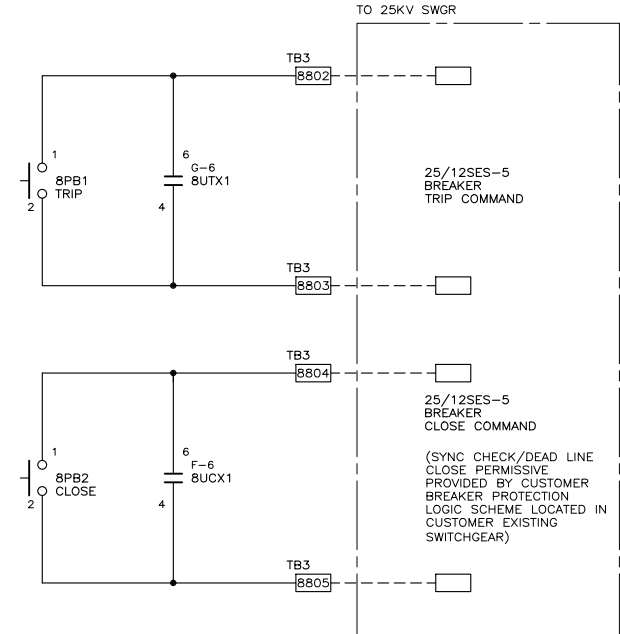
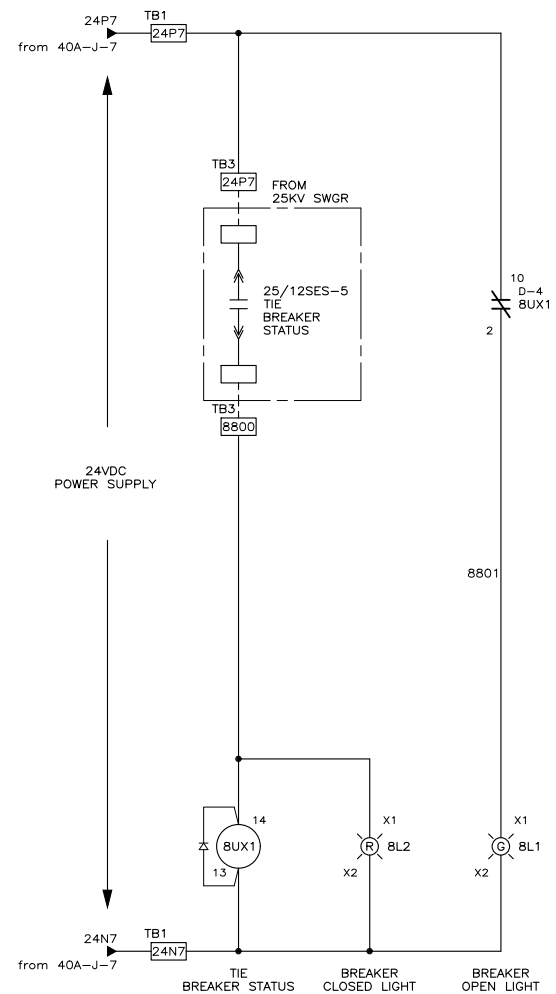
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 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

| CROSS REFERENCE LEGEND |                              |
|------------------------|------------------------------|
| 50C-C-1                | GRID COORDINATE              |
| _____                  | SHEET No. _____              |
| _____                  | DRAWING No. _____            |
| _____                  | REFERENCE DRAWINGS No. _____ |
| _____                  | REVISIONS BY/AUTH/DATE       |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 BCH-2 UTILITY 1 DC CONTROL SCHEMATIC  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
|---|-------------------------|
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-063B          | SHEET 63B               |



| 8UX1 |      |    |          |
|------|------|----|----------|
| T1   | TYPE | T2 | REF      |
| 5    | +    | 9  | E-6      |
| 2    | +    | 10 | E-2      |
| 7    | +    | 11 | 91D-H-4  |
| 8    | +    | 12 | 100B-D-4 |

| 8UCX1 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 6     | +    | 4  | G-4 |

| 8UTX1 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 6     | +    | 4  | G-3 |

SECTION# 5

AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

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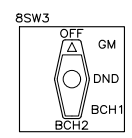
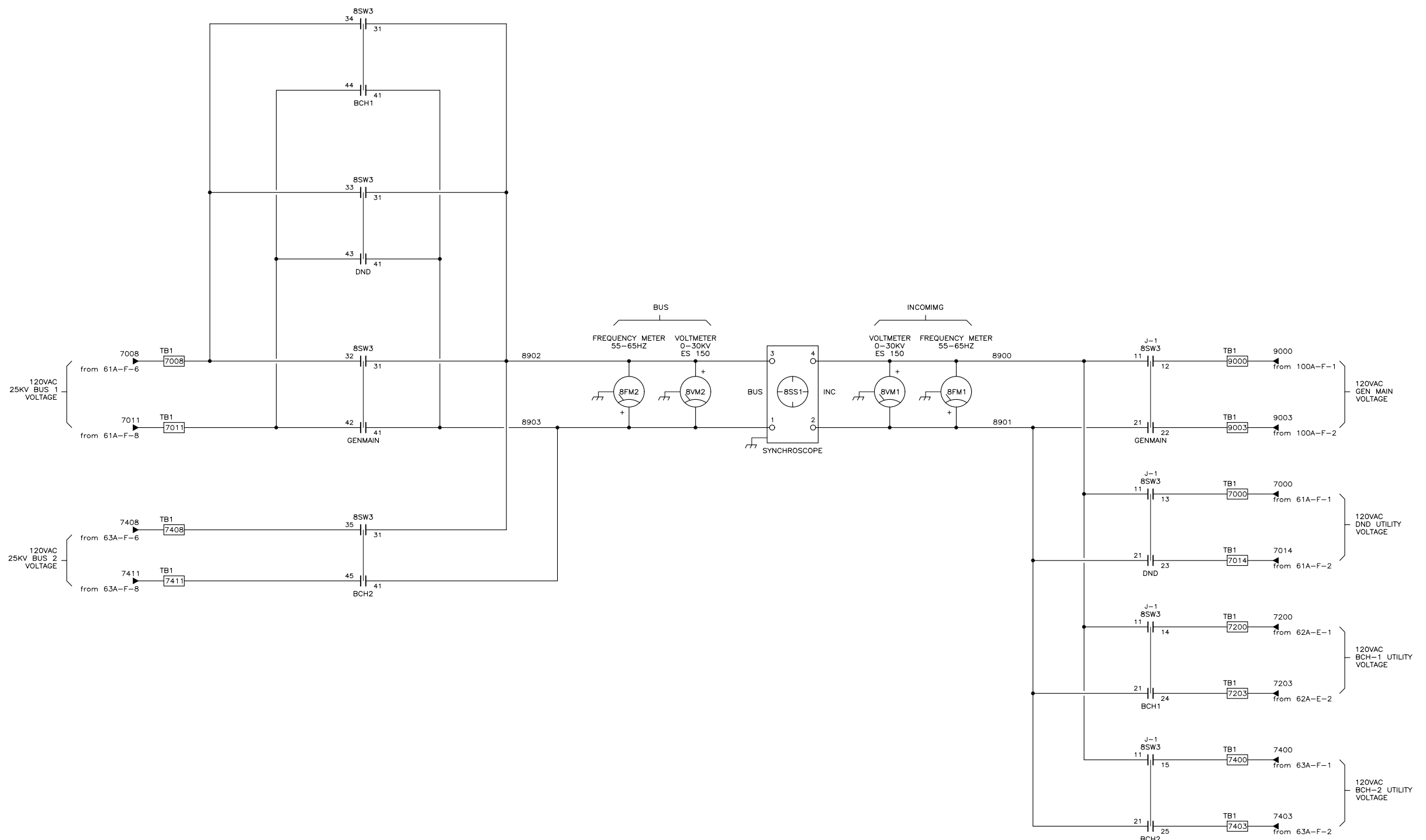
| CROSS REFERENCE LEGEND |                    |
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| 50C-C-1                | GRID COORDINATE    |
|                        | SHEET No.          |
| DRAWING No.            | REFERENCE DRAWINGS |
| No.                    | No.                |

| NO. | REVISIONS                      | BY | AUTH | DATE     |
|-----|--------------------------------|----|------|----------|
| 3   | AS BUILT                       | SD | SS   | 17-01-18 |
| 2   | CUSTOMER COMMENTS INCORPORATED | SD | SS   | 16-10-19 |
| 1   | ADDED SCHEMATIC DRAWINGS       | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 TIE BREAKER AC & DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
|---|----------------------------|
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-070A       | SHEET<br>70A               |



| 8SW3 |      |    |     |
|------|------|----|-----|
| T1   | TYPE | T2 | REF |
| 11   | +    | 12 | H-4 |
| 11   | +    | 13 | H-4 |
| 11   | +    | 14 | H-5 |
| 11   | +    | 15 | H-6 |
| 21   | +    | 22 | H-4 |
| 21   | +    | 23 | H-5 |
| 21   | +    | 24 | H-6 |
| 21   | +    | 25 | H-7 |
| 32   | +    | 31 | C-4 |
| 33   | +    | 31 | C-2 |
| 34   | +    | 31 | C-1 |
| 35   | +    | 31 | C-5 |
| 42   | +    | 41 | C-4 |
| 43   | +    | 41 | C-3 |
| 44   | +    | 41 | C-2 |
| 45   | +    | 41 | C-5 |

| DECK | CONTACTS |   |   |   |   |   |
|------|----------|---|---|---|---|---|
|      |          | 1 | 2 | 3 | 4 | 5 |
| 1    | 11-12    |   |   |   |   |   |
|      | 11-13    |   |   |   |   |   |
|      | 11-14    |   |   |   |   |   |
| 2    | 21-22    |   |   |   |   |   |
|      | 21-23    |   |   |   |   |   |
|      | 21-24    |   |   |   |   |   |
|      | 21-25    |   |   |   |   |   |
|      | 31-32    |   |   |   |   |   |
| 3    | 31-33    |   |   |   |   |   |
|      | 31-34    |   |   |   |   |   |
|      | 31-35    |   |   |   |   |   |
| 4    | 41-42    |   |   |   |   |   |
|      | 41-43    |   |   |   |   |   |
|      | 41-44    |   |   |   |   |   |
|      | 41-45    |   |   |   |   |   |
|      | 41-45    |   |   |   |   |   |

SECTION# 5

AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

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 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

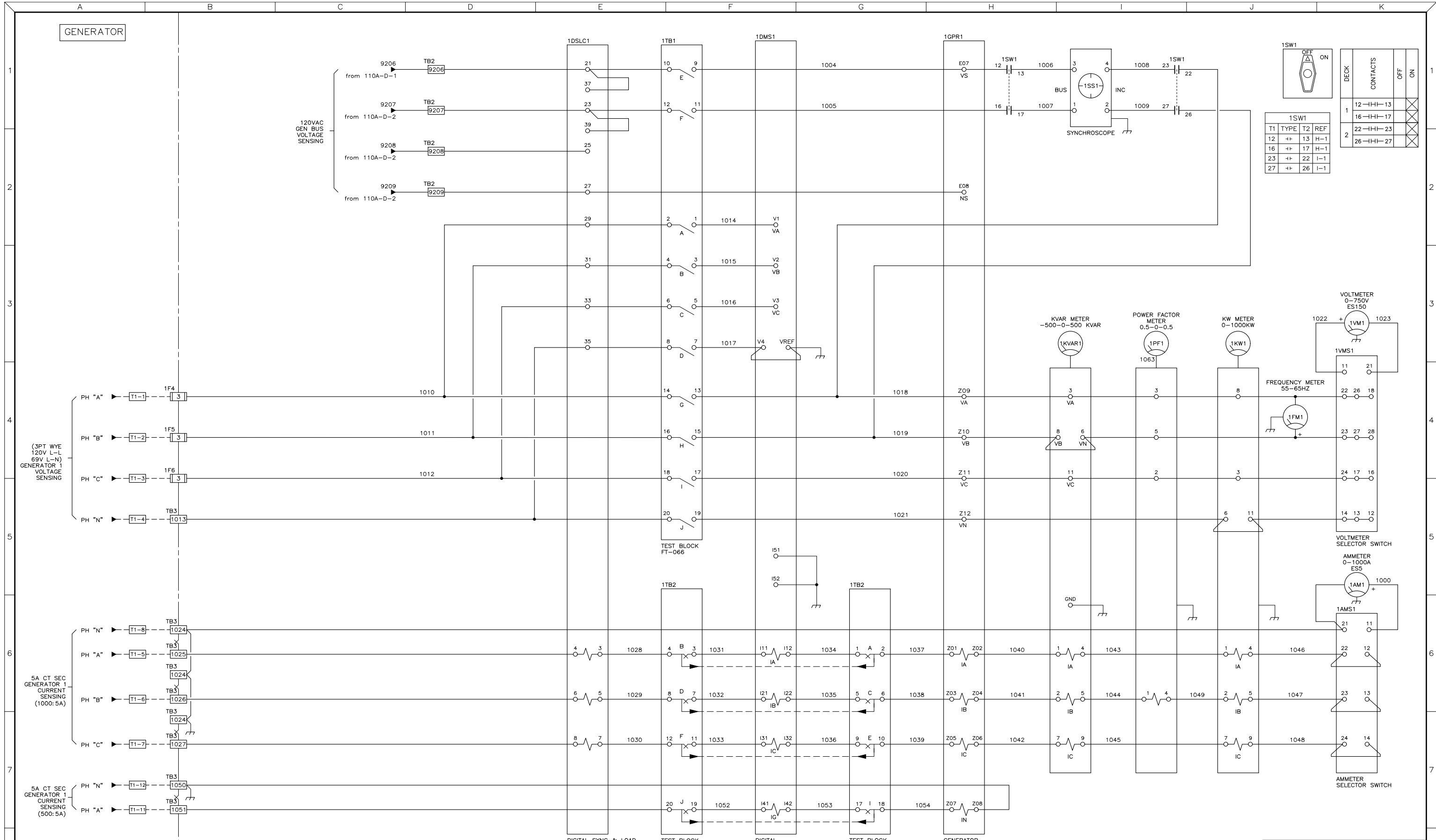
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 50C-C-1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 SYNC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                |
|---|----------------|
| CUSTOMER ORDER No.                      | WORK ORDER No. |
| C-054107                                | W-095112       |
| DRAWN BY SD                             | AUTH BY SS     |
| DATE 16-08-11                           | REV 3          |
| DRAWING/FILE No. W-095112-080A          | SHEET 80A      |



1SW1

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 12 | +H   | 13 | H-1 |
| 16 | +H   | 17 | H-1 |
| 23 | +H   | 22 | I-1 |
| 27 | +H   | 26 | I-1 |

| DECK | CONTACTS | OFF | ON |
|------|----------|-----|----|
| 1    | 12-HH-13 | X   |    |
| 1    | 16-HH-17 | X   |    |
| 2    | 22-HH-23 | X   |    |
| 2    | 26-HH-27 | X   |    |

SECTION# 1 AS BUILT

APPROVED FOR CONSTRUCTION  
 MASTER COPY  REFERENCE COPY OF \_\_\_\_\_ OF \_\_\_\_\_  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

| CROSS REFERENCE LEGEND |                                |    |    |          |
|------------------------|--------------------------------|----|----|----------|
| SOC-C-1                | GRID COORDINATE                |    |    |          |
| SHEET No.              | DRAWING No.                    |    |    |          |
| REFERENCE DRAWINGS     | No.                            |    |    |          |
| REVISIONS              |                                |    |    |          |
| 3                      | AS BUILT                       | SD | SS | 17-01-18 |
| 2                      | CUSTOMER COMMENTS INCORPORATED | SD | SS | 16-10-19 |
| 1                      | ADDED SCHEMATIC DRAWINGS       | SD | SS | 16-08-25 |

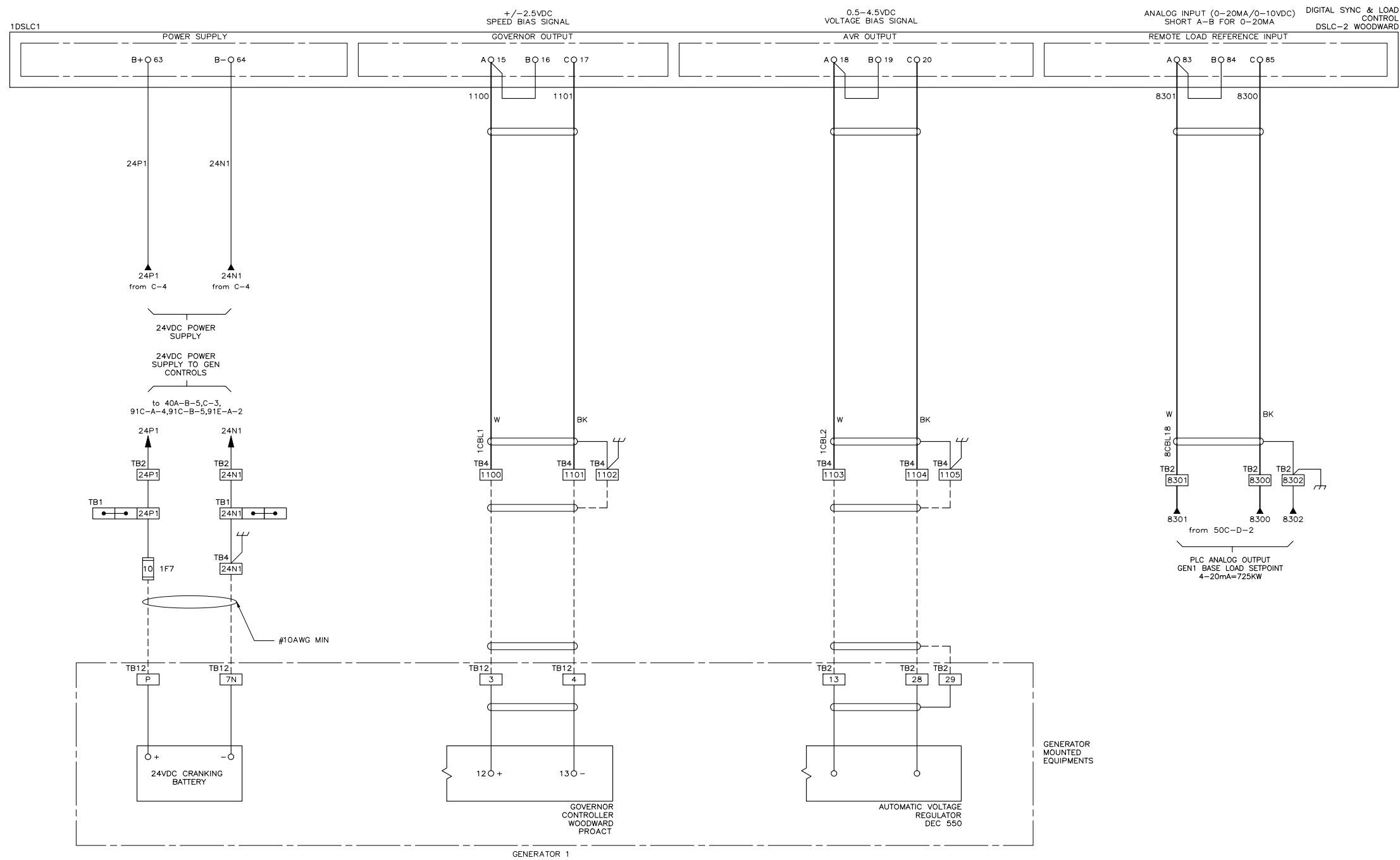


GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 1 AC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
|---|----------------------------|
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-091A       | SHEET<br>91A               |





SECTION# 1

AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

APPROVED FOR CONSTRUCTION  
 MASTER COPY     REFERENCE COPY \_\_\_\_\_ OF \_\_\_\_\_  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

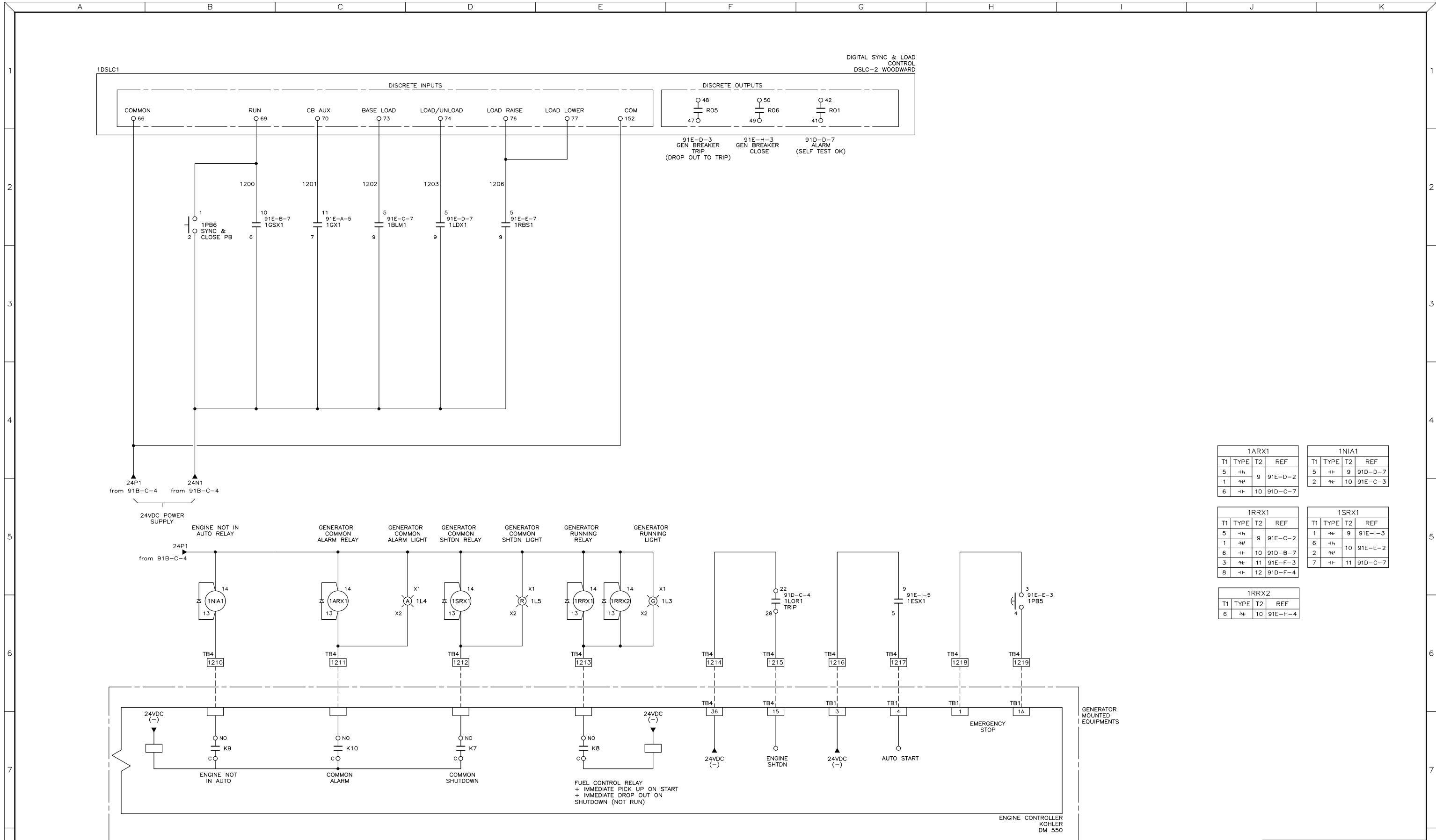
CROSS REFERENCE LEGEND  
 50C-C-1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 1 DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |                            |
|---|----------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-091B       | SHEET<br>91B               |



| 1ARX1 |      |    |         | 1NIA1 |      |    |         |
|-------|------|----|---------|-------|------|----|---------|
| T1    | TYPE | T2 | REF     | T1    | TYPE | T2 | REF     |
| 5     | +h   | 9  | 91E-D-2 | 5     | +h   | 9  | 91D-D-7 |
| 1     | +h   | 2  | 91E-C-3 | 2     | +h   | 10 | 91E-C-3 |
| 6     | +h   | 10 | 91D-C-7 |       |      |    |         |

| 1RRX1 |      |    |         | 1SRX1 |      |    |         |
|-------|------|----|---------|-------|------|----|---------|
| T1    | TYPE | T2 | REF     | T1    | TYPE | T2 | REF     |
| 5     | +h   | 9  | 91E-C-2 | 1     | +h   | 9  | 91E-I-3 |
| 1     | +h   | 6  | 91D-B-7 | 2     | +h   | 10 | 91E-E-2 |
| 6     | +h   | 10 | 91D-B-7 | 7     | +h   | 11 | 91D-C-7 |
| 3     | +h   | 11 | 91E-F-3 |       |      |    |         |
| 8     | +h   | 12 | 91D-F-4 |       |      |    |         |

| 1RRX2 |      |    |         |
|-------|------|----|---------|
| T1    | TYPE | T2 | REF     |
| 6     | +h   | 10 | 91E-H-4 |

SECTION#1 AS BUILT

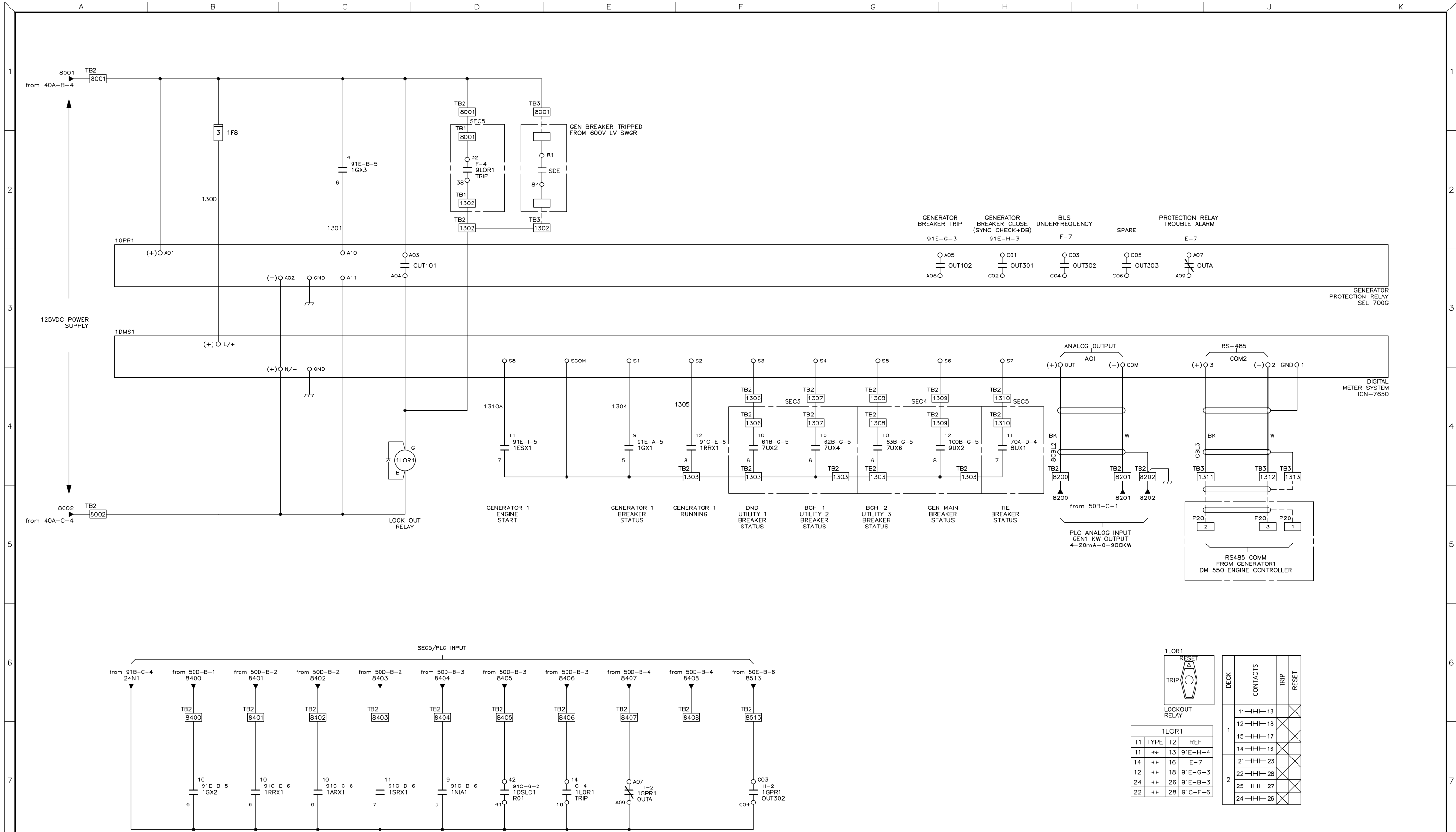
APPROVED FOR CONSTRUCTION  
 MASTER COPY  REFERENCE COPY OF \_\_\_\_\_  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

| CROSS REFERENCE LEGEND |                    |
|------------------------|--------------------|
| 50C-C-1                | GRID COORDINATE    |
|                        | SHEET No.          |
|                        | DRAWING No.        |
|                        | REFERENCE DRAWINGS |
|                        | No.                |
|                        | REVISIONS          |
|                        | BY/AUTH            |
|                        | DATE               |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 1 DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |               |                         |       |
|---|---------------|-------------------------|-------|
| DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE. |               |                         |       |
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP   |               | WORK ORDER No. W-095112 |       |
| CUSTOMER ORDER No. C-054107   | AUTH BY SS    | DATE 16-08-11           | REV 3 |
| DRAWN BY SD   | DATE 16-08-25 | SHEET 3                 |       |
| DRAWING/FILE No. W-095112-091C  |               | 91C                     |       |



SECTION# 1

AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

APPROVED FOR CONSTRUCTION  
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 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

CROSS REFERENCE LEGEND  
 50C-C-1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

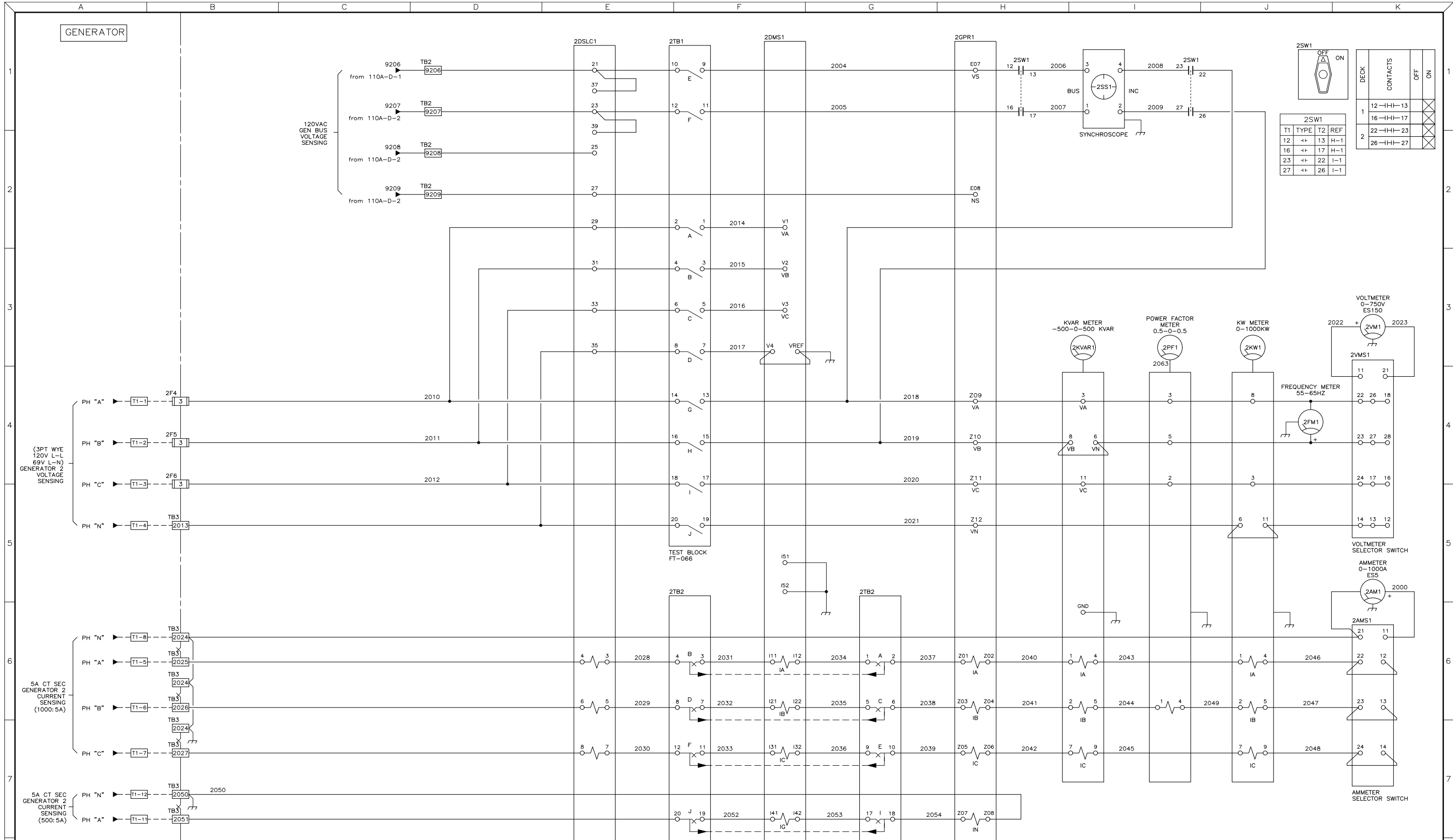
| NO. | REVISIONS                      | BY | AUTH | DATE     |
|-----|--------------------------------|----|------|----------|
| 3   | AS BUILT                       | SD | SS   | 17-01-18 |
| 2   | CUSTOMER COMMENTS INCORPORATED | SD | SS   | 16-10-19 |
| 1   | ADDED SCHEMATIC DRAWINGS       | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 1 DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |                         |
|---|-------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-091D          | SHEET 91D               |





2SW1

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 12 | +H   | 13 | H-1 |
| 16 | +H   | 17 | H-1 |
| 23 | +H   | 22 | I-1 |
| 27 | +H   | 26 | I-1 |

| DECK | CONTACTS | OFF | ON |
|------|----------|-----|----|
| 1    | 12-HH-13 | X   |    |
| 1    | 16-HH-17 | X   |    |
| 2    | 22-HH-23 | X   |    |
| 2    | 26-HH-27 | X   |    |

SECTION# 2 AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

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 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

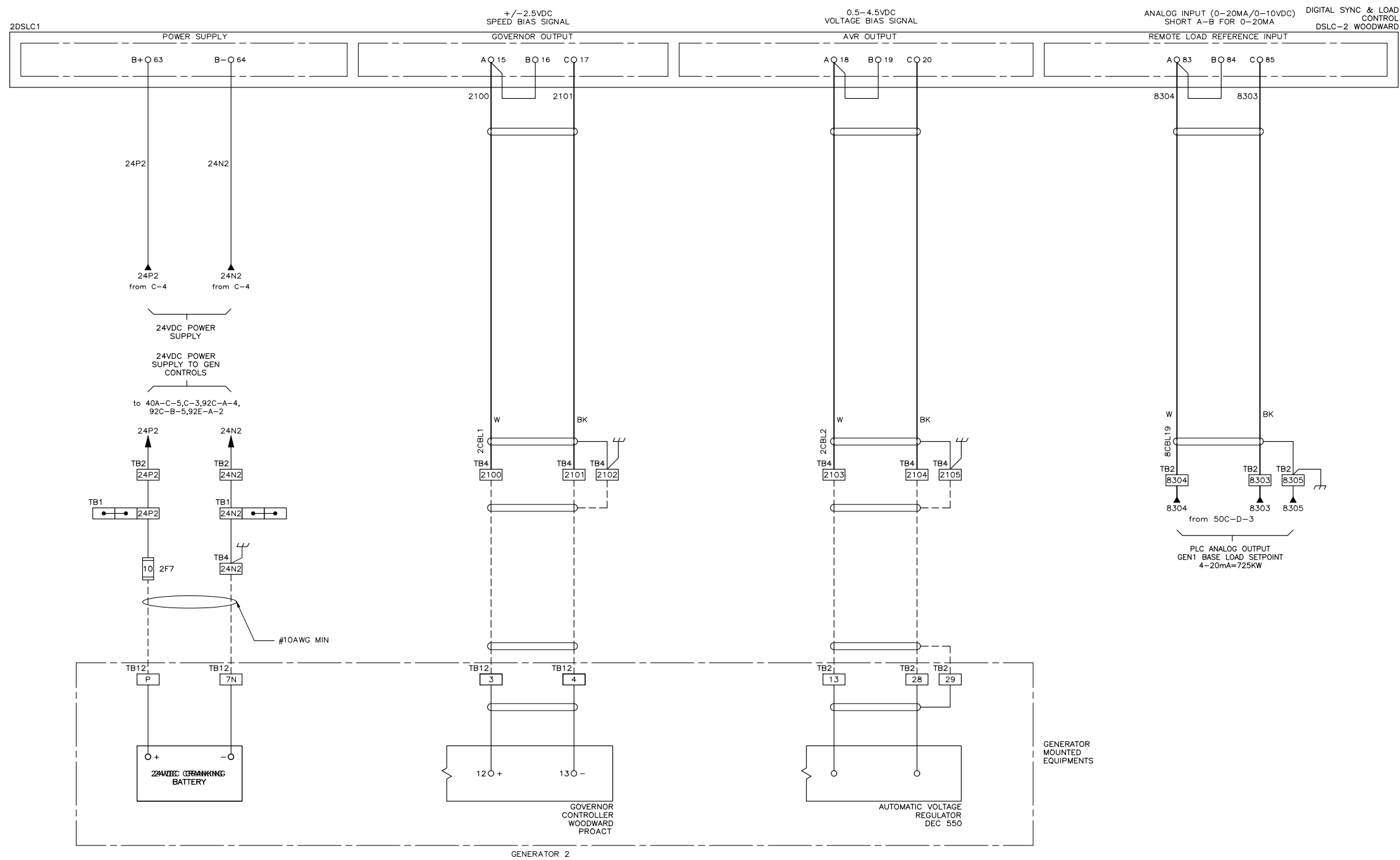
CROSS REFERENCE LEGEND  
 50C-C-1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 2 AC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                |
|---|----------------|
| CUSTOMER ORDER No.                      | WORK ORDER No. |
| C-054107                                | W-095112       |
| DRAWN BY                                | DATE           |
| SD                                      | 16-08-11       |
| AUTH BY                                 | DATE           |
| SS                                      | 16-08-11       |
| REV                                     | SHEET          |
| 3                                       | 3              |
| DRAWING/FILE No.                        | SHEET          |
| W-095112-092A                           | 92A            |



SECTION# 2

AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

APPROVED FOR CONSTRUCTION  
 MASTER COPY  REFERENCE COPY OF \_\_\_\_\_  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

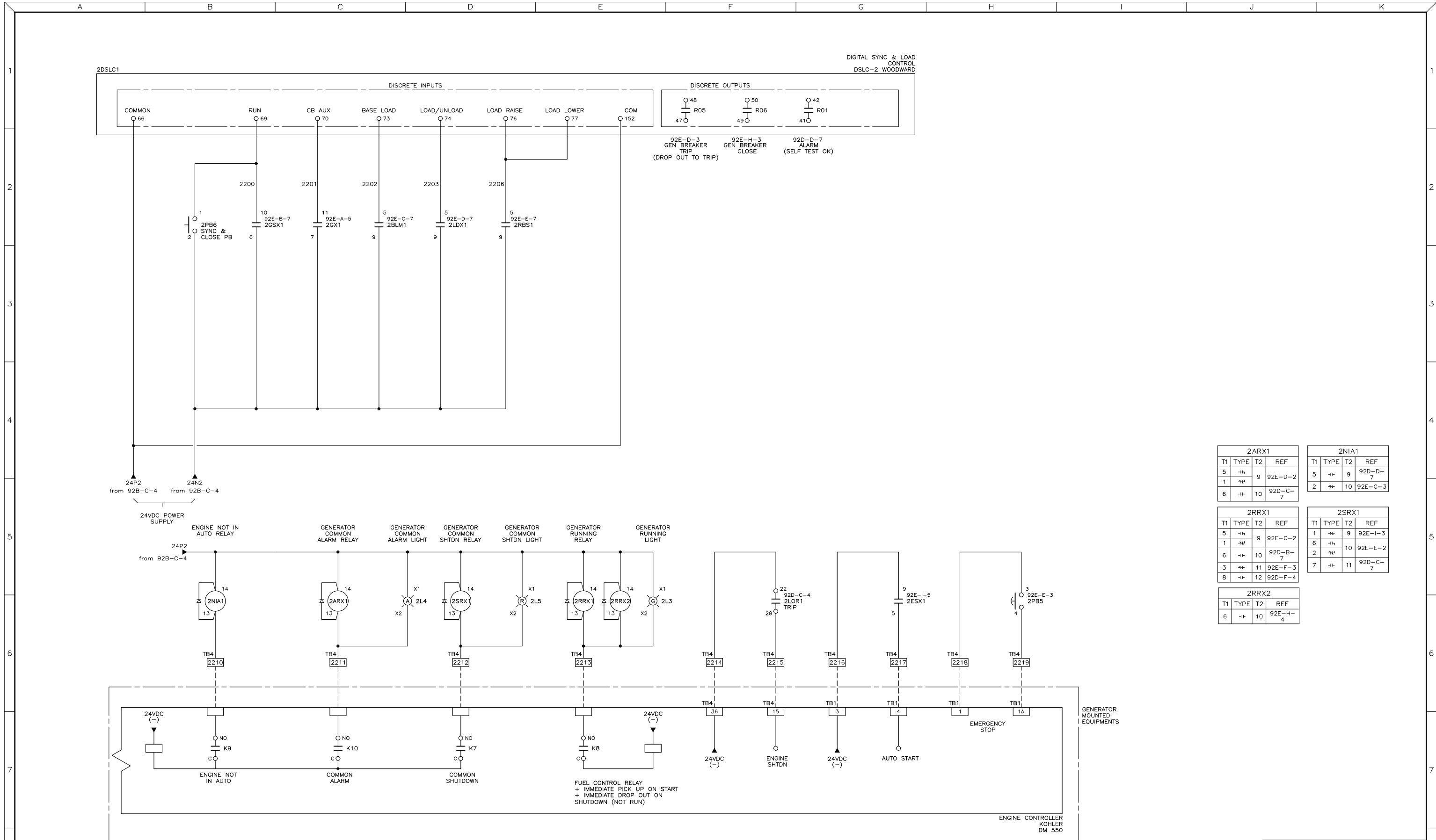
| CROSS REFERENCE LEGEND |                 |
|------------------------|-----------------|
| 50C-C-1                | GRID COORDINATE |
|                        | SHEET No.       |

| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 2 DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
|---|----------------------------|
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-092B       | SHEET<br>92B               |



| 2ARRX1 |      |    |         | 2NIA1 |      |    |         |
|--------|------|----|---------|-------|------|----|---------|
| T1     | TYPE | T2 | REF     | T1    | TYPE | T2 | REF     |
| 5      | +h   | 9  | 92E-D-2 | 5     | +h   | 9  | 92D-D-7 |
| 1      | +h   | 10 | 92D-C-7 | 2     | +h   | 10 | 92E-C-3 |
| 6      | +h   | 10 | 92D-C-7 |       |      |    |         |

| 2RRX1 |      |    |         | 2SRX1 |      |    |         |
|-------|------|----|---------|-------|------|----|---------|
| T1    | TYPE | T2 | REF     | T1    | TYPE | T2 | REF     |
| 5     | +h   | 9  | 92E-C-2 | 1     | +h   | 9  | 92E-I-3 |
| 1     | +h   | 10 | 92D-B-7 | 6     | +h   | 10 | 92E-E-2 |
| 6     | +h   | 10 | 92D-F-3 | 2     | +h   | 11 | 92D-C-7 |
| 3     | +h   | 12 | 92D-F-4 | 7     | +h   | 11 | 92D-C-7 |
| 8     | +h   | 12 | 92D-F-4 |       |      |    |         |

| 2RRX2 |      |    |         |
|-------|------|----|---------|
| T1    | TYPE | T2 | REF     |
| 6     | +h   | 10 | 92E-H-4 |

SECTION# 2

AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

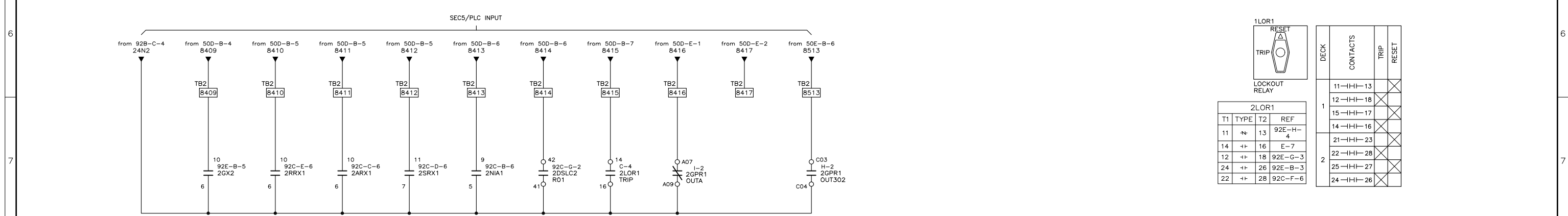
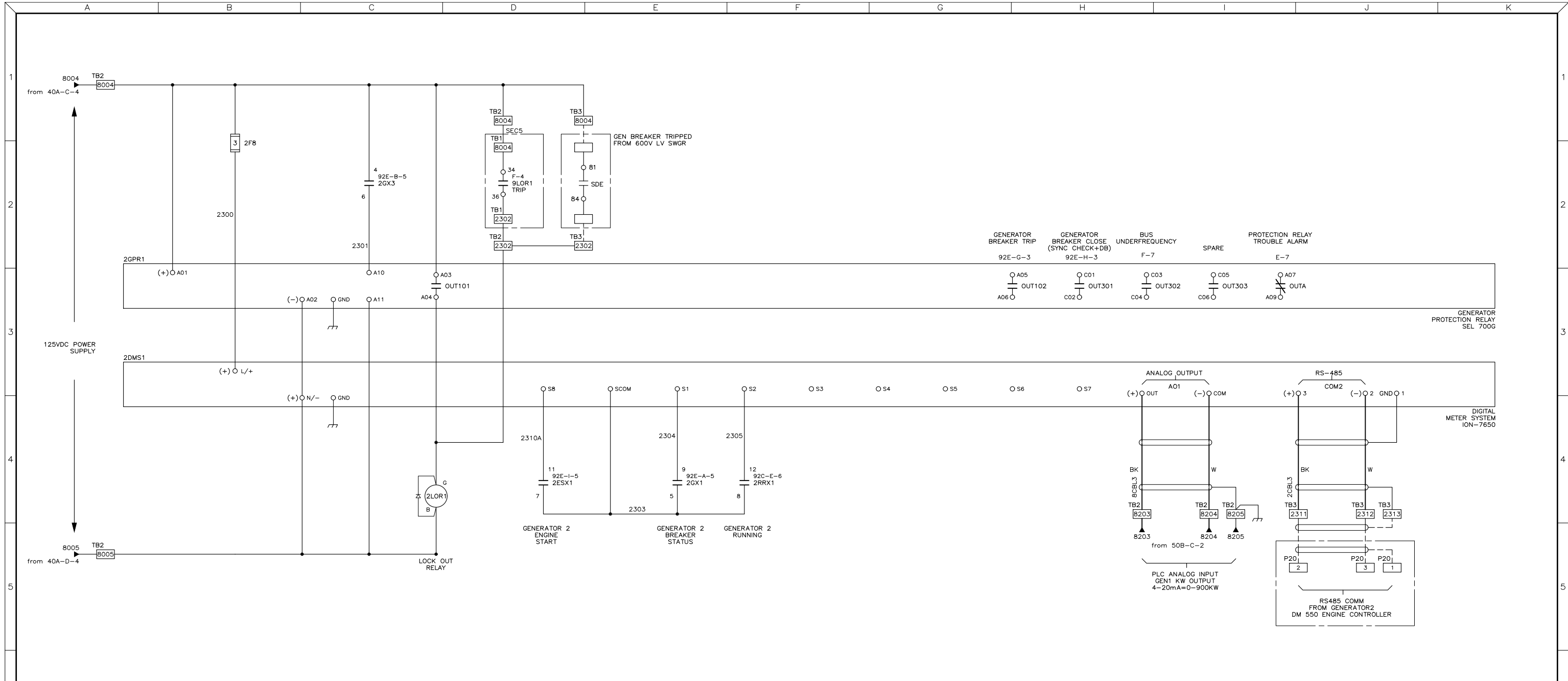
APPROVED FOR CONSTRUCTION  
 MASTER COPY  REFERENCE COPY OF \_\_\_\_\_  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

| CROSS REFERENCE LEGEND |                    |
|------------------------|--------------------|
| 50C-C-1                | GRID COORDINATE    |
|                        | SHEET No.          |
|                        | DRAWING No.        |
|                        | REFERENCE DRAWINGS |
|                        | No.                |
|                        | REVISIONS          |
|                        | BY/AUTH            |
|                        | DATE               |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 2 DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
|---|-------------------------|
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-092C          | SHEET 92C               |



1LOR1  
RESET  
TRIP  
LOCKOUT RELAY

| DECK | CONTACTS | TRIP | RESET |
|------|----------|------|-------|
| 1    | 11-1H-13 |      |       |
|      | 12-1H-18 |      |       |
|      | 15-1H-17 |      |       |
|      | 14-1H-16 |      |       |
| 2    | 21-1H-23 |      |       |
|      | 22-1H-28 |      |       |
|      | 25-1H-27 |      |       |
|      | 24-1H-26 |      |       |

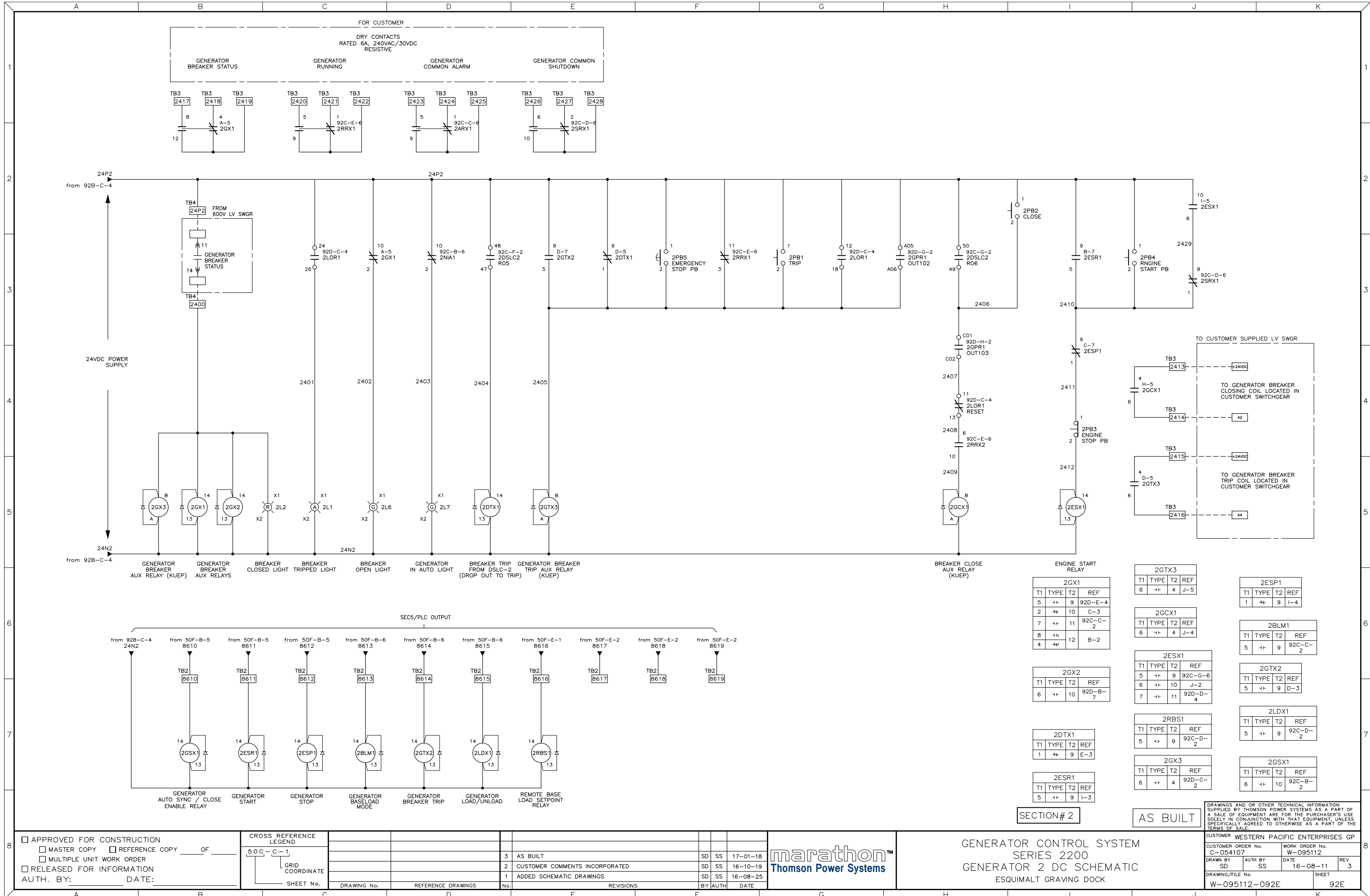
  

| T1 | TYPE | T2 | REF     |
|----|------|----|---------|
| 11 | +    | 13 | 92E-H-4 |
| 14 | +    | 16 | E-7     |
| 12 | +    | 18 | 92E-G-3 |
| 24 | +    | 26 | 92E-B-3 |
| 22 | +    | 28 | 92C-F-6 |

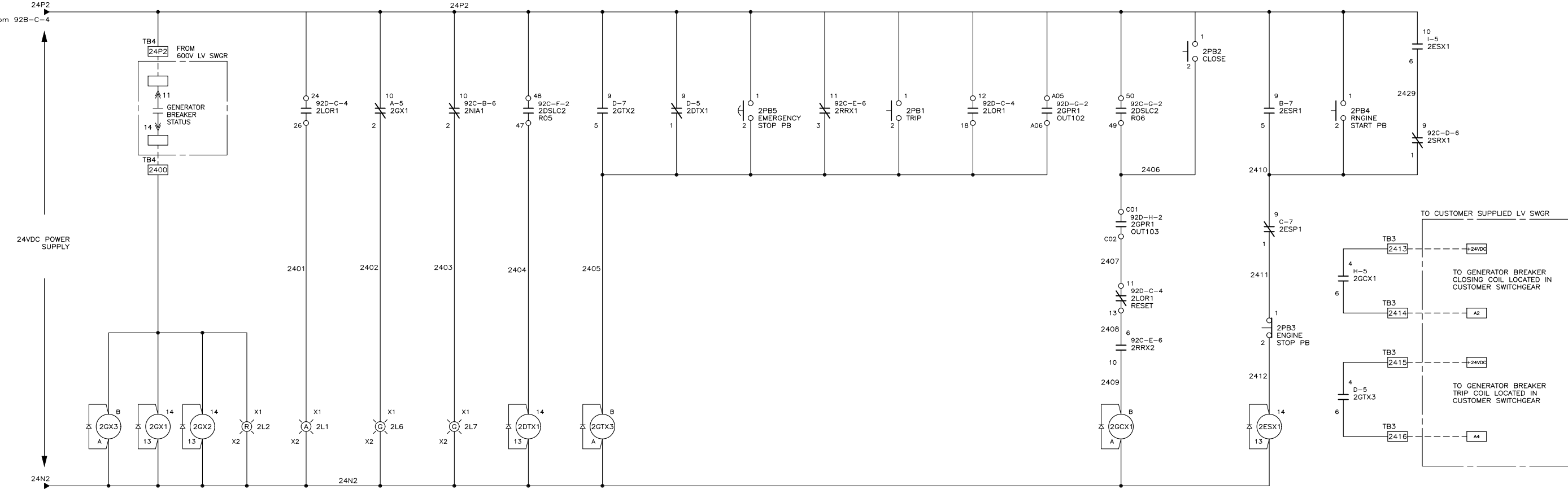
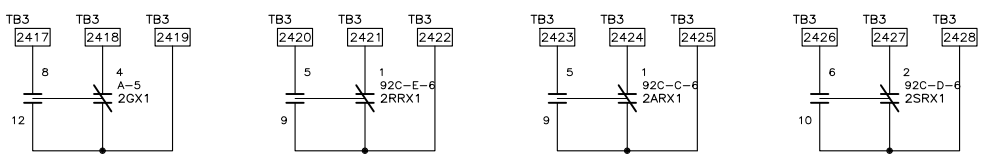
SECTION# 2 AS BUILT

| <input type="checkbox"/> APPROVED FOR CONSTRUCTION<br><input type="checkbox"/> MASTER COPY <input type="checkbox"/> REFERENCE COPY OF _____<br><input type="checkbox"/> MULTIPLE UNIT WORK ORDER<br><input type="checkbox"/> RELEASED FOR INFORMATION<br>AUTH. BY: _____ DATE: _____ | CROSS REFERENCE LEGEND<br>50C-C-1<br>GRID COORDINATE<br>SHEET No. _____ | <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <th>No.</th> <th>REVISIONS</th> <th>BY</th> <th>AUTH</th> <th>DATE</th> </tr> <tr> <td>3</td> <td>AS BUILT</td> <td>SD</td> <td>SS</td> <td>17-01-18</td> </tr> <tr> <td>2</td> <td>CUSTOMER COMMENTS INCORPORATED</td> <td>SD</td> <td>SS</td> <td>16-10-19</td> </tr> <tr> <td>1</td> <td>ADDED SCHEMATIC DRAWINGS</td> <td>SD</td> <td>SS</td> <td>16-08-25</td> </tr> </table> | No.  | REVISIONS | BY | AUTH | DATE | 3 | AS BUILT | SD | SS | 17-01-18 | 2 | CUSTOMER COMMENTS INCORPORATED | SD | SS | 16-10-19 | 1 | ADDED SCHEMATIC DRAWINGS | SD | SS | 16-08-25 |  | GENERATOR CONTROL SYSTEM<br>SERIES 2200<br>GENERATOR 2 DC SCHEMATIC<br>ESQUIMALT GRAVING DOCK | DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.<br>CUSTOMER WESTERN PACIFIC ENTERPRISES GP<br>CUSTOMER ORDER No. C-054107    WORK ORDER No. W-095112<br>DRAWN BY SD    AUTH BY SS    DATE 16-08-11    REV 3<br>DRAWING/FILE No. W-095112-092D    SHEET 92D |
|--|---|---|------|-----------|----|------|------|---|----------|----|----|----------|---|--------------------------------|----|----|----------|---|--------------------------|----|----|----------|--|---|--|
| No.  | REVISIONS   | BY  | AUTH | DATE      |    |      |      |   |          |    |    |          |   |                                |    |    |          |   |                          |    |    |          |  |   |  |
| 3  | AS BUILT  | SD  | SS   | 17-01-18  |    |      |      |   |          |    |    |          |   |                                |    |    |          |   |                          |    |    |          |  |   |  |
| 2  | CUSTOMER COMMENTS INCORPORATED  | SD  | SS   | 16-10-19  |    |      |      |   |          |    |    |          |   |                                |    |    |          |   |                          |    |    |          |  |   |  |
| 1  | ADDED SCHEMATIC DRAWINGS  | SD  | SS   | 16-08-25  |    |      |      |   |          |    |    |          |   |                                |    |    |          |   |                          |    |    |          |  |   |  |





FOR CUSTOMER  
 DRY CONTACTS  
 RATED 6A, 240VAC/30VDC  
 RESISTIVE



GENERATOR BREAKER AUX RELAY (KUEP)

GENERATOR BREAKER AUX RELAYS

BREAKER CLOSED LIGHT

BREAKER TRIPPED LIGHT

BREAKER OPEN LIGHT

GENERATOR IN AUTO LIGHT

BREAKER TRIP FROM DSLC-2 (DROP OUT TO TRIP)

GENERATOR BREAKER TRIP AUX RELAY (KUEP)

BREAKER CLOSE AUX RELAY (KUEP)

ENGINE START RELAY

| 2GX1 |      |    |         |
|------|------|----|---------|
| T1   | TYPE | T2 | REF     |
| 5    | +    | 9  | 92D-E-4 |
| 2    | +    | 10 | C-3     |
| 7    | +    | 11 | 92C-C-2 |
| 8    | +    | 12 | B-2     |
| 4    | +    | 13 | B-2     |

| 2GTX3 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 6     | +    | 4  | J-5 |

| 2ESP1 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 1     | +    | 9  | I-4 |

| 2GCX1 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 6     | +    | 4  | J-4 |

| 2BLM1 |      |    |         |
|-------|------|----|---------|
| T1    | TYPE | T2 | REF     |
| 5     | +    | 9  | 92C-C-2 |

| 2GX2 |      |    |         |
|------|------|----|---------|
| T1   | TYPE | T2 | REF     |
| 6    | +    | 10 | 92D-B-7 |

| 2ESX1 |      |    |         |
|-------|------|----|---------|
| T1    | TYPE | T2 | REF     |
| 5     | +    | 9  | 92C-G-6 |
| 6     | +    | 10 | J-2     |
| 7     | +    | 11 | 92D-D-4 |

| 2GTX2 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 5     | +    | 9  | D-3 |

| 2DTX1 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 1     | +    | 9  | E-3 |

| 2RBS1 |      |    |         |
|-------|------|----|---------|
| T1    | TYPE | T2 | REF     |
| 5     | +    | 9  | 92C-D-2 |

| 2LX1 |      |    |         |
|------|------|----|---------|
| T1   | TYPE | T2 | REF     |
| 5    | +    | 9  | 92C-D-2 |

| 2ESR1 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 5     | +    | 9  | I-3 |

| 2GX3 |      |    |         |
|------|------|----|---------|
| T1   | TYPE | T2 | REF     |
| 6    | +    | 4  | 92C-C-2 |

| 2GSX1 |      |    |         |
|-------|------|----|---------|
| T1    | TYPE | T2 | REF     |
| 6     | +    | 10 | 92C-B-2 |

SECTION# 2

AS BUILT

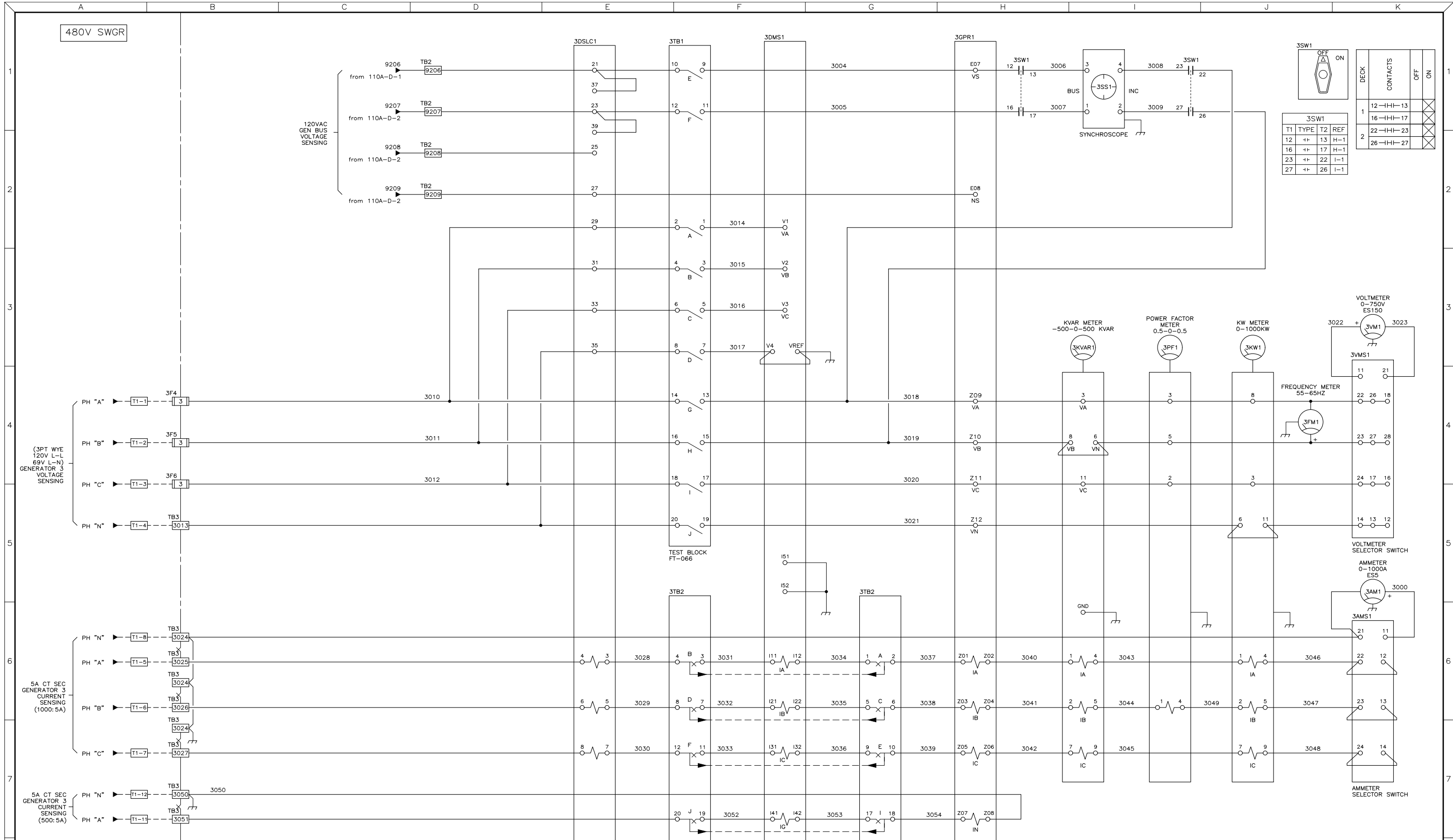
APPROVED FOR CONSTRUCTION  
 MASTER COPY  REFERENCE COPY OF \_\_\_\_\_  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

| CROSS REFERENCE LEGEND |                    |
|------------------------|--------------------|
| 50C-C-1                | GRID COORDINATE    |
| _____                  | SHEET No.          |
| _____                  | DRAWING No.        |
| _____                  | REFERENCE DRAWINGS |
| _____                  | No.                |
| _____                  | REVISIONS          |
| _____                  | BY/AUTH            |
| _____                  | DATE               |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 2 DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
|---|-------------------------|
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-092E          | SHEET 92E               |



3SW1

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 12 | +    | 13 | H-1 |
| 16 | +    | 17 | H-1 |
| 23 | +    | 22 | I-1 |
| 27 | +    | 26 | I-1 |

| DECK | CONTACTS | OFF | ON |
|------|----------|-----|----|
| 1    | 12-HH-13 |     |    |
| 1    | 16-HH-17 |     |    |
| 2    | 22-HH-23 |     |    |
| 2    | 26-HH-27 |     |    |

SECTION# 3

AS BUILT

APPROVED FOR CONSTRUCTION  
 MASTER COPY  REFERENCE COPY OF \_\_\_\_\_ OF \_\_\_\_\_  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

CROSS REFERENCE LEGEND  
 50C-C-1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

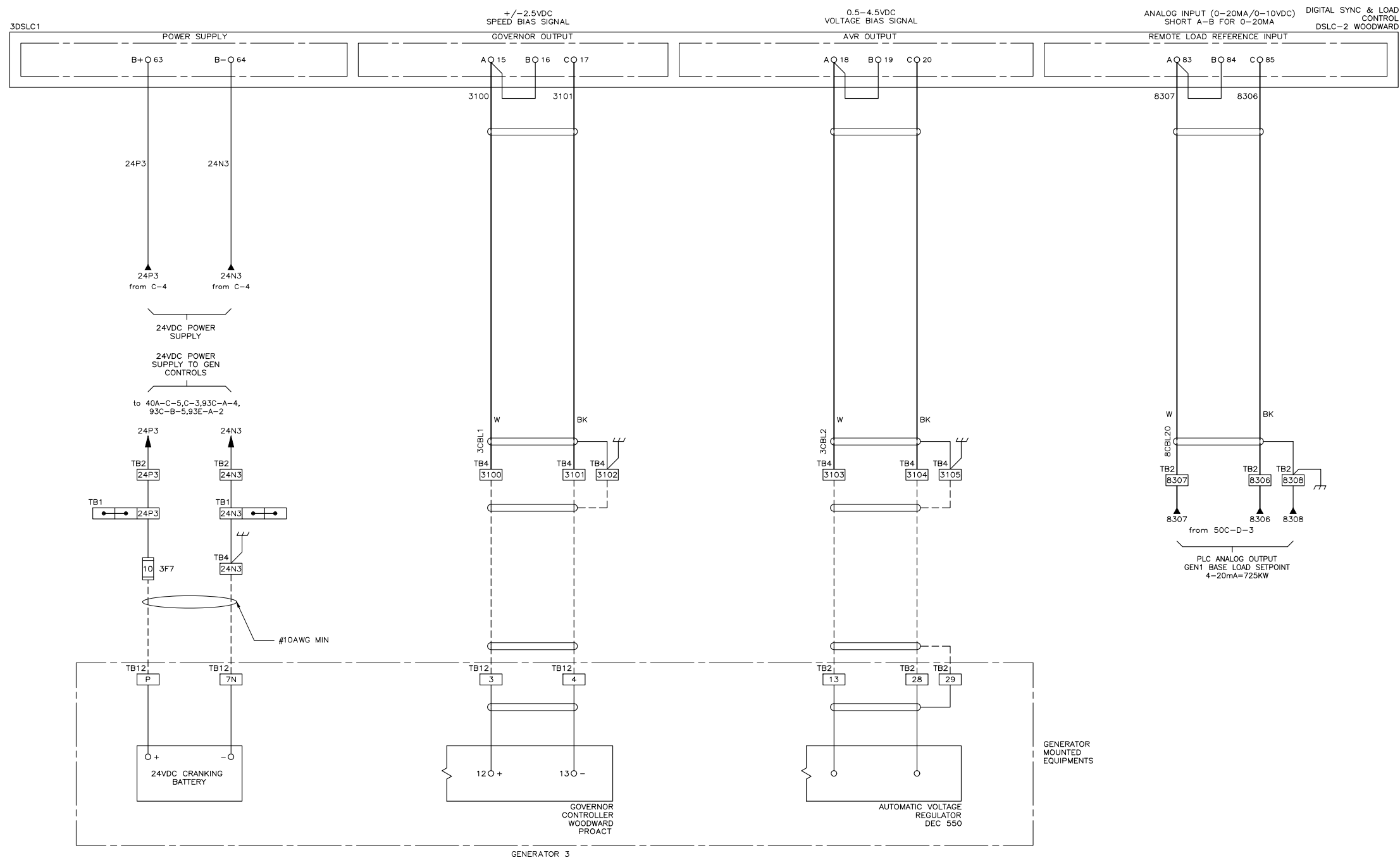
| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 3 AC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                |
|---|----------------|
| CUSTOMER ORDER No.                      | WORK ORDER No. |
| C-054107                                | W-095112       |
| DRAWN BY                                | DATE           |
| SD                                      | 16-08-11       |
| AUTH BY                                 | DATE           |
| SS                                      | 16-08-11       |
| REV                                     | SHEET          |
| 3                                       | 3              |
| DRAWING/FILE No.                        | SHEET          |
| W-095112-093A                           | 93A            |



SECTION# 3

AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

APPROVED FOR CONSTRUCTION  
 MASTER COPY  REFERENCE COPY OF \_\_\_\_\_  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

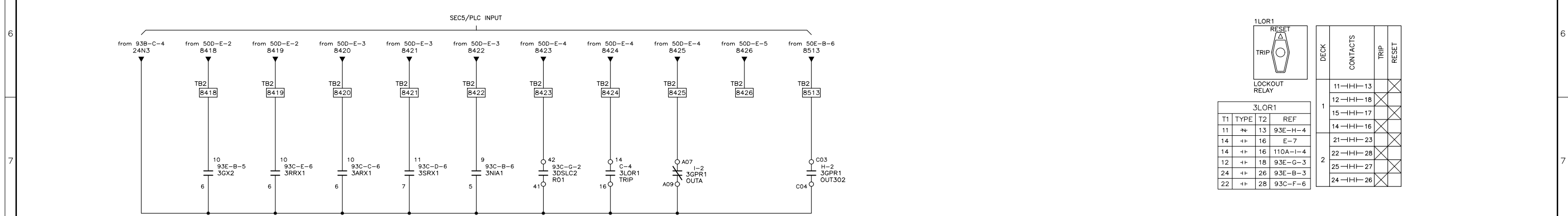
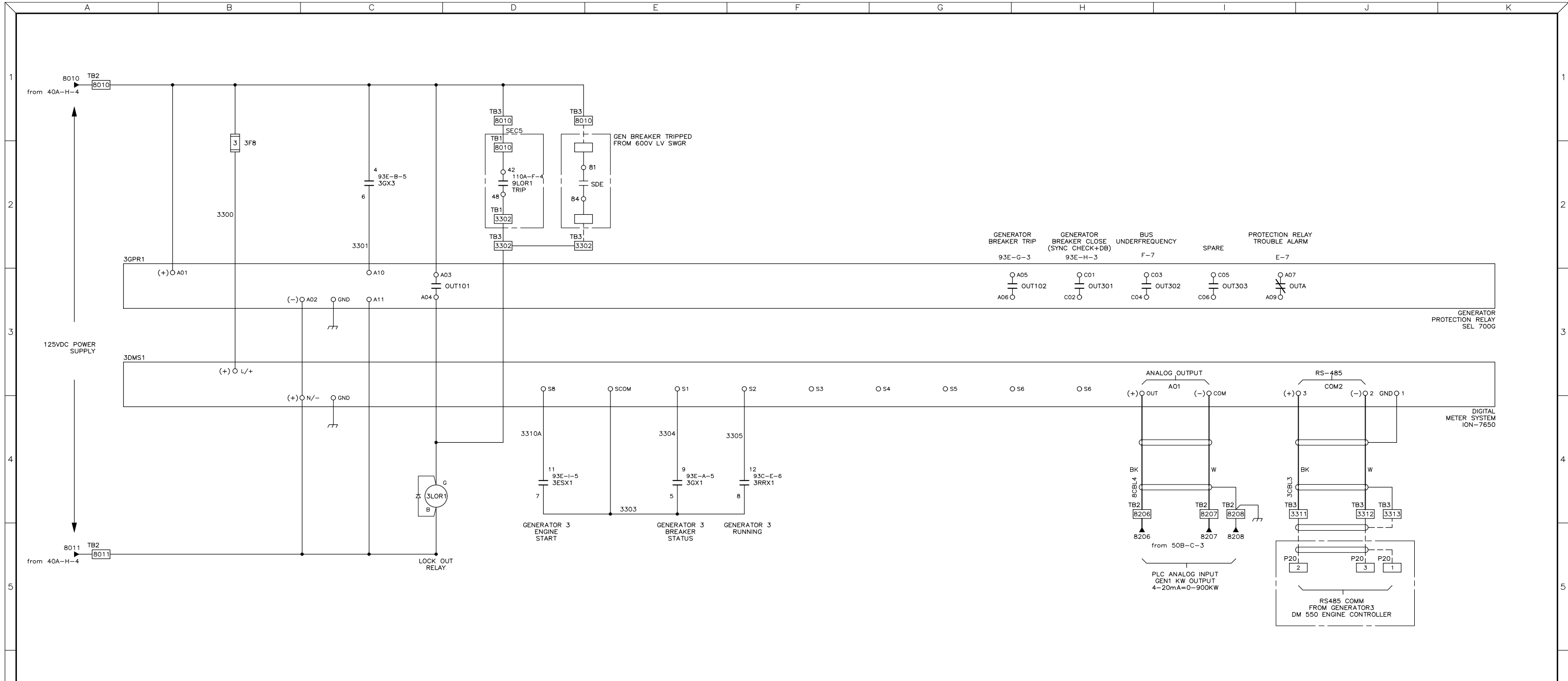
| CROSS REFERENCE LEGEND |                 | REVISIONS |                                |
|------------------------|-----------------|-----------|--------------------------------|
| 50C-C-1                | GRID COORDINATE | 3         | AS BUILT                       |
|                        | SHEET No.       | 2         | CUSTOMER COMMENTS INCORPORATED |
|                        | DRAWING No.     | 1         | ADDED SCHEMATIC DRAWINGS       |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 3 DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |                         |
|---|-------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-093B          | SHEET 93B               |





1LOR1  
RESET  
TRIP  
LOCKOUT RELAY

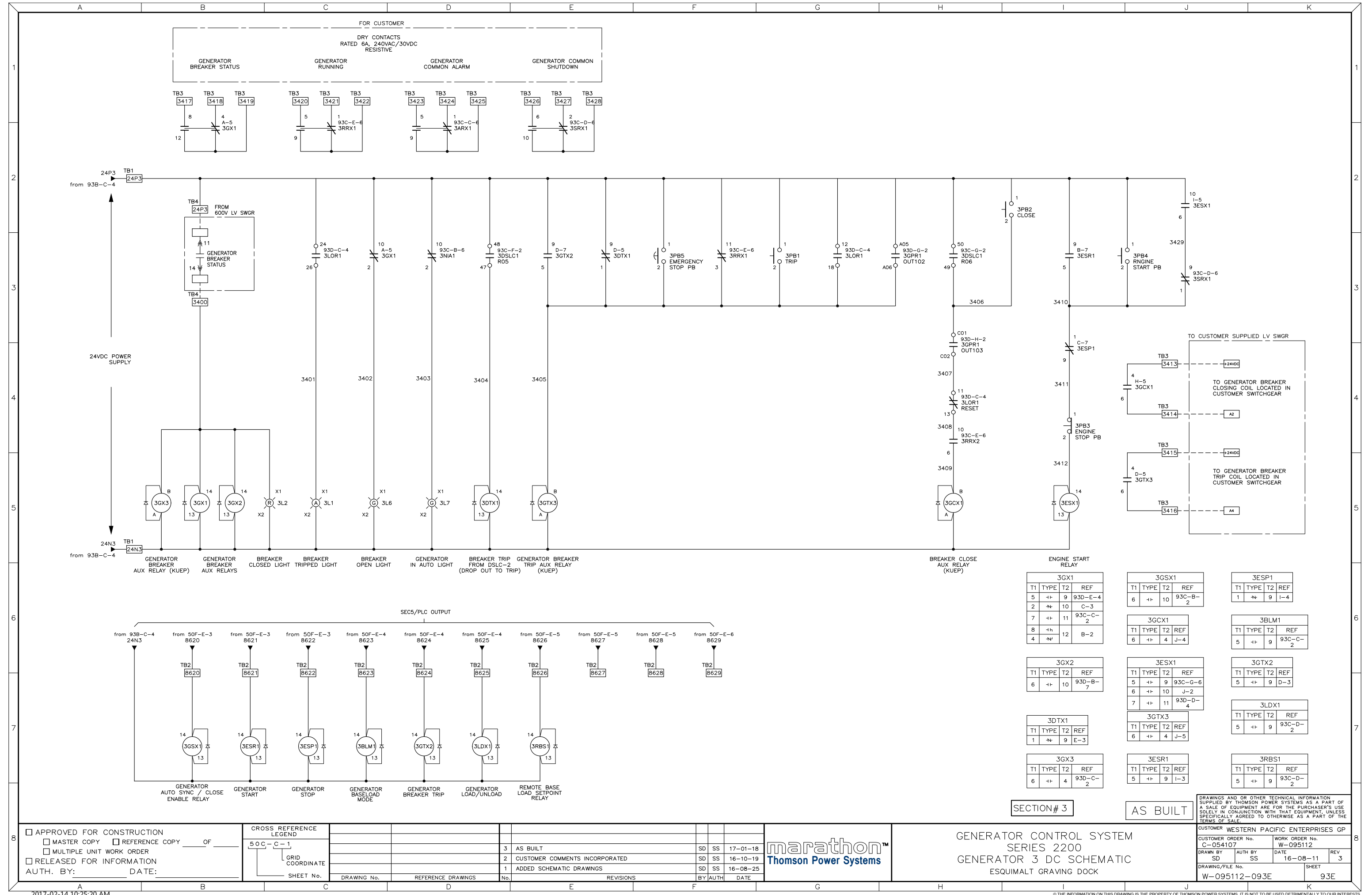
| DECK | CONTACTS | TRIP | RESET |
|------|----------|------|-------|
| 1    | 11-HI-13 |      |       |
|      | 12-HI-18 |      |       |
|      | 15-HI-17 |      |       |
|      | 14-HI-16 |      |       |
| 2    | 21-HI-23 |      |       |
|      | 22-HI-28 |      |       |
|      | 25-HI-27 |      |       |
|      | 24-HI-26 |      |       |

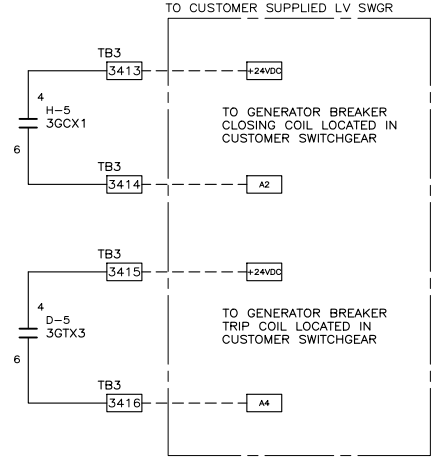
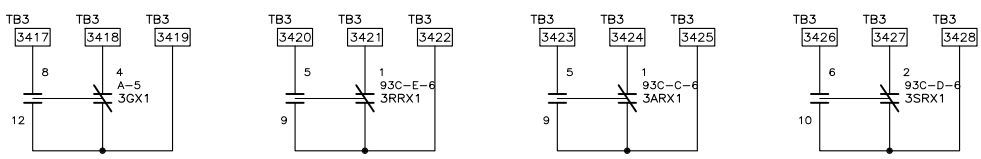
| T1 | TYPE | T2 | REF      |
|----|------|----|----------|
| 11 | +    | 13 | 93E-H-4  |
| 14 | +    | 16 | E-7      |
| 14 | +    | 16 | 110A-I-4 |
| 12 | +    | 18 | 93E-G-3  |
| 24 | +    | 26 | 93E-B-3  |
| 22 | +    | 28 | 93C-F-6  |

SECTION# 3 AS BUILT

| <input type="checkbox"/> APPROVED FOR CONSTRUCTION<br><input type="checkbox"/> MASTER COPY <input type="checkbox"/> REFERENCE COPY    OF _____<br><input type="checkbox"/> MULTIPLE UNIT WORK ORDER<br><input type="checkbox"/> RELEASED FOR INFORMATION<br>AUTH. BY: _____ DATE: _____ |                                | CROSS REFERENCE LEGEND<br>50C-C-1<br>GRID COORDINATE<br>SHEET No. _____ | <table border="1"> <tr> <th>DRAWING No.</th> <th>REFERENCE DRAWINGS</th> <th>No.</th> <th>REVISIONS</th> <th>BY</th> <th>AUTH</th> <th>DATE</th> </tr> <tr> <td>3</td> <td>AS BUILT</td> <td></td> <td></td> <td>SD</td> <td>SS</td> <td>17-01-18</td> </tr> <tr> <td>2</td> <td>CUSTOMER COMMENTS INCORPORATED</td> <td></td> <td></td> <td>SD</td> <td>SS</td> <td>16-10-19</td> </tr> <tr> <td>1</td> <td>ADDED SCHEMATIC DRAWINGS</td> <td></td> <td></td> <td>SD</td> <td>SS</td> <td>16-08-25</td> </tr> </table> | DRAWING No. | REFERENCE DRAWINGS | No.      | REVISIONS | BY | AUTH | DATE | 3 | AS BUILT |  |  | SD | SS | 17-01-18 | 2 | CUSTOMER COMMENTS INCORPORATED |  |  | SD | SS | 16-10-19 | 1 | ADDED SCHEMATIC DRAWINGS |  |  | SD | SS | 16-08-25 |  | GENERATOR CONTROL SYSTEM<br>SERIES 2200<br>GENERATOR 3 DC SCHEMATIC<br>ESQUIMALT GRAVING DOCK | CUSTOMER WESTERN PACIFIC ENTERPRISES GP<br>CUSTOMER ORDER No. C-054107    WORK ORDER No. W-095112<br>DRAWN BY SD    AUTH BY SS    DATE 16-08-11    REV 3<br>DRAWING/FILE No. W-095112-093D    SHEET 93D |
|---|--------------------------------|---|---|-------------|--------------------|----------|-----------|----|------|------|---|----------|--|--|----|----|----------|---|--------------------------------|--|--|----|----|----------|---|--------------------------|--|--|----|----|----------|--|---|---|
| DRAWING No.   | REFERENCE DRAWINGS             | No.   | REVISIONS   | BY          | AUTH               | DATE     |           |    |      |      |   |          |  |  |    |    |          |   |                                |  |  |    |    |          |   |                          |  |  |    |    |          |  |   |   |
| 3   | AS BUILT                       |   |   | SD          | SS                 | 17-01-18 |           |    |      |      |   |          |  |  |    |    |          |   |                                |  |  |    |    |          |   |                          |  |  |    |    |          |  |   |   |
| 2   | CUSTOMER COMMENTS INCORPORATED |   |   | SD          | SS                 | 16-10-19 |           |    |      |      |   |          |  |  |    |    |          |   |                                |  |  |    |    |          |   |                          |  |  |    |    |          |  |   |   |
| 1   | ADDED SCHEMATIC DRAWINGS       |   |   | SD          | SS                 | 16-08-25 |           |    |      |      |   |          |  |  |    |    |          |   |                                |  |  |    |    |          |   |                          |  |  |    |    |          |  |   |   |



FOR CUSTOMER  
 DRY CONTACTS  
 RATED 6A, 240VAC/30VDC  
 RESISTIVE



| 3GX1 |      |    |         | 3GSX1 |      |    |         | 3ESP1 |      |    |     |
|------|------|----|---------|-------|------|----|---------|-------|------|----|-----|
| T1   | TYPE | T2 | REF     | T1    | TYPE | T2 | REF     | T1    | TYPE | T2 | REF |
| 5    | +    | 9  | 93D-E-4 | 6     | +    | 10 | 93C-B-2 | 1     | +    | 9  | I-4 |
| 2    | +    | 10 | C-3     |       |      |    |         |       |      |    |     |
| 7    | +    | 11 | 93C-C-2 |       |      |    |         |       |      |    |     |
| 8    | +    | 12 | B-2     |       |      |    |         |       |      |    |     |
| 4    | +    | 13 | B-2     |       |      |    |         |       |      |    |     |

| 3GX2 |      |    |         | 3ESX1 |      |    |         | 3GTX2 |      |    |     |
|------|------|----|---------|-------|------|----|---------|-------|------|----|-----|
| T1   | TYPE | T2 | REF     | T1    | TYPE | T2 | REF     | T1    | TYPE | T2 | REF |
| 6    | +    | 10 | 93D-B-7 | 5     | +    | 9  | 93C-G-6 | 5     | +    | 9  | D-3 |
|      |      |    |         | 6     | +    | 10 | J-2     |       |      |    |     |
|      |      |    |         | 7     | +    | 11 | 93D-D-4 |       |      |    |     |

| 3DXTX1 |      |    |     | 3GTX3 |      |    |     | 3LDX1 |      |    |         |
|--------|------|----|-----|-------|------|----|-----|-------|------|----|---------|
| T1     | TYPE | T2 | REF | T1    | TYPE | T2 | REF | T1    | TYPE | T2 | REF     |
| 1      | +    | 9  | E-3 | 6     | +    | 4  | J-5 | 5     | +    | 9  | 93C-D-2 |

| 3GX3 |      |    |         | 3ESR1 |      |    |     | 3RBS1 |      |    |         |
|------|------|----|---------|-------|------|----|-----|-------|------|----|---------|
| T1   | TYPE | T2 | REF     | T1    | TYPE | T2 | REF | T1    | TYPE | T2 | REF     |
| 6    | +    | 4  | 93D-C-2 | 5     | +    | 9  | I-3 | 5     | +    | 9  | 93C-D-2 |

SECTION# 3 AS BUILT

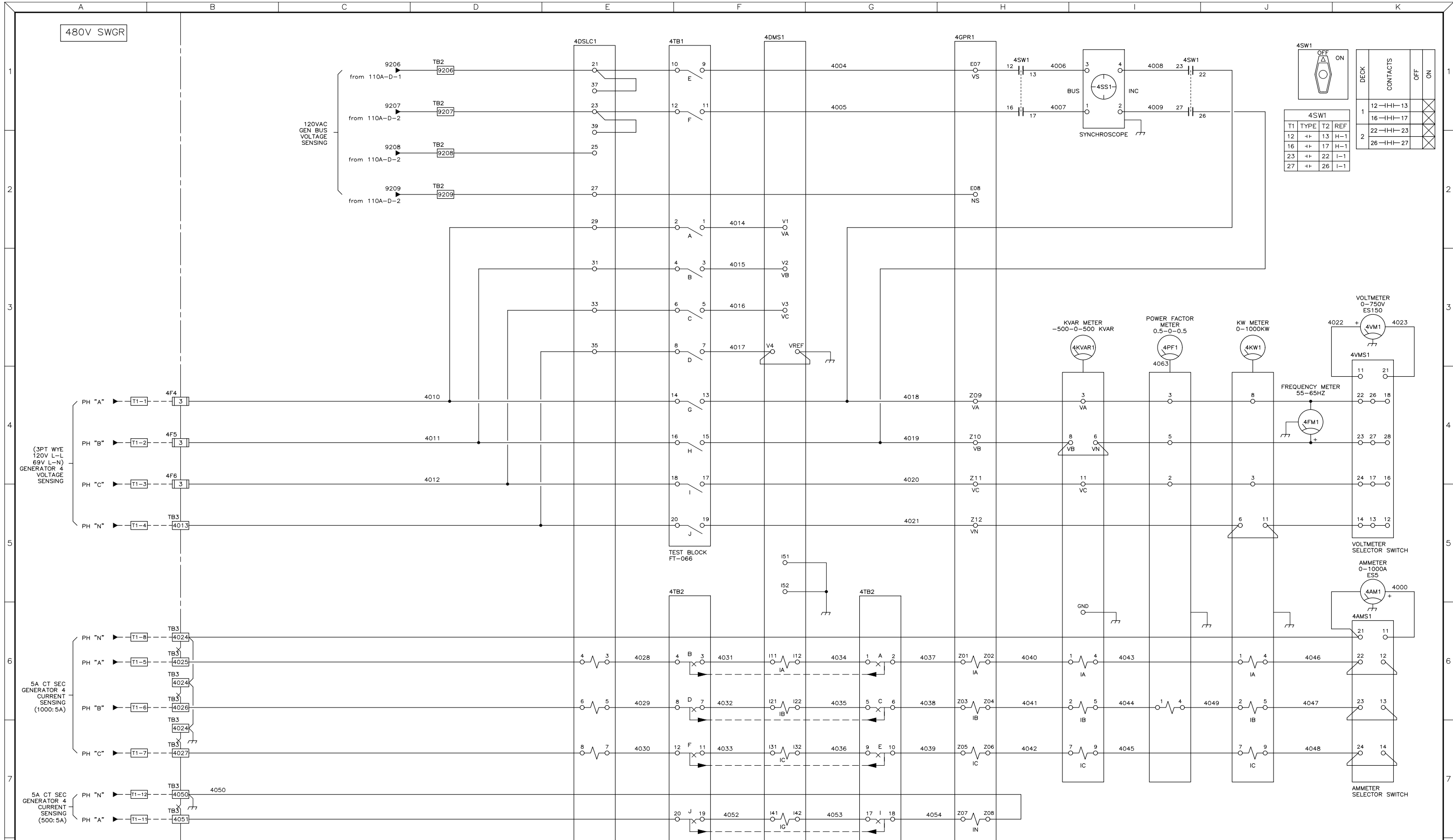
APPROVED FOR CONSTRUCTION  
 MASTER COPY REFERENCE COPY OF  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: DATE:

| CROSS REFERENCE LEGEND |                 | REVISIONS |                                |
|------------------------|-----------------|-----------|--------------------------------|
| SOC-C-1                | GRID COORDINATE | 3         | AS BUILT                       |
|                        | SHEET No.       | 2         | CUSTOMER COMMENTS INCORPORATED |
|                        | DRAWING No.     | 1         | ADDED SCHEMATIC DRAWINGS       |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 3 DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
|---|-------------------------|
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-093E          | SHEET 93E               |



4SW1

| T1 | TYPE | T2 | REF |
|----|------|----|-----|
| 12 | +    | 13 | H-1 |
| 16 | +    | 17 | H-1 |
| 23 | +    | 22 | I-1 |
| 27 | +    | 26 | I-1 |

| DECK | CONTACTS | OFF | ON |
|------|----------|-----|----|
| 1    | 12-HH-13 | X   |    |
| 1    | 16-HH-17 | X   |    |
| 2    | 22-HH-23 | X   |    |
| 2    | 26-HH-27 | X   |    |

SECTION# 4

AS BUILT

APPROVED FOR CONSTRUCTION  
 MASTER COPY  REFERENCE COPY OF \_\_\_\_\_ OF \_\_\_\_\_  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

CROSS REFERENCE LEGEND  
 50C-C-1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

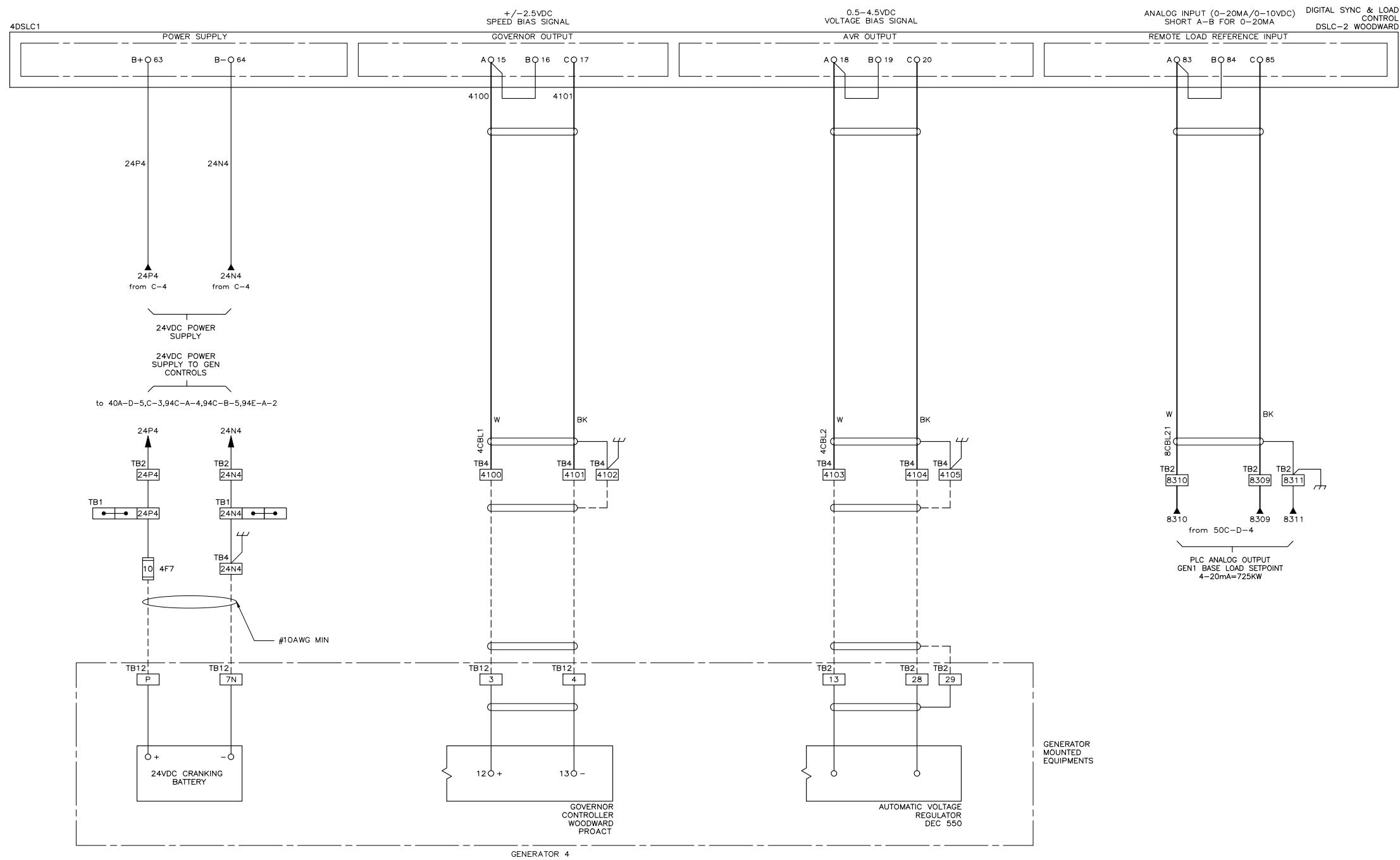
| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 4 AC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

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| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                |
|---|----------------|
| CUSTOMER ORDER No.                      | WORK ORDER No. |
| C-054107                                | W-095112       |
| DRAWN BY                                | DATE           |
| SD                                      | 16-08-11       |
| AUTH BY                                 | DATE           |
| SS                                      |                |
| REV                                     | SHEET          |
| 3                                       | 94A            |



SECTION# 4

AS BUILT

DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE.

APPROVED FOR CONSTRUCTION  
 MASTER COPY  REFERENCE COPY OF \_\_\_\_\_  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

CROSS REFERENCE LEGEND  
 50C-C-1  
 GRID COORDINATE  
 SHEET No. \_\_\_\_\_

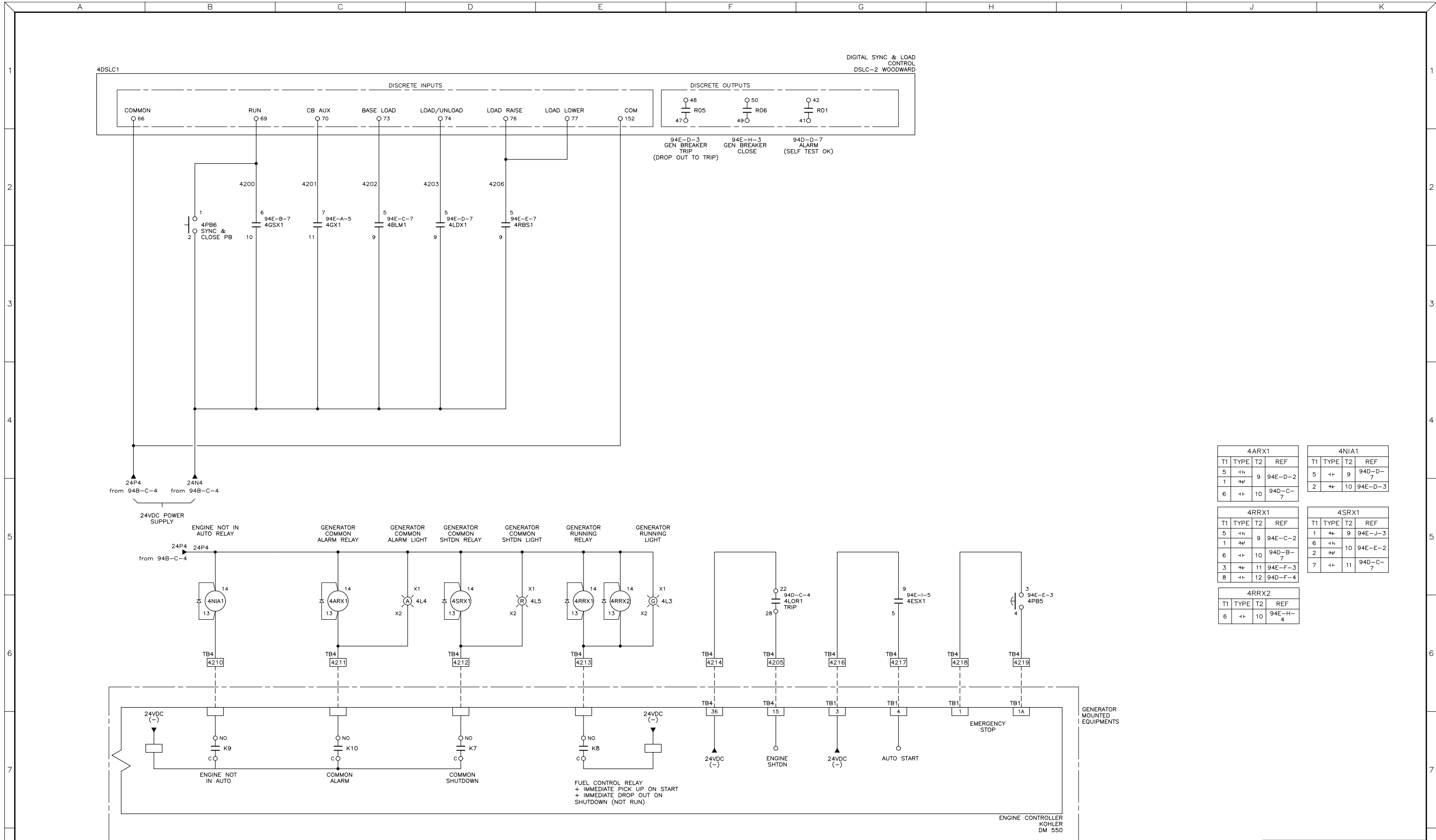
| DRAWING No. | REFERENCE DRAWINGS             | No. | REVISIONS | BY | AUTH | DATE     |
|-------------|--------------------------------|-----|-----------|----|------|----------|
| 3           | AS BUILT                       |     |           | SD | SS   | 17-01-18 |
| 2           | CUSTOMER COMMENTS INCORPORATED |     |           | SD | SS   | 16-10-19 |
| 1           | ADDED SCHEMATIC DRAWINGS       |     |           | SD | SS   | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 4 DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |                         |
|---|-------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-094B          | SHEET 94B               |





| 4ARX1 |      |    |         | 4NIA1 |      |    |         |
|-------|------|----|---------|-------|------|----|---------|
| T1    | TYPE | T2 | REF     | T1    | TYPE | T2 | REF     |
| 5     | +h   | 9  | 94E-D-2 | 5     | ++   | 9  | 94D-D-7 |
| 1     | ↔    | 10 | 94D-C-7 | 2     | ↔    | 10 | 94E-D-3 |
| 6     | ++   | 10 | 94D-C-7 |       |      |    |         |

| 4RRX1 |      |    |         | 4SRX1 |      |    |         |
|-------|------|----|---------|-------|------|----|---------|
| T1    | TYPE | T2 | REF     | T1    | TYPE | T2 | REF     |
| 5     | +h   | 9  | 94E-C-2 | 1     | ↔    | 9  | 94E-J-3 |
| 1     | ↔    | 10 | 94D-B-7 | 6     | +h   | 10 | 94E-E-2 |
| 6     | ++   | 10 | 94D-B-7 | 2     | ↔    | 10 | 94E-E-2 |
| 3     | ↔    | 11 | 94E-F-3 | 7     | ++   | 11 | 94D-C-7 |
| 8     | ++   | 12 | 94D-F-4 |       |      |    |         |

| 4RRX2 |      |    |         |
|-------|------|----|---------|
| T1    | TYPE | T2 | REF     |
| 6     | ++   | 10 | 94E-H-4 |

SECTION# 4

AS BUILT

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 MASTER COPY  REFERENCE COPY OF \_\_\_\_\_  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

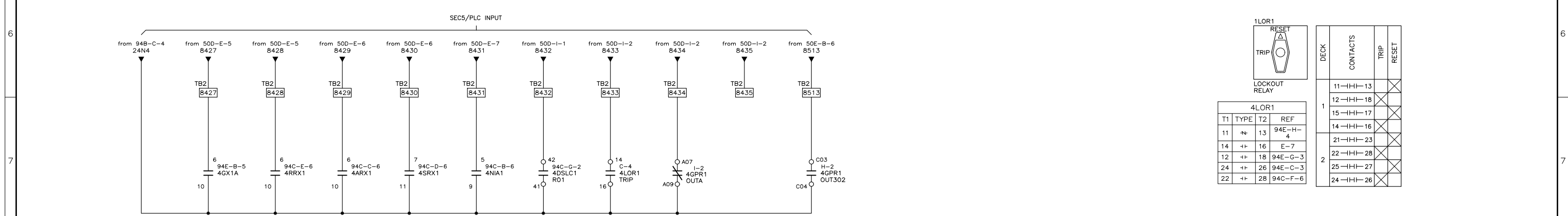
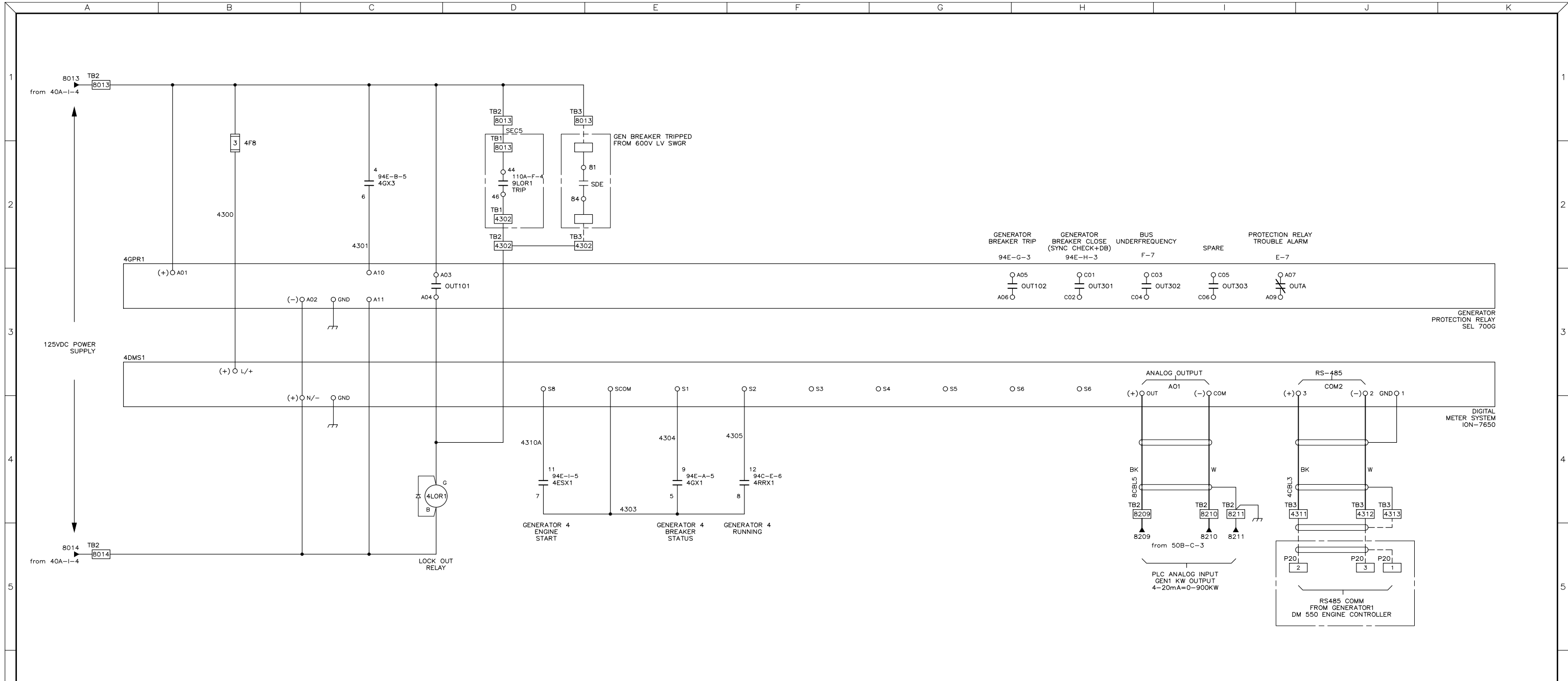
| CROSS REFERENCE LEGEND |                    |
|------------------------|--------------------|
| 50C-C-1                | GRID COORDINATE    |
|                        | SHEET No.          |
|                        | DRAWING No.        |
|                        | REFERENCE DRAWINGS |
|                        | No.                |
|                        | REVISIONS          |
|                        | BY/AUTH            |
|                        | DATE               |

|   |                                |    |    |          |
|---|--------------------------------|----|----|----------|
| 3 | AS BUILT                       | SD | SS | 17-01-18 |
| 2 | CUSTOMER COMMENTS INCORPORATED | SD | SS | 16-10-19 |
| 1 | ADDED SCHEMATIC DRAWINGS       | SD | SS | 16-08-25 |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 4 DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

| DRAWINGS AND/OR OTHER TECHNICAL INFORMATION SUPPLIED BY THOMSON POWER SYSTEMS AS A PART OF A SALE OF EQUIPMENT ARE FOR THE PURCHASER'S USE SOLELY IN CONJUNCTION WITH THAT EQUIPMENT, UNLESS SPECIFICALLY AGREED TO OTHERWISE AS A PART OF THE TERMS OF SALE. |                                |                         |       |
|---|--------------------------------|-------------------------|-------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP   |                                | WORK ORDER No. W-095112 |       |
| CUSTOMER ORDER No. C-054107   | AUTH BY SS                     | DATE 16-08-11           | REV 3 |
| DRAWN BY SD   | DRAWING/FILE No. W-095112-094C | SHEET 94C               |       |



LOCKOUT RELAY

| 4LOR1 |   | DECK | CONTACTS | TRIP | RESET |
|-------|---|------|----------|------|-------|
| 11    | + | 13   | 94E-H-4  |      |       |
| 14    | + | 16   | E-7      |      |       |
| 12    | + | 18   | 94E-G-3  |      |       |
| 24    | + | 26   | 94E-C-3  |      |       |
| 22    | + | 28   | 94C-F-6  |      |       |

SECTION# 4

AS BUILT

APPROVED FOR CONSTRUCTION  
 MASTER COPY  REFERENCE COPY OF \_\_\_\_\_  
 MULTIPLE UNIT WORK ORDER  
 RELEASED FOR INFORMATION  
 AUTH. BY: \_\_\_\_\_ DATE: \_\_\_\_\_

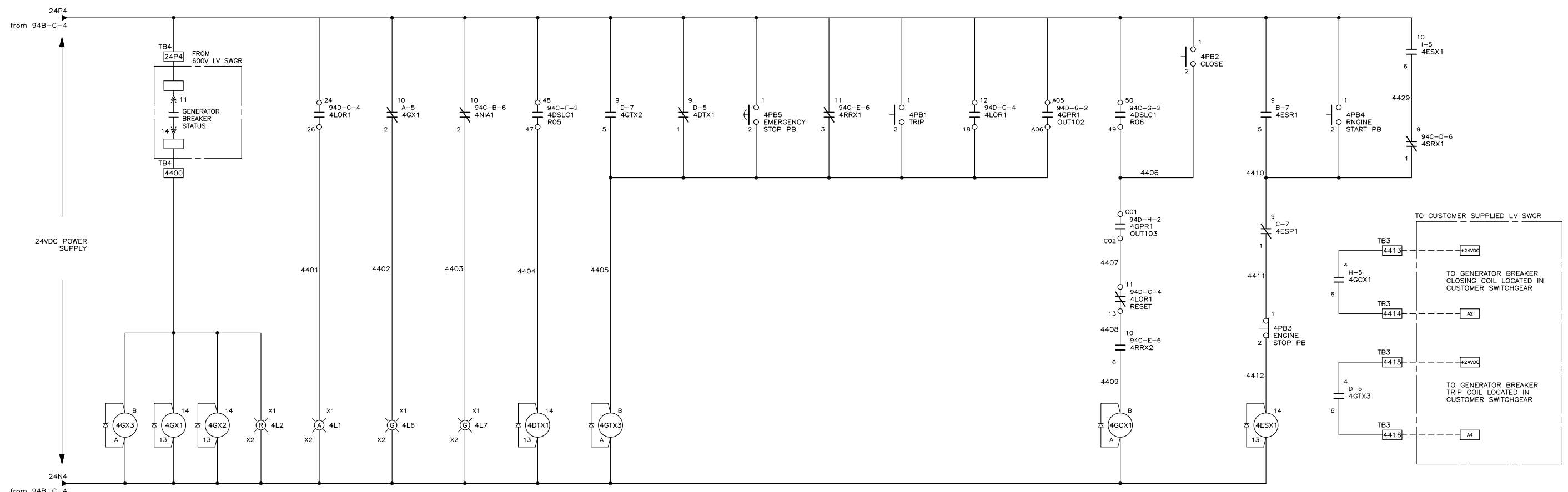
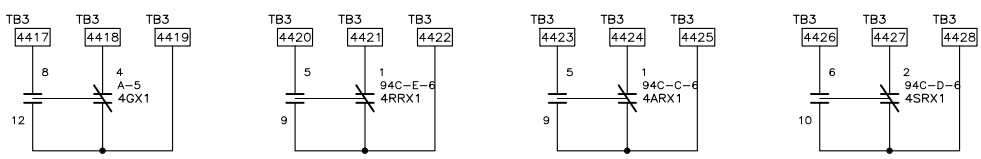
| CROSS REFERENCE LEGEND |                                | SHEET No. |          | DRAWING No. |    | REFERENCE DRAWINGS |  |
|------------------------|--------------------------------|-----------|----------|-------------|----|--------------------|--|
| 5                      | SOC-C-1                        | 3         | AS BUILT | SD          | SS | 17-01-18           |  |
| 2                      | CUSTOMER COMMENTS INCORPORATED | SD        | SS       | 16-10-19    |    |                    |  |
| 1                      | ADDED SCHEMATIC DRAWINGS       | SD        | SS       | 16-08-25    |    |                    |  |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 4 DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

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|---|------------|-------------------------|-------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP   |            | WORK ORDER No. W-095112 |       |
| CUSTOMER ORDER No. C-054107   | AUTH BY SS | DATE 16-08-11           | REV 3 |
| DRAWING/FILE No. W-095112-094D  | SHEET 94D  |                         |       |

FOR CUSTOMER  
 DRY CONTACTS  
 RATED 6A, 240VAC/30VDC  
 RESISTIVE



24N4 from 94B-C-4

GENERATOR BREAKER AUX RELAY (KUEP)  
 GENERATOR BREAKER AUX RELAYS  
 BREAKER CLOSED LIGHT  
 BREAKER TRIPPED LIGHT  
 BREAKER OPEN LIGHT  
 GENERATOR IN AUTO LIGHT  
 BREAKER TRIP FROM DSLC-2 (DROP OUT TO TRIP)  
 GENERATOR BREAKER TRIP AUX RELAY (KUEP)

BREAKER CLOSE AUX RELAY (KUEP)  
 ENGINE START RELAY

| 4GX1 |      |    |         |
|------|------|----|---------|
| T1   | TYPE | T2 | REF     |
| 5    | +    | 9  | 94D-E-4 |
| 2    | +    | 10 | C-3     |
| 7    | +    | 11 | 94C-C-2 |
| 8    | +    | 12 | B-2     |
| 4    | +    | 13 |         |

| 4GTX3 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 6     | +    | 4  | J-5 |

| 4ESP1 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 1     | +    | 9  | I-4 |

| 4GTX2 |      |    |         |
|-------|------|----|---------|
| T1    | TYPE | T2 | REF     |
| 5     | +    | 9  | 94D-C-2 |
| 6     | +    | 10 | J-2     |
| 7     | +    | 11 | 94D-D-4 |

| 4ESX1 |      |    |         |
|-------|------|----|---------|
| T1    | TYPE | T2 | REF     |
| 5     | +    | 9  | 94C-G-6 |
| 6     | +    | 10 | J-2     |
| 7     | +    | 11 | 94D-D-4 |

| 4GTX1 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 4     | +    | 7  | I-1 |
| 3     | +    | 9  | I-4 |

| 4GTX3 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 6     | +    | 4  | J-4 |

| 4ESR1 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 5     | +    | 9  | I-3 |

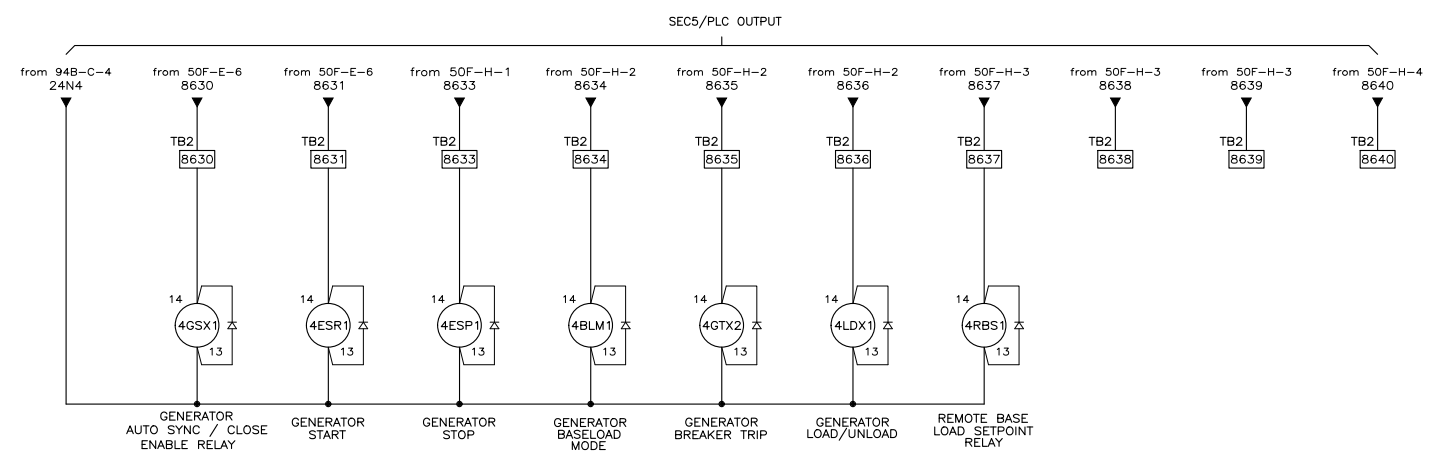
| 4BLS1 |      |    |         |
|-------|------|----|---------|
| T1    | TYPE | T2 | REF     |
| 5     | +    | 9  | 94C-C-2 |

| 4LDM1 |      |    |         |
|-------|------|----|---------|
| T1    | TYPE | T2 | REF     |
| 5     | +    | 9  | 94C-D-2 |

| 4RBS1 |      |    |         |
|-------|------|----|---------|
| T1    | TYPE | T2 | REF     |
| 5     | +    | 9  | 94C-D-2 |



GENERATOR AUTO SYNC / CLOSE ENABLE RELAY  
 GENERATOR START  
 GENERATOR STOP  
 GENERATOR BASELOAD MODE  
 GENERATOR BREAKER TRIP  
 GENERATOR LOAD/UNLOAD  
 REMOTE BASE LOAD SETPOINT RELAY

SECTION# 4

AS BUILT

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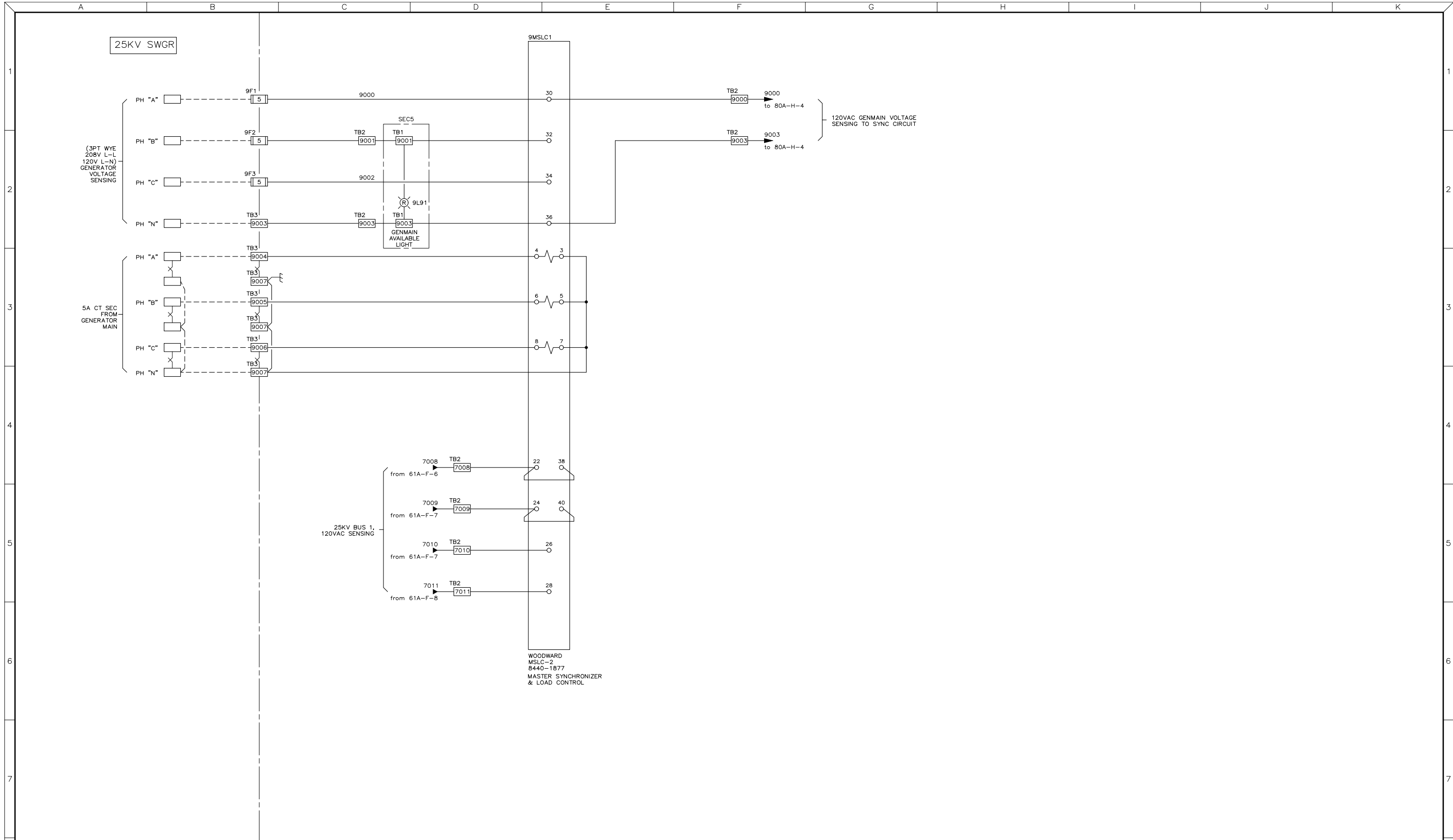
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| CROSS REFERENCE LEGEND |                        |
|------------------------|------------------------|
| 50C-C-1                | GRID COORDINATE        |
|                        | SHEET No.              |
|                        | DRAWING No.            |
|                        | REFERENCE DRAWINGS No. |
|                        | REVISIONS              |
|                        | BY/AUTH                |
|                        | DATE                   |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR 4 DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
|---|-------------------------|
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-094E          | SHEET 94E               |



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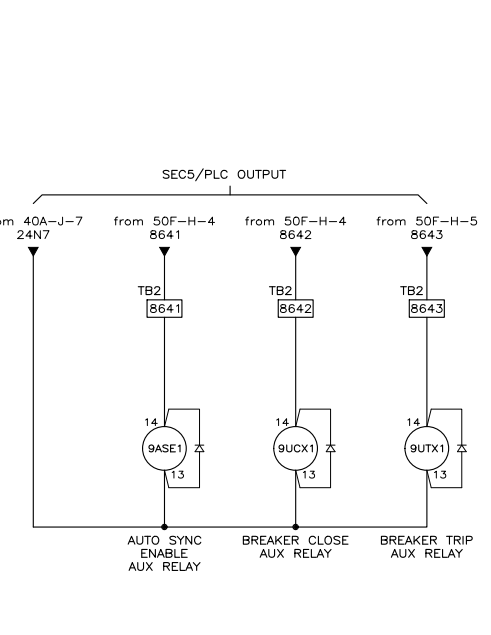
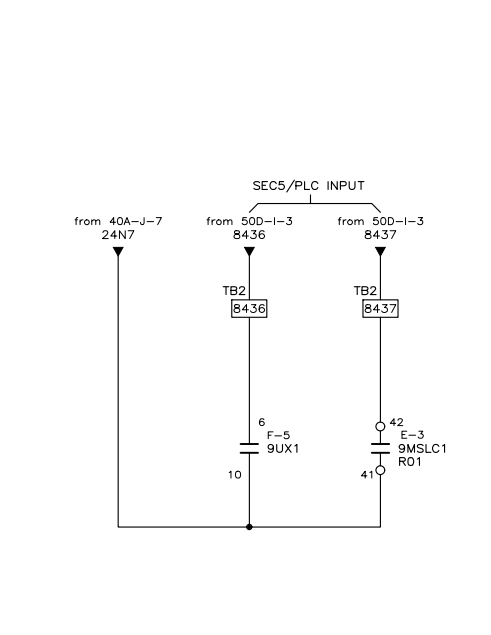
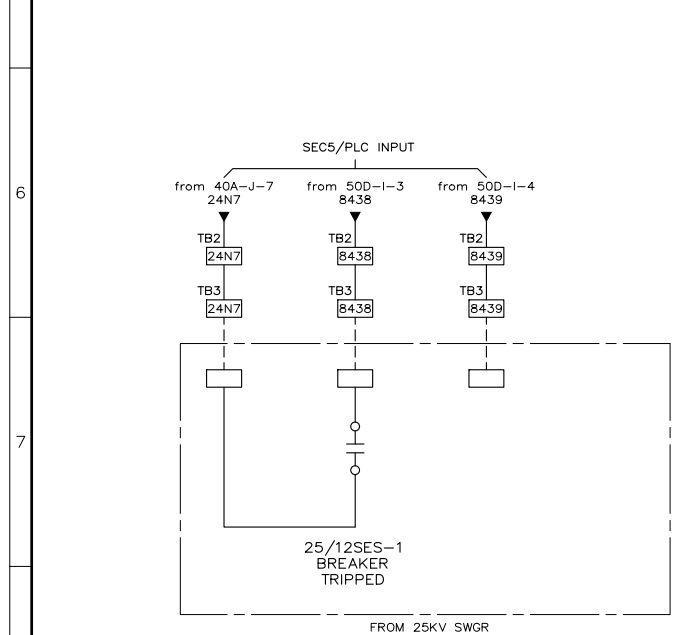
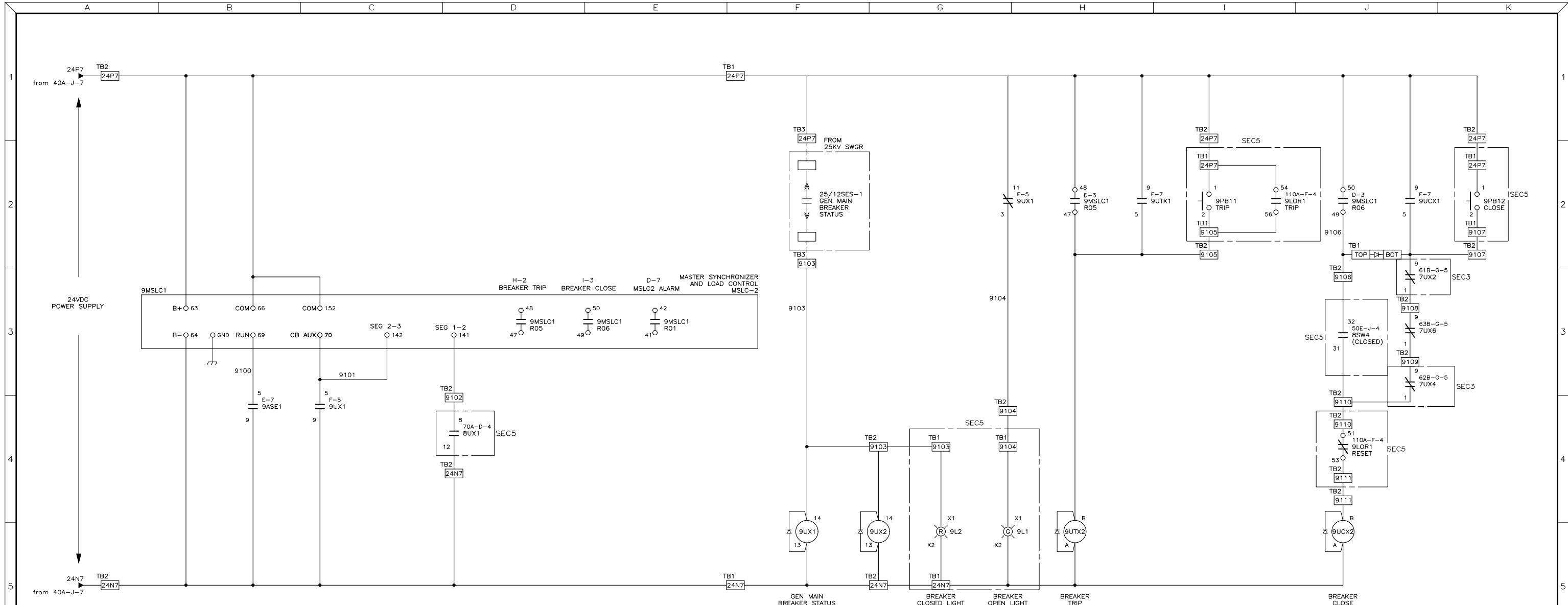
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| CROSS REFERENCE LEGEND |                           | REVISIONS |                                |
|------------------------|---------------------------|-----------|--------------------------------|
| 50C-C-1                | GRID COORDINATE SHEET No. | 3         | AS BUILT                       |
|                        |                           | 2         | CUSTOMER COMMENTS INCORPORATED |
|                        |                           | 1         | ADDED SCHEMATIC DRAWINGS       |
| DRAWING No.            | REFERENCE DRAWINGS        | No.       | REVISIONS                      |
|                        |                           | BY/AUTH   | DATE                           |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR MAIN AC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |                            |
|---|----------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                            |
| CUSTOMER ORDER No.<br>C-054107          | WORK ORDER No.<br>W-095112 |
| DRAWN BY<br>SD                          | AUTH BY<br>SS              |
| DATE<br>16-08-11                        | REV<br>3                   |
| DRAWING/FILE No.<br>W-095112-100A       | SHEET<br>100A              |



| 9UTX2 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 6     | +    | 4  | J-6 |

| 9UX1 |      |    |     |
|------|------|----|-----|
| T1   | TYPE | T2 | REF |
| 5    | +    | 9  | C-4 |
| 6    | +    | 10 | D-7 |
| 3    | +    | 11 | G-2 |

| 9UX2 |      |    |         |
|------|------|----|---------|
| T1   | TYPE | T2 | REF     |
| 1    | +    | 9  | 61B-J-3 |
| 2    | +    | 10 | 62B-J-3 |
| 3    | +    | 11 | 63B-J-3 |
| 8    | +    | 12 | 91D-H-4 |

| 9ASE1 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 5     | +    | 9  | B-4 |

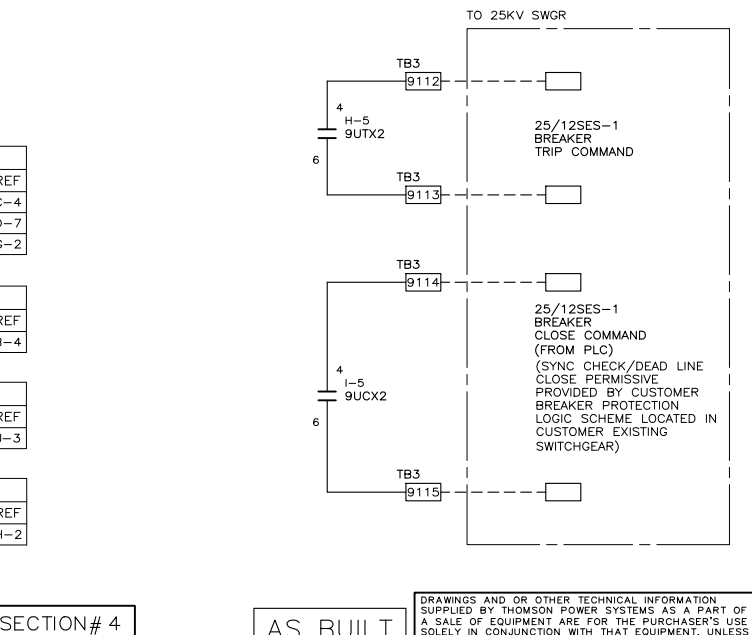
| 9UCX1 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 5     | +    | 9  | J-3 |

| 9UCX2 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 6     | +    | 4  | J-7 |

| 9UTX1 |      |    |     |
|-------|------|----|-----|
| T1    | TYPE | T2 | REF |
| 5     | +    | 9  | H-2 |



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|         |                 |
|---------|-----------------|
| SOC-C-1 | GRID COORDINATE |
|         | SHEET No.       |

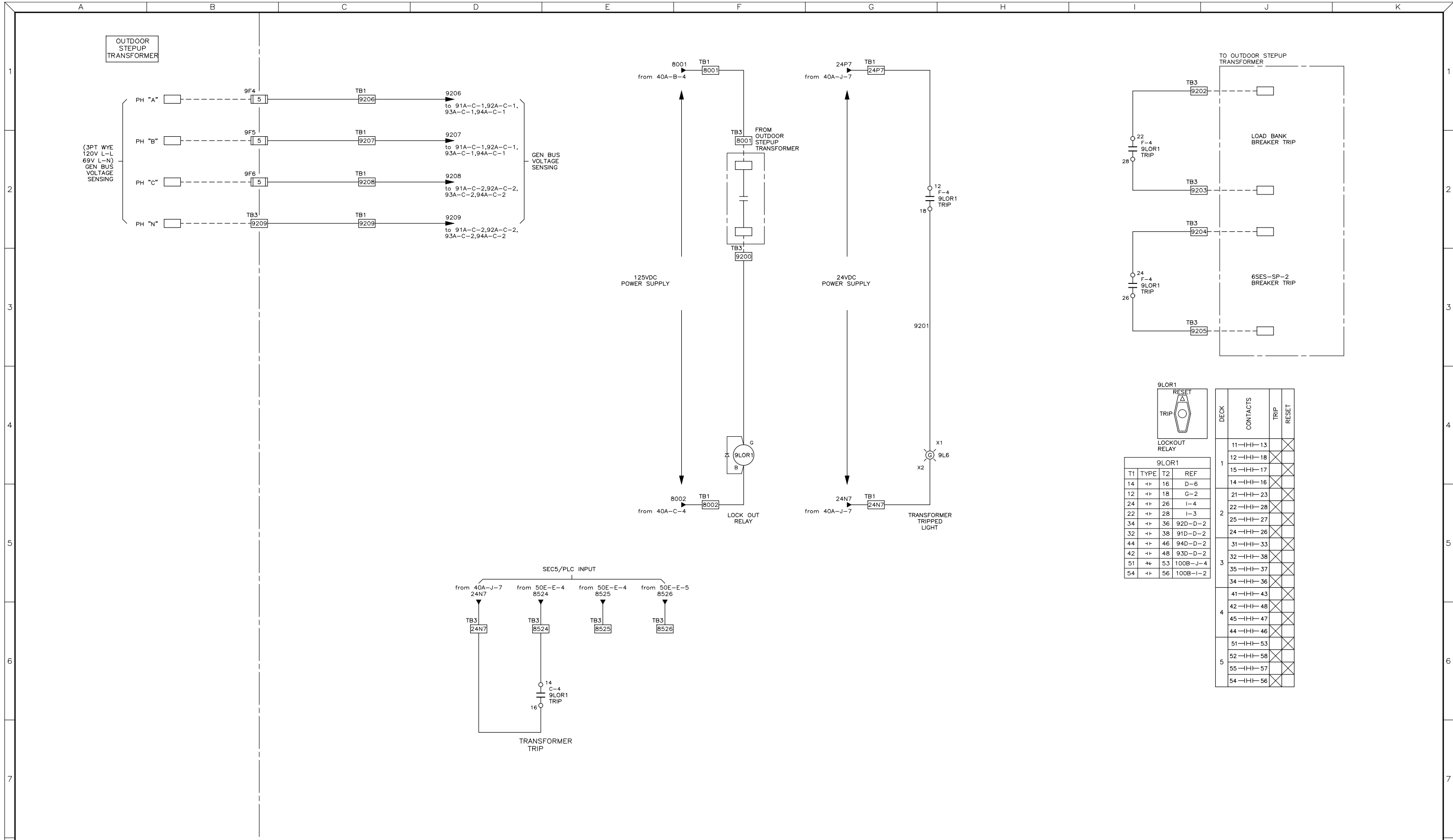
| DRAWING No. | REFERENCE DRAWINGS             | No.   | REVISIONS | BY/AUTH | DATE |
|-------------|--------------------------------|-------|-----------|---------|------|
| 3           | AS BUILT                       | SD SS | 17-01-18  |         |      |
| 2           | CUSTOMER COMMENTS INCORPORATED | SD SS | 16-10-19  |         |      |
| 1           | ADDED SCHEMATIC DRAWINGS       | SD SS | 16-08-25  |         |      |



**SECTION# 4**  
**AS BUILT**  
 GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 GENERATOR MAIN DC CONTROL SCHEMATIC  
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|   |                         |
|---|-------------------------|
| CUSTOMER WESTERN PACIFIC ENTERPRISES GP |                         |
| CUSTOMER ORDER No. C-054107             | WORK ORDER No. W-095112 |
| DRAWN BY SD                             | AUTH BY SS              |
| DATE 16-08-11                           | REV 3                   |
| DRAWING/FILE No. W-095112-100B          | SHEET 100B              |



9LOR1 TRIP

| T1 | TYPE | T2 | REF      |
|----|------|----|----------|
| 14 | +P   | 16 | D-6      |
| 12 | +P   | 18 | G-2      |
| 24 | +P   | 26 | I-4      |
| 22 | +P   | 28 | I-3      |
| 34 | +P   | 36 | 92D-D-2  |
| 32 | +P   | 38 | 91D-D-2  |
| 44 | +P   | 46 | 94D-D-2  |
| 42 | +P   | 48 | 93D-D-2  |
| 51 | +P   | 53 | 100B-J-4 |
| 54 | +P   | 56 | 100B-I-2 |

| DECK | CONTACTS | TRIP | RESET |
|------|----------|------|-------|
| 1    | 11-IH-13 | X    |       |
| 1    | 12-IH-18 | X    |       |
| 1    | 15-IH-17 | X    |       |
| 1    | 14-IH-16 | X    |       |
| 2    | 21-IH-23 | X    |       |
| 2    | 22-IH-28 | X    |       |
| 2    | 25-IH-27 | X    |       |
| 2    | 24-IH-26 | X    |       |
| 3    | 31-IH-33 | X    |       |
| 3    | 32-IH-38 | X    |       |
| 3    | 35-IH-37 | X    |       |
| 3    | 34-IH-36 | X    |       |
| 4    | 41-IH-43 | X    |       |
| 4    | 42-IH-48 | X    |       |
| 4    | 45-IH-47 | X    |       |
| 4    | 44-IH-46 | X    |       |
| 5    | 51-IH-53 | X    |       |
| 5    | 52-IH-58 | X    |       |
| 5    | 55-IH-57 | X    |       |
| 5    | 54-IH-56 | X    |       |

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|------------------------|-----------------|-----------|---|
| 50C-C-1                | GRID COORDINATE | 3         | AS BUILT SD SS 17-01-18                       |
|                        | SHEET No.       | 2         | CUSTOMER COMMENTS INCORPORATED SD SS 16-10-19 |
|                        | DRAWING No.     | 1         | ADDED SCHEMATIC DRAWINGS SD SS 16-08-25       |



GENERATOR CONTROL SYSTEM  
 SERIES 2200  
 OUTDOOR TRANSFORMER AC & DC SCHEMATIC  
 ESQUIMALT GRAVING DOCK

|   |                         |
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| CUSTOMER ORDER No. C-054107   | DATE 16-08-11           |
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| DRAWING/FILE No. W-095112-110A  | SHEET 110A              |

## Three-phase pad-mounted compartmental type transformer installation and maintenance instructions



*Powering Business Worldwide*

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## Safety for life



Eaton meets or exceeds all applicable industry standards relating to product safety in its Cooper Power™ series products. We actively promote safe practices in the use and maintenance of our products through our service literature, instructional training programs, and the continuous efforts of all Eaton employees involved in product design, manufacture, marketing, and service.

We strongly urge that you always follow all locally approved safety procedures and safety instructions when working around high voltage lines and equipment, and support our “Safety For Life” mission.

## Safety information

The instructions in this manual are not intended as a substitute for proper training or adequate experience in the safe operation of the equipment described. Only competent technicians who are familiar with this equipment should install, operate, and service it.

A competent technician has these qualifications:

- Is thoroughly familiar with these instructions.
- Is trained in industry-accepted high and low-voltage safe operating practices and procedures.
- Is trained and authorized to energize, de-energize, clear, and ground power distribution equipment.
- Is trained in the care and use of protective equipment such as arc flash clothing, safety glasses, face shield, hard hat, rubber gloves, clampstick, hotstick, etc.

Following is important safety information. For safe installation and operation of this equipment, be sure to read and understand all cautions and warnings.

### Hazard Statement Definitions

This manual may contain four types of hazard statements:

#### DANGER

Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

#### WARNING

Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

#### CAUTION

Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

**CAUTION:** Indicates a potentially hazardous situation which, if not avoided, may result in equipment damage only.

### Safety instructions

Following are general caution and warning statements that apply to this equipment. Additional statements, related to specific tasks and procedures, are located throughout the manual.

#### DANGER

**Hazardous voltage. Contact with hazardous voltage will cause death or severe personal injury. Follow all locally approved safety procedures when working around high- and low-voltage lines and equipment.**

G103.3

#### WARNING

**Before installing, operating, maintaining, or testing this equipment, carefully read and understand the contents of this manual. Improper operation, handling or maintenance can result in death, severe personal injury, and equipment damage.**

G101.0

#### WARNING

**This equipment is not intended to protect human life. Follow all locally approved procedures and safety practices when installing or operating this equipment. Failure to comply can result in death, severe personal injury and equipment damage.**

G102.1

#### WARNING

**Power distribution and transmission equipment must be properly selected for the intended application. It must be installed and serviced by competent personnel who have been trained and understand proper safety procedures. These instructions are written for such personnel and are not a substitute for adequate training and experience in safety procedures. Failure to properly select, install or maintain power distribution and transmission equipment can result in death, severe personal injury, and equipment damage.**

G122.3

---

## IMPORTANT

---

**Do not Exceed Transformer Ratings. Transformers should be operated only at the ratings specified on the transformer nameplate. Prolonged overload operation will measurably shorten the projected service life of a mineral oil-filled transformer. Eaton's Cooper Power™ series PEAK™ transformers may help to extend insulation life and can be operated at higher capacities than traditional units while still exceeding ANSI® standard insulation life.**

---

## Introduction

Eaton provides installation and maintenance instructions for its Cooper Power™ series transformers in *Service Information MN202001EN*. These transformers are designed for installation on three-phase underground systems. All units are constructed for weather-exposed mounting on a concrete pad with high- and low-voltage cable entering the operating compartments through an opening in the pad.

### Read this manual first

Read and understand the contents of this manual and follow all locally approved procedures and safety practices before installing or operating this equipment.

### Additional information

These instructions are not intended to cover all details or variations in the equipment, procedures, or process described, nor to provide directions for meeting every possible contingency during installation, operation, or maintenance. For additional information, contact your Eaton representative.

### Acceptance and initial inspection

#### Receiving Inspection

It is important that a thorough inspection of the transformer be made before it is unloaded from the carrier.

1. Ensure that *all* parts listed on the bill of lading are present.
2. Before unloading the transformer, inspect for signs of damage or mishandling. Locate accessory parts that may have been shipped separately.
3. If damage is detected or shortages are noticed, write a brief description on the freight bill. Normally, the transformer is shipped FOB point of manufacture, and it is the customer's responsibility to file a claim against the carrier. If the transformer was shipped FOB destination, notify your Eaton representative. He or she will, with the inspector's report, take the necessary steps to file a claim against the carrier.

---

## WARNING

---

**Heavy Equipment. Improper handling can cause severe injury, death, or damage to transformer. Before moving the transformer, read the handling instructions provided in this manual.**

---

## Handling

Special procedures must be followed when handling transformer in ambient temperatures below -20 °C. Contact your Eaton representative for further instructions. Failure to follow special handling procedures may cause premature failure of transformer and its components.

## Transformer weight

The transformer weight is shown on the transformer nameplate. Most of the weight in a pad-mounted transformer assembly is in the main tank that holds the core and coil assembly and the insulating liquid.

## Moving transformers shipped on pallets

Transformers shipped on pallets may be lifted or moved by forklift trucks of proper capacity. When using a forklift, lift with the transformer tank closest to the mast of the forklift since most of the transformer weight is in the tank. Pallet-mounted equipment may also be moved by crane or hoist.

## Lifting transformers by crane or hoist

Check the weight of the transformer and the capacity and condition of all hoisting or lifting equipment. Do not use worn, frayed or damaged cables or slings. Do not use hoisting machinery with load capacity less than the weight of the transformer. Improper use of hoist or jack could seriously damage the transformer or its attachments or cause serious personal injury.

For unloading, lifting lugs are provided near the top of the transformer tank. Lifting chain or cable angles should not be over 30° from vertical. Otherwise, spreaders should be used to hold the lifting cables apart to avoid any bending of the structure or lifting lugs.

Do not attempt to lift the transformer by placing a continuous loop of chain or cable around the unit or lifting lugs. This can damage the transformer and can cause accidents resulting in serious personal injury.

If the transformer cannot be lifted by crane, it may be skidded or moved by rollers.

## Using jacks

Place jacks under the tank base on the open ends of the transformer tank. Jacking pads are provided for transformers with bases greater than 6". Do not place jacks under radiators or terminal compartment frames.

When jacking a transformer for insertion of rollers underneath it, ensure that four jacks are used and that two adjacent corners are raised simultaneously and evenly to avoid warping the base. When using rollers, use as many as necessary to distribute the weight uniformly.

Do not attach pulling lines to moldings or other sheet metal parts of the transformer.

## Storage

Transformers that will not be placed in service immediately should be stored with terminal compartment doors closed and sealed to prevent damage to bushings or other attachments.

## Installation

### Installation location

The transformer must be located to meet applicable fire codes. For indoor installations, the installation location must meet the requirements of the National Electrical Code (NEC®) with sufficient space requirements and proper over-current protection as specified by the listing body that has jurisdiction over the installation.

These pad-mounted transformers are built to operate at altitudes up to 3300 feet at 30 °C average and 40 °C maximum ambient, unless otherwise specified. Before operating a standard transformer at higher altitudes, contact your Eaton representative.

### Mounting the transformer

The transformer should be mounted on a level concrete pad. The pad should be strong enough to support the weight of the transformer. The site must be adequately prepared to prevent the transformer from tilting beyond two degrees from horizontal.

---

### WARNING

---

**Fire Hazard. Non-level installation of transformer can result in fire and cause severe personal injury or death. Prepare transformer installation site such that transformer does not tilt more than two (2.0) degrees from horizontal while the transformer is in service at the site.**

---

Tilting beyond two degrees may cause internal components to come out of the oil and/or cables to mechanically stress the bushings and bushing gaskets. Excessive tilt (beyond two degrees) can result in a lower dielectric strength for the transformer than the basic insulation level (BIL) listed on the nameplate. Reduced BIL can result in an internal dielectric breakdown with a risk of explosion, tank rupture, or fire.

To maintain full cabinet security, the transformer tank and cabinet base have provisions for installing cleats to secure transformer to pad. If gaps still exist between the cabinet and pad after cleating the cabinet, the installation will not provide the security needed to prevent tampering by the public. Add a permanent mortar seal to fill the gaps.

## Quality standards

ISO 9001 certified quality management system

### Pre-service inspection (exterior)

New transformers, or transformers which are being activated after a period of storage, should be thoroughly inspected before being connected to the power distribution system to identify damage which may have occurred during storage.

1. The transformer exterior should be inspected for nicks, dents, and scratches. Repair damage to weather-resistant finishes promptly.
2. The tank cover and manhole/handhole cover seals and all gaskets or seals at bushings, gauges, fuses, operating devices, etc., should be inspected for evidence of insulating liquid seepage. Repair leaking or improperly tightened gaskets and seals before the transformer is placed in service.
3. Under normal conditions, the transformer leaves the factory with a slight positive pressure in the tank over the oil. However, due to changes in atmospheric conditions, the unit may arrive under vacuum (negative pressure). This is itself is not cause for concern, however continued absence of either negative or positive pressure may indicate a leak at a gasket seal or tank seam, and require further investigation. To leak test transformer, remove the pressure relief valve (see Figure 1) and pressurize the headspace to ensure that there are no leaks. The test pressure should not exceed 7 psig. The established pressure should be maintained for at least four hours to ensure that all the seals are proper.

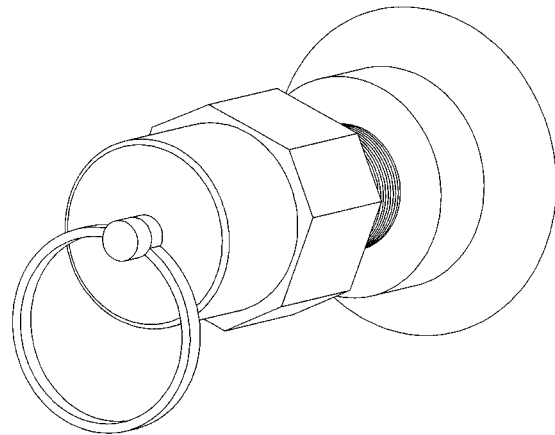


Figure 1. Pressure relief valve.

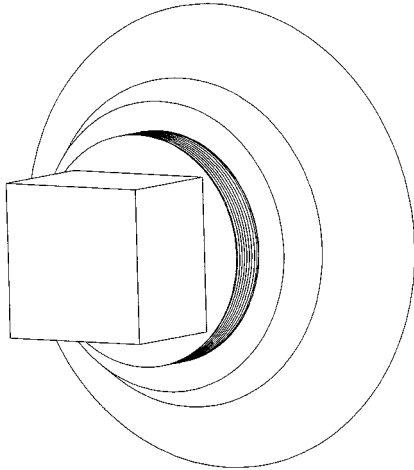
---

**⚠ CAUTION**

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**Elevated Pressure. Can cause severe personal injury. Do not remove liquid level plug (see Figure 2) before venting transformer to zero pressure. Pull ring on pressure relief valve to relieve pressure.**

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**Figure 2. Liquid level plug.**

4. The liquid level inside the tank must be checked (see Insulating Liquid Maintenance section of this manual). On transformers equipped with a liquid level gauge, the liquid level may be read directly from the gauge. On transformers that are not gauge equipped, the tank liquid level must be determined by removing the liquid level plug (see Figure 2). At 25 °C liquid temperature, the liquid level should be at the bottom edge of the liquid level plug hole.

If the tank temperature is greater than ambient air temperature, the transformer tank must be vented to zero pressure before the liquid level plug is removed. Failure to do so may cause hot oil to be sprayed from the plug hole and may result in severe personal injury.

---

**⚠ WARNING**

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**Fire Hazard. Energizing transformer in ambient temperatures below -20 °C can result in fire and cause severe personal injury or death. Contact your Eaton representative for further instructions on energizing transformer in ambient temperatures below -20 °C.**

---

5. Special procedures must be followed when energizing a transformer in ambient temperatures below -20 °C. Contact your Eaton representative for further instructions. Failure to follow special start-up procedures may cause premature failure of the transformer and its components. Also, note warning and caution statements in **Switches and Protective Devices** section of this manual for further precautions

when operating under-oil loadbreak accessories in insulating liquid temperatures below 0 °C.

**Pre-service inspection (interior)**

Pre-service interior inspection may not be required if exterior inspection reveals no evidence of damage.

---

**CAUTION**

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**Before opening the transformer tank for Pre-Service Inspection, read the Insulating Liquid Maintenance section in this manual. This section explains safety precautions that should be taken and gives instructions on how to prevent insulating liquid contamination.**

If interior inspection is required, the transformer must be opened by removing the manhole/handhole or tank cover. See the **Tank Cover Removal and Installation** section of this manual.

Pre-service interior inspections should be restricted to noting defects or damage that may prevent proper operation of the transformer.

**Inspect for:**

1. Moisture on underside of the tank cover or man-hole cover.
2. Loose, shifted, or damaged parts (bushings, fuse holders, etc.).
3. Broken or loose connections.
4. Contaminated insulating liquid (sediment or foreign objects on the tank bottom, dirt or air bubbles suspended in the liquid).

**Internal damage**

If concealed internal damage is suspected, it may be necessary to lower the insulating liquid level to complete the inspection. Refer to the **Insulating Liquid Maintenance** section of this manual.

**Contaminated insulating liquid**

If moisture is found inside the tank, or there is evidence that the insulating liquid may be otherwise contaminated, a liquid sample should be taken for analysis. Samples should be drawn from the bottom of the tank. For instruction on sampling the insulating liquid please see the **Insulating Liquid Maintenance** section of this manual.

If moisture is present in the liquid, the transformer must be dried out. Contact your Eaton representative for special instructions on dry-out or other decontamination processes.

## External connections

### WARNING

**Hazardous voltage. Can cause severe injury, death, or damage to equipment. Ground transformer following industry-accepted safe grounding practices before making other electrical connections. De-energize power distribution wires that will be connected to transformer. Verify that wires are de-energized at the transformer before connecting to transformer.**

Transformers that require no internal inspection or repair may be connected to the system. Transformers must be connected and operated as indicated by the transformer nameplate. Clean bushings and terminals before making connections. Remove dirt, grease or foreign material. Contamination can cause failure of the bushings.

Cables connected to the transformer terminals are to have sufficient flex to allow normal pad movement due to ground freeze/thaw and settling. Insufficient cable flex may cause premature failure of the bushings.

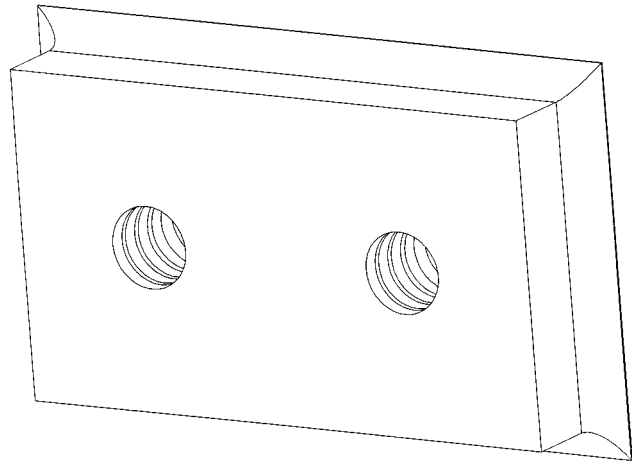
### Ground connections

The transformer tank must be connected to a permanent, low-resistance ground. If the tank is not solidly grounded and the transformer is connected to the power distribution system, then the tank should be regarded as energized. An energized tank is extremely dangerous. Contact with an energized tank can shock, burn, or cause death.

Three-phase pad-mounted transformers are equipped with two grounding pads for making the ground connection. The pads (see Figure 3) are located on the faceplate of the transformer behind the terminal compartment doors. One pad is in the primary compartment and the other in the secondary compartment.

### Grounded wye-grounded wye transformer connections

Grounded wye-grounded wye winding connection transformers are designed for power distribution systems that have a grounded neutral connector. All windings designed for grounded neutral operation must be permanently and solidly grounded to the system neutral without electrical resistance.



**Figure 3. Grounding pad.**

### High voltage connections

Make connections as shown in the diagrams and information on the transformer nameplate. Transformer neutrals must be connected to system neutrals. Leads and connections that are not used must be insulated from ground and all other leads.

### Livefront transformer connections

Externally clamped porcelain bushings are normally provided for high voltage connection to three-phase pad-mounted livefront transformers. The bushings have tin-plated eyebolt terminals suitable for both copper and aluminum conductors. The bushings are positioned to allow vertical takeoff of primary cables entering from below.

### Deadfront transformer connections

Deadfront three-phase pad-mounted transformers are equipped with universal bushing wells, one-piece bushings, or bushing wells with factory-installed inserts. Universal bushing wells must be field equipped with bushing well inserts before loadbreak cable connections can be made. Bushing well inserts must be compatible with the universal bushing well. Use of improperly rated inserts can cause premature failure of the transformer or its components. Read the manufacturer's instructions furnished with the inserts before installing to determine if they are compatible.

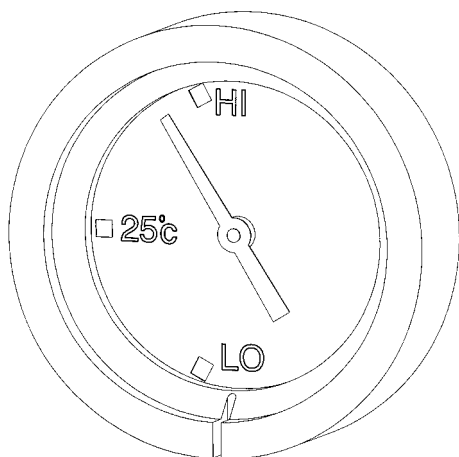
### Low voltage connections

Spade terminals are the standard low voltage connectors used for three-phase pad-mounted transformers. The low voltage bushings are externally clamped to the transformer tank wall.

## Accessories

Three-phase pad-mounted transformers can be equipped with a variety of optional equipment. Most such accessories are factory installed and no fieldwork is required to prepare them for operation.

### Liquid level gauge

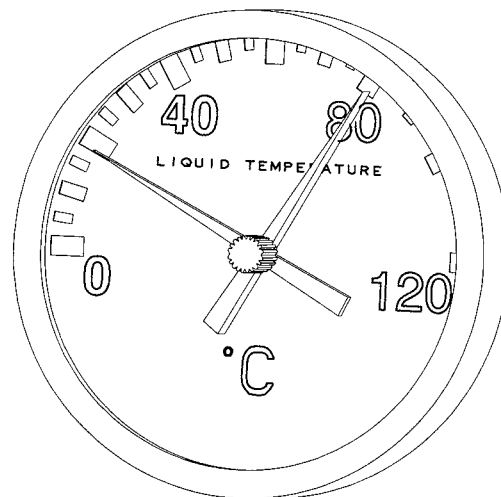


**Figure 4. Liquid level gauge.**

Transformers may be furnished with a liquid level indicator as optional equipment to aid in the systematic inspection of the transformer under load. It consists of a float-arm inside the tank, an indicating pointer and a magnetic coupling between the two across a liquid-tight separation.

The gauge may have one or two SPDT (Single Pole Double Throw) alarm contacts to give a remote annunciation of low liquid level. For wiring and contact ratings, refer to the schematic furnished with the transformer.

### Liquid temperature gauge



**Figure 5. Liquid temperature gauge.**

Transformers may be furnished with a temperature gauge as optional equipment to indicate the top liquid temperature in the tank in degrees Celsius. The temperature-sensitive element is mounted in a leak-proof well, permitting removal of the thermometer without lowering the oil level. The device is furnished with an additional red pointer to show the highest temperature attained since the last reset. To reset the maximum indicator, turn the knob in the center of the dial.

The thermometer may have two SPDT contacts for energizing a fan circuit or for a high temperature alarm. For wiring and contact ratings, refer to the schematic furnished with the transformer.

## Pressure-vacuum gauge

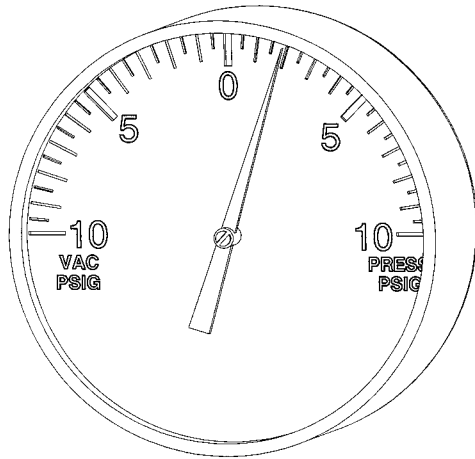


Figure 6. Pressure-vacuum gauge.

Transformers may be furnished with a pressure-vacuum gauge as optional equipment to indicate whether the gas space in the tank is under positive or negative pressure. The pressure will vary depending on the transformer temperature. If the transformer is de-energized or operating under light load in low ambients, the pressure may be negative.

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### CAUTION

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**If the indicator reads zero and does not change under any load condition, the transformer should be checked for a possible leak in the seal.**

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If sufficient air has been absorbed by the liquid during shipment or storage, the transformer may operate indefinitely in the vacuum range, depending upon the loading conditions. This, in itself, is not cause for concern, provided the pressure vacuum gauge does not remain on zero for any length of time - an indication of a leak. The transformer can safely operate in pressures ranging from -2 to +6 psig.

The transformer may have pressure vacuum switches with two SPDT contacts for remote alarm on positive and negative pressure. For wiring and contact ratings, refer to the schematic furnished with the transformer.

## Pressure relief device

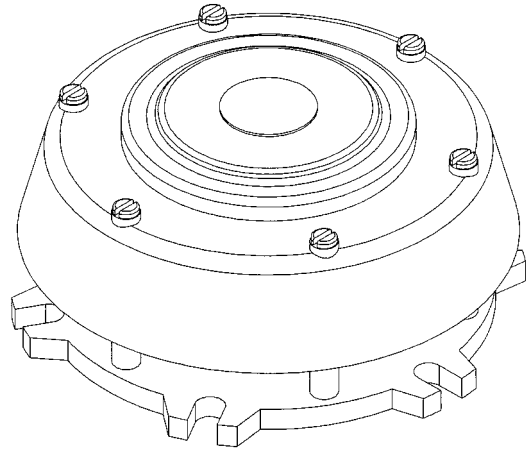


Figure 7. Pressure relief device.

Transformers may have a cover-mounted pressure relief device (PRD) in addition to the faceplate-mounted pressure relief valve (PRV) standard on all three-phase pad-mounted designs. The cover-mounted PRD consists of a self-resetting, spring-loaded diaphragm and a mechanical operation indicator. Should the tank pressure increase above that for which the device is set, the gas pressure will lift the diaphragm and let the gas escape quickly. Immediately after the pressure returns to normal, the diaphragm will reset and reseal the transformer. A mechanical indicator will protrude vertically. This must be reset manually to indicate subsequent operations.

The PRD may have SPDT alarm contacts for remote signaling of device activation. For wiring and contact ratings, refer to the schematic furnished with the transformer.



## Switches and protective devices

### Bay-O-Net fuse

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**⚠ WARNING**

---

Hazardous voltage. Can cause severe injury, death, or damage to equipment.

- Do not operate loadbreak equipment if a fault condition is suspected. Doing so can cause an explosion or fire.
- Use a hotstick to operate transformer loadbreak equipment.
- After operating transformer loadbreak equipment, check that voltages at transformer terminals are the expected values. Checking voltages verifies that loadbreak equipment operated properly and that electrical circuit conditions are as expected.
- Before servicing transformer secondary connected equipment, verify that all transformer secondary terminals have zero voltage and ground the transformer secondary terminals following industry accepted safe grounding practices. Grounding secondary terminals protects against situations such as a standby generator energizing transformer from the secondary circuit.
- Before servicing transformer, ALWAYS de-energize the transformer from a remote upstream source and then proceed to ground all primary and secondary transformer terminals following industry accepted safe grounding practices. Grounding secondary terminals protects against situations such as a standby generator energizing transformer from the secondary circuit.
- Follow industry accepted safety practices. Utilize protective clothing and equipment when working with loadbreak equipment.

---

**⚠ WARNING**

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Three-phase pad-mounted transformers use conventional transformer oil, R-Temp fluid, or Envirotemp™ FR3™ fluid for an insulating liquid. When the insulating liquid temperature is less than -20 °C (-4 °F) for conventional transformer oil, less than 0 °C (32 °F) for R-Temp fluid, or less than -10 °C (14 °F) for Envirotemp™ FR3™ fluid, viscosity is reduced, which may reduce make and break capabilities of loadbreak devices. Below these temperatures, under-oil loadbreak accessories should not be used to make or break a load. Instead, de-energize transformer from a remote upstream source before operating under-oil loadbreak devices.

---

---

**⚠ WARNING**

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Hazardous voltage. Can cause severe injury, death, or damage to equipment. Use a hotstick to service a Bay-O-Net fuse. Do not install a Bay-O-Net fuse to complete an electrical circuit if a fault condition is suspected. Do not re-energize suspected failed equipment. After installing Bay-O-Net fuse, energize transformer from a remote upstream source.

---

Eaton's Cooper Power series Bay-O-Net fuse assemblies are used to protect transformers and distribution systems. The assemblies are mounted on the faceplate of pad-mounted transformers and combine the ease of hotstick operation with the safety of deadfront construction (see Figure 8).

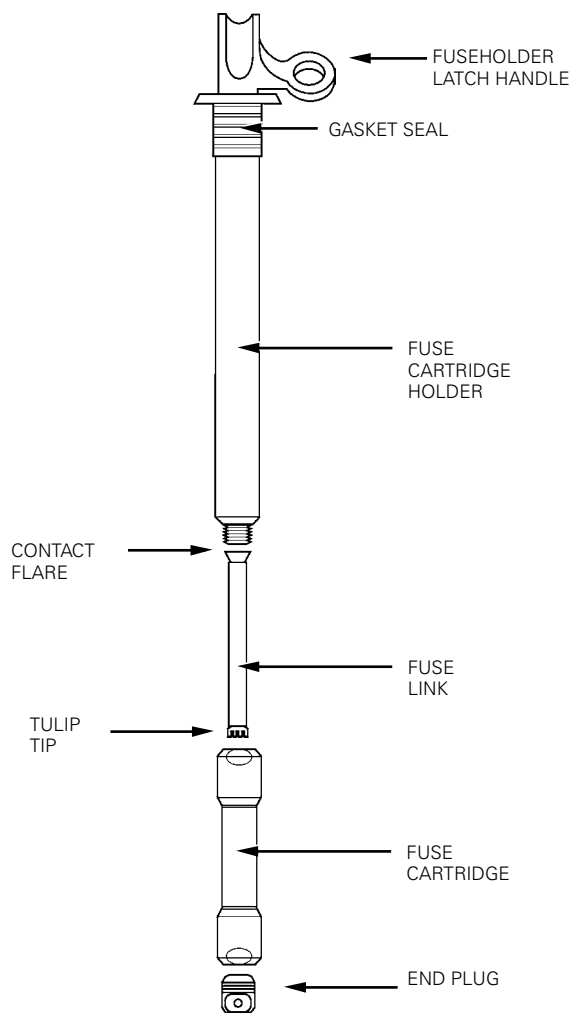


Figure 8. Bay-O-Net fuse assembly.

A Bay-O-Net fuse is not recommended for fault closing. Do not re-energize suspected failed equipment; serious personal injury may result. Internal fault conditions can cause the transformer to rupture or the cover to blow off. Always energize transformer from a remote upstream source.

When replacing a blown fuse, the feed circuit should be opened and closed from a remote location. The Bay-O-Net fuse should be replaced using the procedure described below and re-energized from a remote upstream source. If equipment is re-fused while energized, the fuse could close in on the system's maximum fault current. Any equipment that has a suspected failure should not be closed in with the fuse.

For additional information on Eaton's Cooper Power series Bay-O-Net fuse assembly, including loadbreak ratings, refer to catalog section CA132015EN, Service Information MN132003EN, and Service Information MN132002EN.

Current sensing, dual sensing, dual element, and high ampere overload links can be used in a Bay-O-Net fuse assembly. For additional information on these links, including interrupting ratings, see catalog sections CA132009EN, CA132010EN, CA132011EN, and CA132007EN respectively.

### Bay-O-Net fuse re-fusing instructions

#### Remove fuse holder

##### Step 1 - Relieve tank pressure.

Use a hotstick to perform the following steps:

1. Pull ring on pressure relief valve to open valve. Hold the valve open for 30 seconds after pressurized air can no longer be heard hissing through the valve.

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### CAUTION

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**If tank pressure has not been released, the fuse holder may be forced out of the Bay-O-Net housing. Maintain control of fuse holder at all times.**

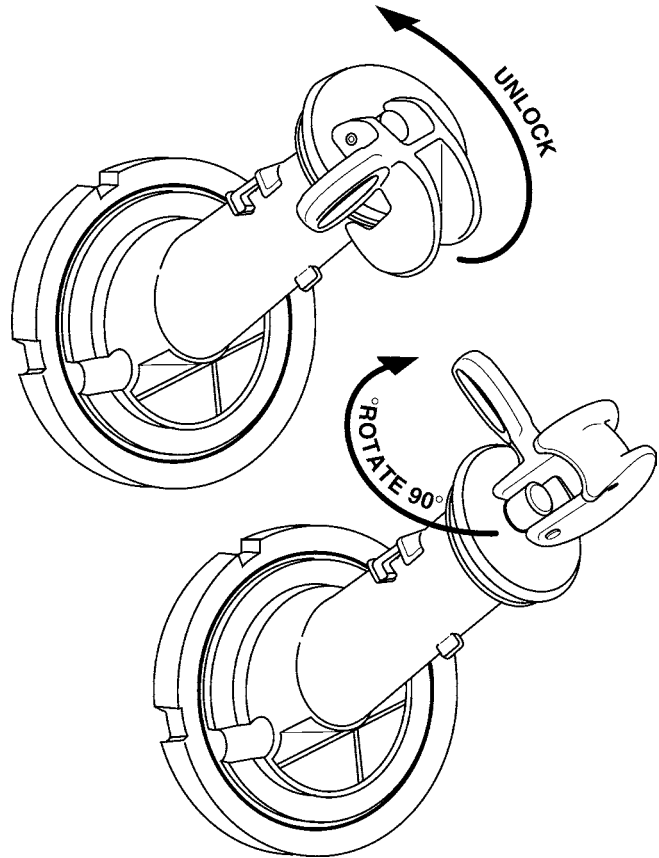
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2. Close pressure relief valve and wait 30 seconds.
3. Pull pressure relief valve open. Hold the valve open until hissing stops, and then for another 5 seconds. Pulling the valve open again allows any residual pressure to be released from tank.

##### Step 2 - Unlock fuseholder and break seal.

Use a hotstick to perform the following steps:

1. Stand to one side of the Bay-O-Net being removed.
2. Attach hotstick to fuseholder eye.
3. Twist hotstick to unlock fuseholder (see Figure 9).
4. Turn fuseholder 90° in the Bay-O-Net housing to break seal between seal gasket and Bay-O-Net housing (see Figure 10).



**Figure 9. Unlock and turn fuseholder 90° in the Bay-O-Net housing.**

##### Step 3 - Draw fuseholder out.

Use a hotstick to perform the following steps:

1. Draw fuseholder out quickly 8 to 10 inches to interrupt load (see Figure 10).
2. Wait several seconds for fluid to drain from fuseholder.

---

### CAUTION

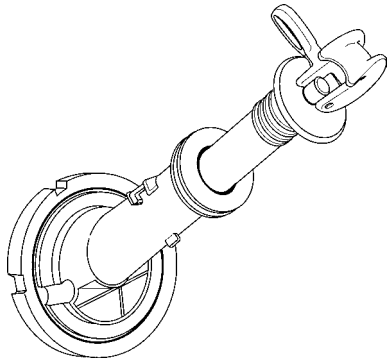
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**If fluid is coming out of the Bay-O-Net assembly, open the pressure relief valve again to equalize pressure inside the tank.**

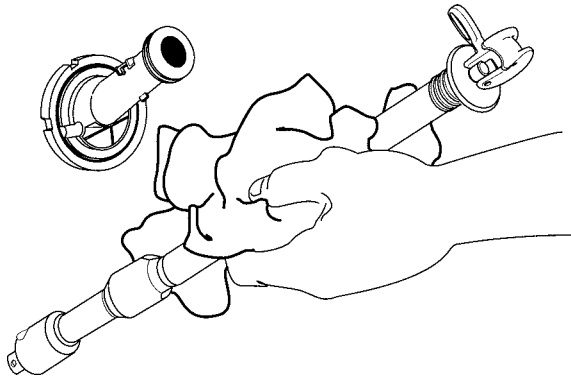
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##### Step 4 - Remove fuseholder from Bay-O-Net housing.

1. Remove fuseholder from Bay-O-Net housing.
2. Wipe off fuse cartridge holder and fuse cartridge (see Figure 11).



**Figure 10. Draw fuseholder out 8 to 10 inches.**



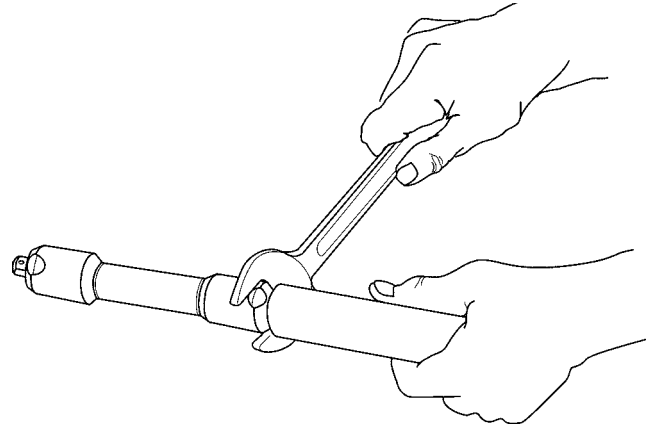
**Figure 11. Remove fuseholder from Bay-O-Net housing and wipe clean.**

### Replace fuse link

A separate replaceable fuse link, fuse cartridge, and end plug are available for all Eaton Bay-O-Net fuses except catalog numbers 4000358C16CB and C18CB, 4038361C03CB, C04CB, C05CB, and solid link 4038361C10CB. These catalog numbers are integral assemblies which include the link, cartridge and end plug. For the above listed integral assemblies follow Step 5 and then tighten new cartridge/fuse/end plug against fuse holder using 50 to 70 in-lbs. torque; then, proceed to Step 9. For all other Bay-O-Net fuses, follow Steps 5 through 9.

### Step 5 - Remove fuse cartridge.

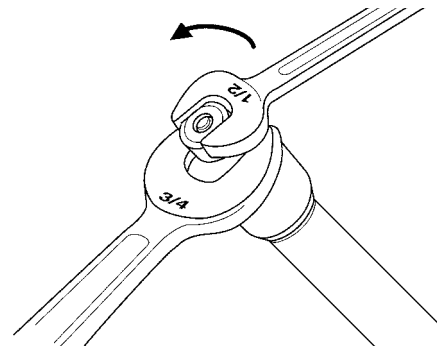
Use a 3/4 inch wrench to remove fuse cartridge from fuse cartridge holder (see Figure 12).



**Figure 12. Remove fuse cartridge holder.**

### Step 6 - Remove end plug and fuse link from fuse cartridge.

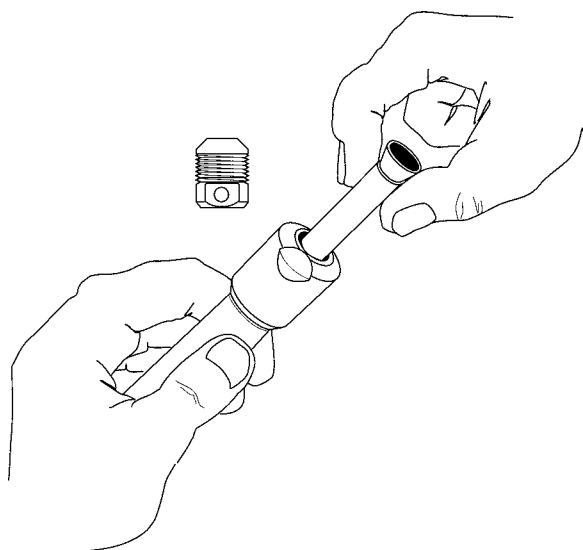
1. Use 3/4 inch and 1/2 inch wrenches to remove end plug (see Figure 13).
2. Use screwdriver or other tool to straighten tulip tip end of fuse link and push fuse link out of fuse cartridge. Replace fuse cartridge if damaged.



**Figure 13. Remove end plug from fuse cartridge.**

### Step 7 - Insert replacement fuse link into fuse cartridge (see Figure 14).

1. A slight resistance may occur when inserting fuse link into cartridge.
2. If the catalog number of the fuse being replaced is not known, consult specifications or contact your Eaton representative. Fuse catalog numbers may also be indicated on the transformer door and/or nameplate.



**Figure 14. Insert replacement fuse link.**

**Step 8 - Tighten cartridge to fuse cartridge holder.**

1. Tighten fuse contact flare end against fuse cartridge holder using 50 to 70 in-lbs. torque.
2. Replace end plug on the other end of fuse cartridge and tighten to 50 to 70 in-lbs. torque.
3. Remove end plug and ensure that petals of tulip tip have spread uniformly.
4. Replace end plugs, applying 50 to 70 in-lbs. torque to both connections.

**Step 9 - Install fuse holder.**

Use a hotstick to perform the following steps.

1. Pull pressure relief valve, holding it open until hissing stops, and then for another five seconds.
2. Attach end of fuseholder assembly to hotstick and insert holder assembly firmly into Bay-O-Net housing.
3. Twist locking handle so that latch engages Bay-O-Net housing's shoulder, and steel washer seats tightly on end of tube of Bay-O-Net holder assembly.

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**CAUTION**

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**Visually inspect entire fuseholder assembly to ensure it is installed properly.**

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**Internal cartridge fuse**

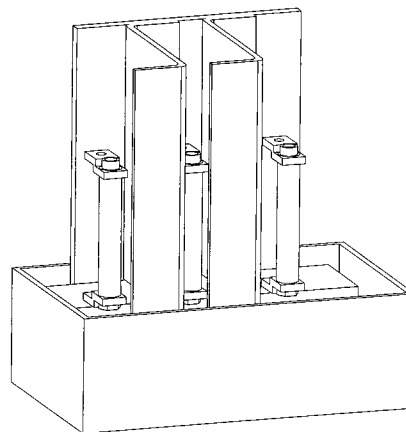
**WARNING**

**Hazardous voltage. Can cause severe injury, death, or damage to equipment. Turn off power to transformer before servicing internal cartridge fuses. Ground transformer following industry accepted safe grounding practices.**

Internal cartridge fuses are "weak link" expulsion-type fuses used to protect transformers and distribution systems. Internal cartridge fuse assemblies are mounted inside the transformer tank and are compatible for use in many insulating liquids. See fuse manufacturer's product literature for maximum interrupting ratings.

**Internal cartridge fuse replacement**

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals.
2. Remove tank cover as outlined in **Tank Cover Removal and Installation** section of this manual.
3. Locate cartridge fuse assembly (see Figure 15) on back tank wall.



**Figure 15. Cartridge fuse assembly.**

4. Carefully remove all nuts that attach wire leads to fuse, making sure not to drop nuts into the transformer tank. Note position of all nuts, flat washers, spring washers, etc., so that they can be reinstalled in the same locations.
5. Replace fuses as required. Reconnect leads and re-install washers and nuts in original locations.
6. Re-install cover as outlined in **Tank Cover Removal and Installation** section of this manual.

## Internal loadbreak switches

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### WARNING

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**Hazardous voltage. Can cause severe injury, death, or damage to equipment.**

- **Do not operate loadbreak equipment if a fault condition is suspected. Doing so can cause an explosion or fire.**
- **Use a hotstick to operate transformer loadbreak equipment.**
- **After operating transformer loadbreak equipment, check that voltages at transformer terminals are the expected values. Checking voltages verifies that loadbreak equipment operated properly and that electrical circuit conditions are as expected.**
- **Before servicing transformer secondary connected equipment, verify that all transformer secondary terminals have zero voltage and ground the transformer secondary terminals following industry accepted safe grounding practices. Grounding secondary terminals protects against situations such as a standby generator energizing transformer from the secondary circuit.**
- **Before servicing transformer, ALWAYS de-energize the transformer from a remote upstream source and then proceed to ground all primary and secondary transformer terminals following industry accepted safe grounding practices. Grounding secondary terminals protects against situations such as a standby generator energizing transformer from the secondary circuit.**
- **Follow industry accepted safety practices. Utilize protective clothing and equipment when working with loadbreak equipment.**

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### WARNING

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Three-phase pad-mounted transformers use conventional transformer oil, R-Temp fluid, or Envirotemp™ FR3™ fluid for an insulating liquid. When the insulating liquid temperature is less than -20 °C (-4 °F) for conventional transformer oil, less than 0 °C (32 °F) for R-Temp fluid or less than -10 °C (14 °F) for Envirotemp™ FR3™ fluid, viscosity is reduced, which may reduce make and break capabilities of loadbreak devices. Below these temperatures, under-oil loadbreak accessories should not be used to make or break a load. Instead, de-energize transformer from a remote upstream source before operating under-oil loadbreak devices.

It is recommended that remote energization be used whenever possible. Operate loadbreak switches using hotstick tool. After loadbreak switch is switched to "OPEN" position, verify that transformer secondary terminals have zero voltage and then ground the secondary terminals to prevent transformer backfeed energization.

## Two-position loadbreak switch

The operating mechanism of the Eaton's Cooper Power series two-position loadbreak switch employs a manually-charged over-toggle stored spring assembly which performs independent of operator speed. The spring-loaded activating mechanism ensures quick loadbreak or loadmake operations in less than one cycle. Incorporated into the switch mechanism are internal stops that restrict the handle orientation to only two positions: "OPEN" and "CLOSED" (see Figure 16). The switch should be hotstick-operated and will require 15 ft-lbs. minimum input torque to operate.

Refer to *Catalog Section CA800019EN Two-Position Sidewall (Horizontal) and Cover (Vertical) Mounted Loadbreak Switches* for two-position loadbreak switch ratings.

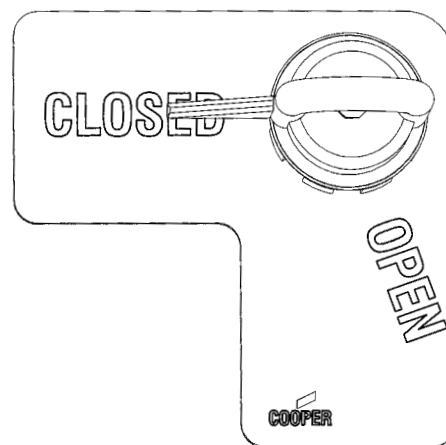


Figure 16. Two-position loadbreak switch handle and indicator plate.

## External visible loadbreak switch

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### CAUTION

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**Always fully cover and lock external visible loadbreak switch window during operation. Failure to cover and lock this window could cause personal injury. Before operating the on/off/ground switch, it is important to ensure the transformer tank has been fully grounded. Always check fluid temperature before operating loadbreak devices.**

The Eaton's Cooper Power series external visible loadbreak switch is a great way to verify isolation of internal transformer circuitry. Having visual confirmation that the secondary bushings are de-energized saves both time and money, while providing an added safety feature. It is strongly recommended that if breaking load with this switch, the viewing window be fully covered and locked into place. Viewing this switch during operation under load could be dangerous to the human eye. The external visible loadbreak switch is always shipped with a padlockable cover box. It is also important to remember that even after breaking load, the incoming high voltage cables are still live and dangerous.

### Sectionalizing loadbreak switch

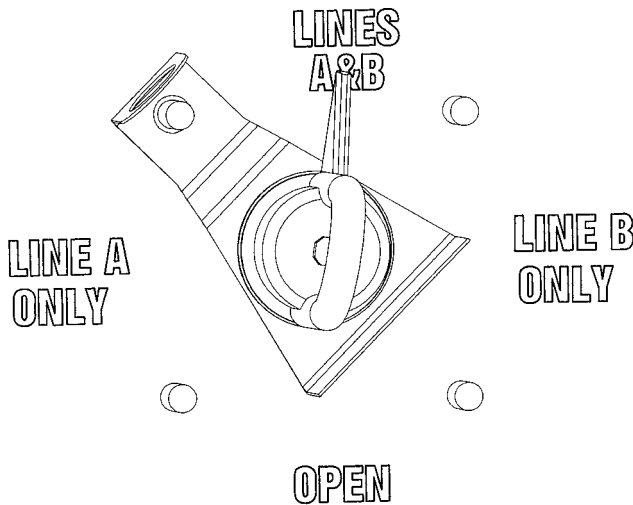
Eaton's Cooper Power series sectionalizing loadbreak switch rotates 360° in either direction for alternate source selection. An externally-installed index plate prevents rotation to positions other than the one desired. The switch cannot be switched more than one position without resetting the index plate.

A spring-loaded activating mechanism ensures quick loadbreak action and positive contact engagement through all positions. Switching can be accomplished in less than one cycle, and should be performed with a hotstick. To follow are operation examples for the two most common sectionalizing switch configurations.

The following is a V-blade switch operation example (see Figure 17):

If "A" is the feeder and it is desired to switch to "B" feeder, then the V-blade switch can be rotated as follows:

1. Set index stop plate between "line A only" and "Open".
2. Rotate switch handle counterclockwise to "Open". Transformer and loop conductor are now "Open".
3. Move index plate between "Open" and "line B only".
4. Rotate switch handle counterclockwise to "line B only". Transformer is now energized for "B" feeder.



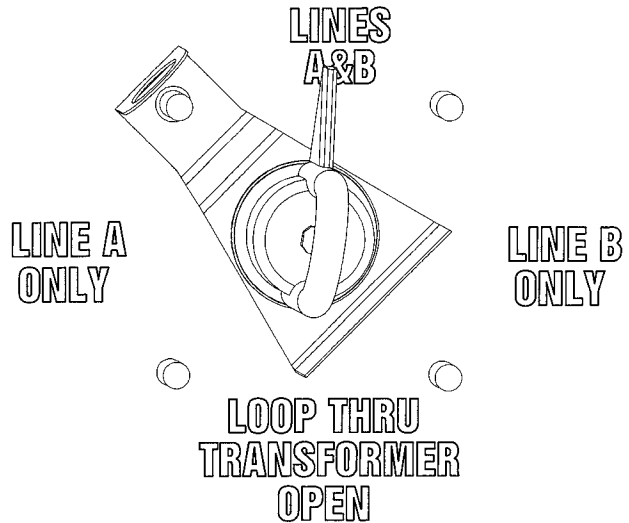
**Figure 17. V-blade four-position sectionalizing switch handle and index plate.**

The following is a T-blade switch operation example (see Figure 18):

If "A" is the feeder and it is desired to switch to "B" feeder, the T-blade switch can be rotated as follows:

1. Set index stop plate between "line A only" and "loop thru transformer open".
2. Rotate switch handle counterclockwise to "loop thru transformer open". The transformer is now "OPEN" and the loop conductor is electrically connected.

3. Move index plate between "loop thru transformer open" and "line b only".
4. Rotate switch handle counterclockwise to "line b only". The transformer is now energized for "B" feeder.



**Figure 18. T-blade four-position sectionalizing switch handle and index plate.**

For switch ratings and additional switch configurations refer to *Catalog Section CA800005EN, Four-Position Sectionalizing Loadbreak Switches*.

### **WARNING**

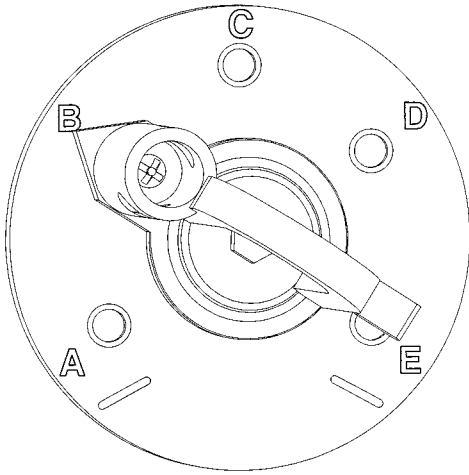
**Hazardous voltage. Can cause severe injury, death, or damage to equipment. De-energize transformer from a remote upstream source before operating non-loadbreak tap-changers, dual-voltage switches, or delta-wye switches.**

### Tap-changer

Transformers equipped with a tap-changer can be changed from one operating voltage to another. The transformer must be de-energized and grounded before the tap-changer is operated. Operating voltages accessible through use of the tap-changer are indicated on the transformer nameplate.

On most three-phase pad-mounted transformers equipped with tap-changers, the tap-changer operating handle is located on the faceplate in the high-voltage terminal compartment.

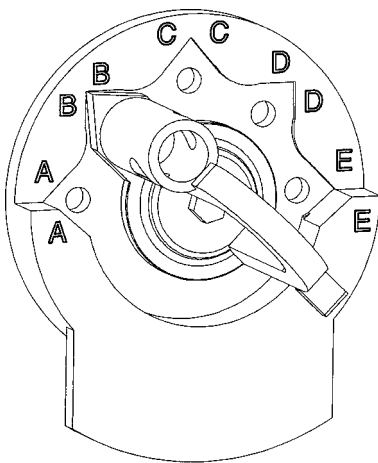
The standard style of tap-changer will have a hotstick-operable handle. There are two styles of tap-changer with this type of handle, each requiring a slightly different method for changing tap settings.



**Figure 19. Hotstick-operable tap-changer (Style I).**

The tap-changer shown in Figure 19 can be switched to a new tap position as follows:

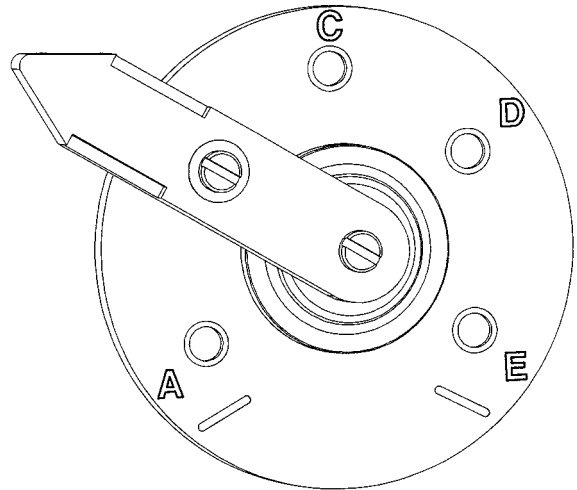
1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals before operating the tap switch.
2. Back out lock screw to clear index plate.
3. Rotate handle to desired position.
4. Secure handle in its new position by tightening lock screw through index plate until it bottoms.
5. Padlocking may be accomplished through hole provided.



**Figure 20. Hotstick-operable tap-changer (Style II).**

The tap-changer shown in Figure 20 can be switched to a new tap position as follows:

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals before operating the tap switch.
2. Back out lock screw to clear index plate.
3. Pull handle out to clear index plate.
4. Rotate handle to desired position and allow pointer to drop into slot of index plate.
5. Secure handle in its new position by tightening lock screw through index plate until it bottoms.
6. Padlocking may be accomplished through hole provided.



**Figure 21. Lever handle tap-changer.**

On some transformers, tap-changers have a lever handle (see Figure 21). A lock screw secures the handle at a particular setting. Such tap-changers can be switched to a new position as follows;

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals before operating the tap switch.
2. Back out lock screw to clear index plate.
3. Rotate handle to desired position.
4. Secure handle in its new position by tightening lock screw through index plate until it bottoms.

## Dual-voltage and delta-wye switch

### WARNING

**Hazardous voltage. Can cause severe injury, death, or damage to equipment. De-energize transformer from a remote upstream source before operating non-loadbreak tap-changers, dual-voltage switches, or delta-wye switches.**

### CAUTION

**Excessive current. Can cause damage to transformer winding. When dual-voltage or delta-wye switches are set to connect transformer windings in parallel, tap-changers must be in the position shown on the transformer nameplate.**

Transformers equipped for dual-voltage or delta-wye (reconnectable winding) operations usually have an externally-operable switch mounted on the faceplate in the high-voltage terminal compartment. Units combining dual-voltage and delta-wye may have two separate switches. The transformer must be de-energized and grounded before dual-voltage or delta-wye switches are operated. Attempting to change dual-voltage or delta-wye switches on an energized transformer may result in damage to the equipment and severe personal injury.

Dual-voltage windings are either connected in series (for the higher voltage) or in parallel (for the lower voltage). Dual-voltage and delta-wye switches have two positions. Switch positions are identified on the transformer nameplate and marked by corresponding numerals on the switch mounting plate.

When dual-voltage or delta-wye switches are set to connect transformer windings in parallel, tap-changers must be in the position shown on the transformer nameplate. Tap-changers cannot be used to adjust voltage when transformer windings are connected in parallel. Improper tap-changer settings will cause circulating currents in the windings, which will damage the windings and cause failure of the transformer.

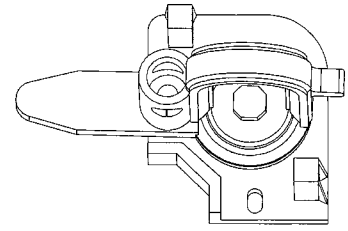
### To change dual winding switch settings:

The standard type of dual-voltage or delta-wye switch will have a hotstick-operable handle (see Figure 22).

This type of dual-voltage or delta-wye switch can be switched to a new position as follows:

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals before operating dual-voltage or delta-wye switch.
2. Back out lock screw to clear index plate.
3. Pull handle out to clear index plate and rotate handle 90°. Drop handle into new position.
4. Secure handle in its new position by tightening lock screw through index plate until it bottoms.

12.47 KV



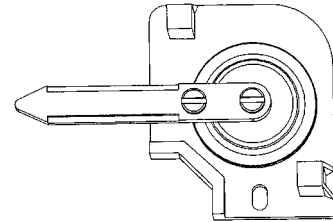
4.16 KV

**Figure 22. Dual-voltage/delta-wye switch (hotstick-operable).**

5. Padlocking may be accomplished through hole provided.

On some transformers, dual-voltage or delta-wye switches have a lever handle (see Figure 23).

12.47 KV



4.16 KV

**Figure 23. Dual-voltage/delta-wye switch (lever handle).**

This type of dual-voltage or delta-wye switch can be switched to a new position as follows:

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals before operating dual-voltage or delta-wye switch.
2. Back out lock screw to clear index plate.
3. Rotate handle 90° to new position.
4. Secure handle in its new position by tightening lock screw through index plate until it bottoms.



## Vacuum fault interrupter (VFI)

### WARNING

Hazardous voltage. Can cause severe injury, death, or damage to equipment.

- Do not operate loadbreak equipment if a fault condition is suspected. Doing so can cause an explosion or fire.
- Use a hotstick to operate transformer loadbreak equipment.
- After operating transformer loadbreak equipment, check that voltages at transformer terminals are the expected values. Checking voltages verifies that loadbreak equipment operated properly and that electrical circuit conditions are as expected.
- Before servicing transformer secondary connected equipment, verify that all transformer secondary terminals have zero voltage and ground the transformer secondary terminals following industry accepted safe grounding practices. Grounding secondary terminals protects against situations such as a standby generator energizing transformer from the secondary circuit.
- Before servicing transformer, ALWAYS de-energize the transformer from a remote upstream source and then proceed to ground all primary and secondary transformer terminals following industry accepted safe grounding practices. Grounding secondary terminals protects against situations such as a standby generator energizing transformer from the secondary circuit.
- Follow industry accepted safety practices. Utilize protective clothing and equipment when working with loadbreak equipment.

### WARNING

Three-phase pad-mounted transformers use conventional transformer oil, R-Temp fluid, or Envirotemp™ FR3™ fluid for an insulating liquid. When the insulating liquid temperature is less than -20 °C (-4 °F) for conventional transformer oil, less than 0 °C (32 °F) for R-Temp fluid or less than -10 °C (14 °F) for Envirotemp™ FR3™ fluid, viscosity is reduced, which may reduce make and break capabilities of loadbreak devices. Below these temperatures, under-oil loadbreak accessories should not be used to make or break a load. Instead, de-energize transformer from a remote upstream source before operating under-oil loadbreak devices.

## IMPORTANT

**For 75 °C AWR transformers, applications with maximum ambient temperatures exceeding 30 °C or loading in excess of nameplate rating, contact your Eaton representative.**

Eaton's Cooper Power series VFI transformers utilize vacuum interrupters to provide fault current interruption and load make/break switching capabilities. The VFI transformer uses the same technology used in Eaton's Cooper Power series VFI pad-mounted switchgear.

VFI transformers can be specified for either transformer protection or loop protection. A VFI transformer with transformer protection protects the transformer and provides proper coordination with upstream protective devices. A VFI transformer with loop protection protects the loop or downstream section of a feeder. Consequently, when a fault occurs downstream, the VFI breaker trips and isolates the fault, leaving the transformer load uninterrupted.

The VFI interrupter mechanism in a VFI transformer has a hotstick-operable handle located on the faceplate of the transformer, with the operating mechanisms configured for ganged three-phase operation (see Figure 24). The VFI interrupter mechanism is opened by pulling the operation handle down to the open position. The VFI interrupter mechanism is closed by briskly pushing the handle up, into the closed position. If the VFI interrupter mechanism has tripped as the result of a fault or overload condition, the mechanism must be reset before it can be closed. To reset the mechanism, firmly pull the operation handle down toward the ground until the latch resets. After the latch has been successfully re-set, the VFI interrupter mechanism can be closed normally.

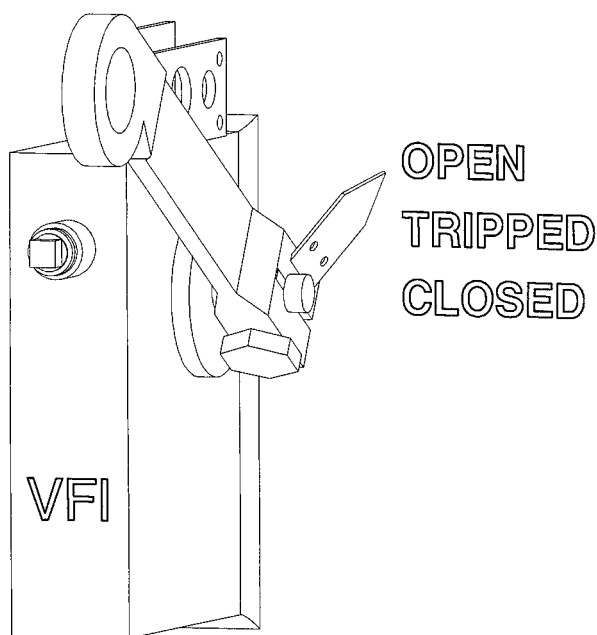


Figure 24. VFI operating handle.

Current-sensing transformers (CTs) located inside the VFI transformer provide line current information to the electronic control. When line current exceeds the minimum trip setting, the control initiates a signal which causes the VFI interrupter mechanism to trip and then interrupt the circuit. All three phases will open when the VFI interrupter mechanism is tripped, regardless of whether the trip was single-phase or three-phase initiated.

Refer to *Service Information S285-75-1, Tri-Phase, TPG, and TPG with SCADA Electronic Control Installation and Operation Instructions* for electronic control operation instructions.

Standard electrical ratings for Eaton VFI transformers are as follows:

|   |             |
|---|-------------|
| Continuous Current (max) . . . . .            | 600 A       |
| Interrupting Current (sym./asym.) . . . . .   | 12 kA/20 kA |
| Momentary Current 10 cycles (asym.) . . . . . | 20 kA       |
| 1-Second Withstand Current (sym.) . . . . .   | 12 kA       |
| Making Current (sym.) . . . . .               | 12 kA       |

For further information on Eaton VFI transformers including additional ratings, contact your Eaton representative.

## Air switches (Arc-Strangler®)

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### WARNING

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**Hazardous voltage. Can cause severe injury, death, or damage to equipment.**

- **Do not operate loadbreak equipment if a fault condition is suspected. Doing so can cause an explosion or fire.**
- **Use a hotstick to operate transformer loadbreak equipment.**
- **After operating transformer loadbreak equipment, check that voltages at transformer terminals are the expected values. Checking voltages verifies that loadbreak equipment operated properly and that electrical circuit conditions are as expected.**
- **Before servicing transformer secondary connected equipment, verify that all transformer secondary terminals have zero voltage and ground the transformer secondary terminals following industry accepted safe grounding practices. Grounding secondary terminals protects against situations such as a standby generator energizing transformer from the secondary circuit.**
- **Before servicing transformer, ALWAYS de-energize the transformer from a remote upstream source and then proceed to ground all primary and secondary transformer terminals following industry accepted safe grounding practices. Grounding secondary terminals protects against situations such as a standby generator energizing transformer from the secondary circuit.**
- **Follow industry accepted safety practices. Utilize protective clothing and equipment when working with loadbreak equipment.**

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### WARNING

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**Three-phase pad-mounted transformers use conventional transformer oil, R-Temp™ fluid, or Envirotemp™ FR3™ fluid for an insulating liquid. When the insulating liquid temperature is less than -20 °C (-4 °F) for conventional transformer oil, less than 0 °C (32 °F) for R-Temp fluid or less than -10 °C (14 °F) for Envirotemp™ FR3™ fluid, viscosity is reduced, which may reduce make and break capabilities of loadbreak devices. Below these temperatures, under-oil loadbreak accessories should not be used to make or break a load. Instead, de-energize transformer from a remote upstream source before operating under-oil loadbreak devices.**

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**⚠ WARNING**

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**Hazardous voltage. Can cause severe injury, death, or damage to equipment. Depending on configuration, Arc-Strangler fuses or switchblades may be energized even when in the “open” position. Refer to catalog section 240-60 for further information.**

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### Arc-Strangler loadbreaking device with NX® fusing

NX® full-range current-limiting fuses up to 15.5 kV can be ordered with an integral Arc-Strangler® loadbreaking device. These in-air devices are mounted on the faceplate of the transformer. The Arc-Strangler device has the same operating characteristics as the basic NX clip-style fuse, along with loadbreaking capabilities.

The Arc-Strangler loadbreaking device is a spring-loaded sliding sleeve that extinguishes the arc drawn between the mounting contacts and the fuse conductor when the fuse is opened while load current is flowing. All magnitudes of current through the continuous current rating of the fuse can be interrupted positively and safely under proper conditions. A pull-ring at the top of the fuse assembly (for hotstick operation) and a hinge at the bottom complete the loadbreak device.

### Arc-Strangler switchblades

Switchblades with integral Arc-Strangler loadbreaking devices are available for use in NX type fuse mountings. Arc-Strangler switchblades are designed to break load current only (up to 200 A) and do not incorporate a fuse of any type for overload or fault interruption.

### Surge arresters

Surge arresters are used in three-phase pad-mounted

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**⚠ WARNING**

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**Hazardous voltage. Can cause severe injury, death, or damage to equipment. De-energize transformer from a remote upstream source before servicing or operating surge arresters or disconnect switches. Check that all transformer terminals and bushings have zero voltage. Ground transformer following industry accepted safe grounding practices.**

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**⚠ CAUTION**

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**Excessive test voltage can damage surge arresters. Disconnect surge arresters before running impulse or applied potential tests on the transformer.**

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transformers to protect underground distribution equipment and cable from overvoltage surges. During steady state conditions, line-to-ground voltage is applied continuously across the arrester terminals. When surges occur, the arrester immediately limits the overvoltage to the required protective level by conducting the surge current to ground. Upon passage of the surge, the arrester returns to its initial state, conducting minimal leakage current.

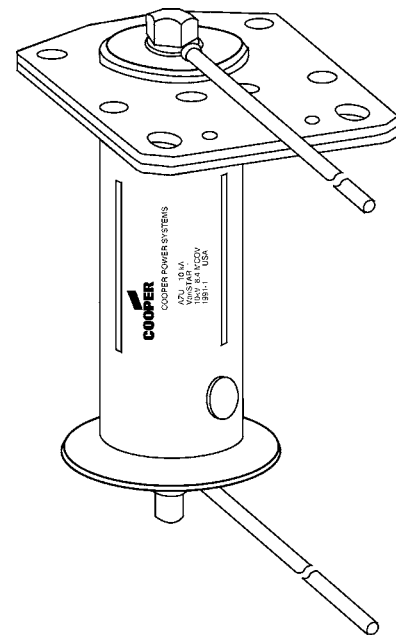
Surge arresters should be installed only on systems where the power frequency voltage at the arrester does not exceed published maximum continuous operating voltage (MCOV) values.

The transformer should not be tested (impulse or applied potential) with the arrester connected. If connected during impulse tests, the arrester will clamp the discharge voltage applied by the test equipment. If the arrester is connected to the transformer during an applied potential test, there is a possibility that the arrester will be damaged. Disconnect surge arresters before tests are performed on the transformer. Arresters should be reconnected immediately after tests are completed.

### Under-oil MOV arrester

Eaton's Cooper Power series heavy-duty distribution-class under-oil MOV arrester is designed to be mounted inside the transformer tank (see Figure 25). Internal, under-oil mounting of the arrester prevents shortened arrester life due to surface contamination, wildlife damage, vandalism, or moisture ingress.

Under-oil arresters are designed to operate when submerged in oil. It is recommended that the average oil temperature not exceed 90 °C and that the maximum oil temperature not exceed 125 °C.



**Figure 25. Heavy-duty distribution-class under-oil MOV arrester.**

### Under-oil arrester disconnection during test (with arrester disconnect switch)

Eaton's Cooper Power series arrester disconnecter provides a means of disconnecting and reconnecting an under-oil arrester ground for transformer testing. Separate disconnecters are used for each arrester in the transformer, and are located on the transformer faceplate.

#### The arrester disconnecter is operated as follows:

##### Operating from closed to open position (see Figure 26):

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals.
2. Unscrew handle from shaft.
3. Re-attach small diameter end of handle to shaft.
4. Push handle and shaft toward transformer until shaft flange (adjacent to handle) is flush to sealing gland.
5. Transformer is now ready for Impulse or Applied Potential testing.

##### Operating from open to closed position:

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals.
2. Pull handle and shaft away from transformer completely.
3. Unscrew handle and re-attach with large diameter end toward the transformer. To assure good ground contact, the handle should be re-tightened by rotating handle 3/4 to 1 turn after handle has come in contact with seal gland.

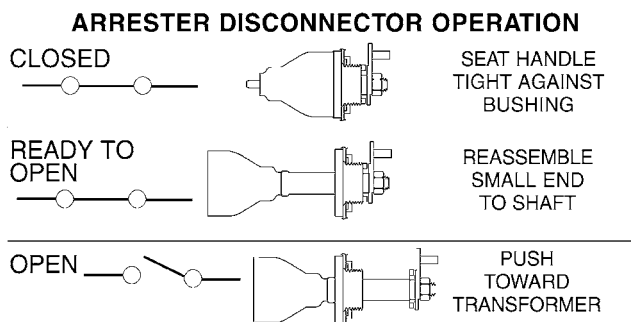


Figure 26. Arrester disconnecter operation.

### Under-oil arrester disconnection during test (without arrester disconnect switch)

#### CAUTION

**Before opening the transformer tank for internal maintenance, read the Insulating Liquid Maintenance section in this manual. This section explains safety precautions that should be taken and gives instructions on how to prevent insulating liquid contamination.**

##### To disconnect arresters without a disconnect switch:

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals.
2. Remove tank cover following procedures in **Tank Cover Removal and Installation** section of this manual.
3. Locate arrester ground lead pad (see Figure 27) attached to tank wall.
4. Disconnect arrester ground leads from ground lead pad and separate leads ends a minimum of 5" from each other and from any part of the transformer.
5. Transformer is now ready for impulse or applied potential testing.

##### To reconnect:

1. Reconnect arrester ground leads to ground lead pad.
2. Re-install tank cover as outlined in **Tank Cover Removal and Installation** section of this manual.

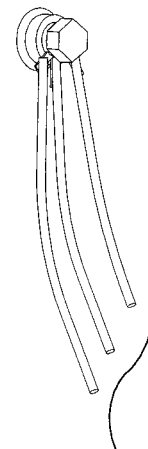


Figure 27. Under-oil arrester jumper ground lead pad with ground leads.

## External arrester

External surge arresters ordered with the transformer must be installed and connected in the field before the transformer is put into service.

Arrester and tank ground connections must be completed before the transformer is connected to the high-voltage or low-voltage lines. Proper connection places the arrester in a direct shunt relationship to the transformer insulation.

## Maintenance

### Exterior maintenance

On an annual or more frequent interval, inspect all exposed surfaces for evidence of tampering, battered metal, gouges, etc. Dents or deformities should be repaired at once. Scratched or weathered paint or protective coatings should be touched up promptly.

Keep the area around the transformer clean. Do not store tools, materials or equipment on or against the transformer.

### Cabinet interior maintenance

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 **WARNING**

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**Hazardous voltage. Can cause severe injury, death, or damage to equipment. De-energize transformer from a remote upstream source before opening cabinet and doing cabinet interior inspection or maintenance. Check that all transformer terminals and bushings have zero voltage. Ground transformer following industry accepted safe grounding practices.**

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Periodically inspect the terminal compartment interior and all operating equipment. Check all gauges and controls for proper operation. Repair or replace damaged or defective equipment.

Inspect drain cocks, plugs, fuse mountings, and switches. Look for evidence of insulating liquid seepage around tank-wall gaskets, seals, etc. Repair as required.

Replacement of gaskets or seals in the tank wall may require that the tank be opened and the insulating liquid lowered to the appropriate level. For instruction on opening the tank and for draining and replacing the insulating liquid, refer to the **Insulating Liquid Maintenance** section in this manual.

## Tank internal maintenance

*(For Envirotran® Transformers see the Envirotran Transformers section of this manual before continuing)*

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 **CAUTION**

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**Elevated Pressure. Can cause personal injury or damage to transformer. Release internal pressure with pressure relief device before removing tank cover, manhole cover or handhole cover.**

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 **WARNING**

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**Hazardous voltage. Can cause severe injury, death, or damage to equipment. De-energize transformer from a remote upstream source before opening cabinet and doing internal tank inspection or maintenance. Check that all transformer terminals and bushings have zero voltage. Ground transformer following industry accepted safe grounding practices.**

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Service to bushings or equipment inside the transformer tank will require that the tank be opened and the insulating liquid lowered to the appropriate level. Before opening the transformer tank, read the **Insulating Liquid Maintenance** section in this manual. The **Liquid Maintenance** section explains safety precautions that should be taken and gives instructions on how to prevent insulating liquid contamination. Precautions must be taken to prevent dirt or moisture from entering the opened transformer tank. Contamination of the insulating liquid will prevent the transformer from operating properly and may cause serious damage to the transformer.

Three-phase pad-mounted transformers may have either bolt-on or weld-on main tank covers. Bolt-on covers can be removed to access the tank interior. Access to the interior of a transformer with a weld-on tank cover is typically through a manhole/handhole. To gain additional internal access to tanks with weld-on tank covers, the tank cover must be cut open.

### Tank cover removal and installation

*(For Envirotran Transformers see the Envirotran Transformers section of this manual before continuing)*

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 **CAUTION**

---

**Elevated Pressure. Can cause personal injury or damage to transformer. Release internal pressure with pressure relief device before removing tank cover, manhole cover or handhole cover.**

---

---

 **WARNING**

---

**Hazardous voltage. Can cause severe injury, death, or damage to equipment. De-energize transformer from a remote upstream source before opening cabinet and doing internal tank inspection or maintenance. Check that all transformer terminals and bushings have zero voltage. Ground transformer following industry accepted safe grounding practices.**

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Transformers that have been system-connected should be de-energized, grounded, and disconnected before being opened for inspection.

If the tank seal is broken, it is recommended that a leak test be performed to verify that the tank is properly sealed. To leak test, remove the pressure relief device and pressurize the headspace. The test pressure should not exceed 7 psig. The established pressure should be maintained for at least four hours to insure that all the seals are proper.

### **Bolt-On tank cover removal**

Transformer tanks are factory-sealed to prevent ingress of ambient air and moisture. Do not open under any precipitation conditions.

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals before removing cover.
2. Thoroughly clean tank cover to help prevent contamination of insulating liquid when removing the cover. Remove all dirt, grease, and moisture.
3. From within the cabinet, remove the hardware (3/8" nuts using a 9/16" socket) which attaches the cover nutguard to the faceplate.
4. Relieve internal tank pressure by operating the pressure relief valve. Remove the hardware (3/8" nuts using a 9/16" socket) which attaches the cover to the tank.
5. Gently pry the cover upward. Do not allow the cover gasket to come in contact with the transformer insulating liquid. Allowing the gasket to contact the liquid will make it slippery and difficult to hold in position during cover installation. Lift cover straight up to prevent damage to cover, bolts, and tank gasket.
6. Note the location and orientation (up/down) of each gasket section as they are removed from the tank flange so that they can be reinstalled properly.

### **Bolt-On tank cover installation**

1. Return the gasket sections to their original positions and orientation.
2. Re-install the cover, using 25 ft-lbs. torque to tighten the cover hardware. After installing all the nuts, re-torque each nut to ensure proper torque is achieved.
3. Remove the pressure relief valve and pressurize the headspace through the pressure relief valve coupling to ensure that there are no leaks. Test pressure should not exceed 7 psig. Established pressure should be maintained for at least four hours to insure that all seals are proper.
4. Re-install the nutguard using 25 ft-lbs. torque to tighten nutguard access hardware.
5. Re-install pressure relief valve.

### **Bolt-On manhole/handhole cover removal**

Transformer tanks are factory-sealed to prevent ingress of ambient air and moisture. Do not open under any precipitation conditions.

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals before removing cover.
2. From within cabinet, remove hardware (3/8" nuts using a 9/16" socket) attaching manhole/handhole access cover to cabinet.
3. Remove manhole/handhole access cover.
4. Thoroughly clean tank and manhole/handhole cover to help prevent contamination of insulating liquid when removing manhole/handhole cover. Remove all dirt, grease, and moisture.
5. Relieve internal tank pressure by operating pressure relief valve.
6. Remove hardware (3/8" nuts using a 9/16" socket) attaching manhole/handhole cover to tank.
7. Gently pry cover upward. Do not allow cover gasket to come in contact with transformer insulating liquid. Allowing the gasket to contact the liquid will make it slippery and difficult to hold in position during cover installation. Lift cover straight up to prevent damage to cover, bolts, and tank gasket.
8. Note location and orientation (up/down) of each gasket section as they are removed from tank flange so they can be re-installed properly.

### **Bolt-On manhole/handhole cover installation**

1. Return gasket sections to their original positions and orientation.
2. Re-install manhole/handhole, using 25 ft-lbs. torque to tighten hardware. After installing all nuts, re-torque each nut to ensure proper torque is achieved.
3. Remove pressure relief valve and pressurize headspace through pressure relief valve coupling to ensure that there are no leaks. Test pressure should not exceed 7 psig. Established pressure should be maintained for at least four hours to ensure that all seals are proper.
4. Re-install access cover using 25 ft-lbs. torque to tighten access cover hardware.
5. Re-install pressure relief valve.

## Weld-on tank cover removal



**Explosive gas. Can cause severe injury, death, or damage to equipment. Before cutting open a weld-on tank cover, fill tank headspace with nitrogen gas. Keep nitrogen gas flowing while cutting. Keep tank headspace filled with nitrogen until cutting is finished.**

Transformer tanks are factory-sealed to prevent ingress of ambient air and moisture. Do not open under any precipitation conditions.

Explosive gases can develop inside a transformer tank headspace during the life of the transformer. It is strongly recommended that weld-on cover removal be done only in a controlled repair facility by experienced maintenance personnel. To prevent explosions, the following procedures must be followed during weld-on cover removal:

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals before removing cover.
2. Relieve internal tank pressure by operating pressure relief valve.
3. Remove manhole/handhole cover as outlined in the **Tank Cover Removal and Installation** section of this manual.
4. Drain insulating liquid to the top of core clamp as outlined in the **Insulating Liquid Maintenance** section of this manual.
5. Allow transformer to sit with manhole/handhole removed for a minimum of 24 hours to allow explosive gases to escape.
6. Place a rubberized blanket on top of core clamp and completely cover core/coil assembly to protect core/coil assembly from weld spatter contamination during cover cutting.
7. Remove pressure relief valve and attach a nitrogen source in its place.
8. Fill headspace with nitrogen with manhole/ handhole cover still removed. Nitrogen gas will help prevent a volatile gas explosion while tank cover is being cut off.
9. While continuing to keep nitrogen flowing into the headspace, use carbon air arc machinery or a hand-wheel grinder to cut cover weld.
10. Thoroughly clean tank cover to help prevent contamination of insulating liquid when removing cover. Remove all dirt, grease, and moisture.
11. Remove tank cover from tank.

## Weld-on tank cover installation

1. Grind smooth and then clean cover, removing all weld spatter accumulated during cover removal.
2. It is recommended that the tank weld rope gasket be replaced around the tank lip prior to re-installing cover. The tank weld rope gasket helps prevent weld spatter from entering the tank during cover weld. The rubberized blanket installed during cover removal should still be covering the core/coil assembly.
3. Re-position cover on tank.
4. Fill headspace with nitrogen through pressure relief valve coupling, with manhole/handhole still removed.
5. Continue to keep nitrogen source flowing into headspace, and weld cover fully around the tank lip.
6. Remove rubberized blanket that was installed during cover removal.
7. Refill insulating liquid as outlined in **Insulating Liquid Maintenance** section of this manual.
8. Re-install manhole/handhole cover as outlined in **Tank Cover Removal and Installation** section of this manual.
9. Pressurize headspace through pressure relief valve coupling to insure that there are no leaks. The test pressure should not exceed 7 psig. The established pressure should be maintained for at least four hours to ensure that all seals are proper.
10. Re-install pressure relief valve.

## Bushing removal and replacement

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals before performing maintenance on bushings.
2. Open tank by removing tank cover or manhole/handhole cover as outlined in **Tank Cover Removal and Installation** section of this manual.
3. Lower insulating liquid level as outlined in **Insulating Liquid Maintenance** section of this manual. Lower liquid level to completely expose the bushing.
4. Disconnect all internal and external cable and leads. Note position of all nuts, flat washers, spring washers, etc., so they can be re-installed in same locations.
5. Remove all bushing clamp hardware, noting position of all nuts, flat washers, spring washers, etc., so they can be re-installed in same locations.
6. Remove external bushing clamp, bushing, and gasket.
7. Install a new bushing and gasket. Center bushing and gasket to obtain an effective seal. Install exterior bushing clamp and clamp hardware. Tighten clamp nuts per torque specified in Table 1.
8. Re-connect all external and internal cables and leads. Replace all nuts, flat washers, spring washers, etc., in their original position. Tighten all connections per torque specified in Table 1.
9. Restore insulating liquid to appropriate level as outlined in **Insulating Liquid Maintenance** section of this manual. Close, reseal, and leak test tank as outlined in the Tank Cover Removal and Installation section of this manual. Inspect bushing-to-tank seal for leaks or seepage.

## Cabinet removal and installation

### Cabinet removal

#### CAUTION

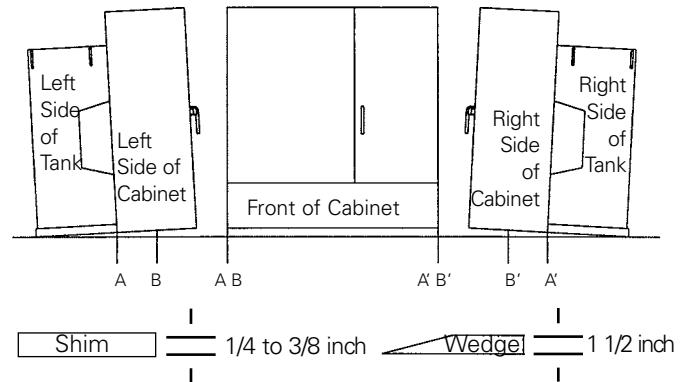
**Potential Falling Object. Can cause personal injury or damage to transformer. Do not open cabinet doors when cabinet is removed from transformer tank. Opening cabinet doors will cause cabinet to fall forward.**

#### WARNING

**Hazardous voltage. Can cause severe injury, death, or damage to equipment. De-energize transformer from a remote upstream source before opening cabinet and doing cabinet interior inspection or maintenance. Check that all transformer terminals and bushings have zero voltage. Ground transformer following industry accepted safe grounding practices.**

**Table 1. Bushing Hardware Tightening Torque**

| Bushings With Internal Spade Connections |                            |
|--|----------------------------|
| Clamp Type                               | Hardware Tightening Torque |
| Cast Aluminum Clamp                      | 70-80 in-lbs.              |
| Molded Polymer Tri-Clamp                 | 40-60 in-lbs.              |
| All other 3 & 4 hole Clamps              | 40-60 in-lbs.              |
| Bushings With Internal Stud Connections  |                            |
| Bushing Hardware                         | Hardware Tightening Torque |
| 1/2" Steel (Grade 8)                     | 50 ft-lbs.                 |
| 3/8" Steel (Grade 8)                     | 50 ft-lbs.                 |
| Bushings With Internal Stud Connections  |                            |
| Bushing Hardware                         | Hardware Tightening Torque |
| 3/8"-16 Brass Nuts                       | 16 ft-lbs.                 |
| 5/8"-11 Aluminum Nuts                    | 60 ft-lbs.                 |
| 5/8"-11 Brass Nuts                       | 75 ft-lbs.                 |
| 1"-14 Brass Nuts                         | 121 ft-lbs.                |
| Bushing Lead Block, 1/2" Steel Hardware  | 110 ft-lbs.                |



**Figure 28. Cabinet removal diagram.**

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals before performing maintenance on cabinet.
2. Place one 1/4 to 3/8 inch shim directly below faceplate on both sides of tank at points A and A' (see Figure 28).
3. Place one 1 1/2 inch wedge under each side of cabinet at points B and B' to relieve strain on the cabinet.
4. Note position and orientation of gasket that is between top of cabinet and tank so it can be re-installed in same fashion.
5. Disconnect HV-LV barrier from vertical bracket of faceplate.



6. Remove hardware attaching cabinet to faceplate on left and right sides of faceplate. Note position of all nuts, flat washers, spring washers, etc., so they can be re-installed in same locations.
7. Fully close HV and LV doors.
8. Slide cabinet assembly away from tank.

### **Cabinet installation**

Reverse removal procedure to re-install cabinet. Re-attach cabinet using shims under front of tank and wedges under sides of cabinet, making sure cabinet gasket is inserted into cabinet back channel prior to attaching cabinet. Tighten cabinet hardware to 20 ft-lbs. torque.

### **Insulating liquid maintenance**

Transformer tanks are factory-sealed to prevent ingress of ambient air and moisture. Do not open under any precipitation conditions.

If it is necessary to drain and refill the transformer, special care should be taken to avoid the entrapment of gas bubbles in the system. Gas bubbles have lower dielectric integrity than the insulating liquid and will degrade the performance characteristics of the insulating system.

### **Conventional oil-filled transformers**

Refer to IEEE Std C57.106™-2006 standard, "Guide For Acceptance and Maintenance of Insulating Oil in Equipment," for additional guidelines when testing and handling conventional transformer oil. Periodic maintenance tests should be performed.

### **R-Tran™ transformers**

Eaton's Cooper Power series R-Tran™ transformers are filled with R-Temp fluid. R-Temp fluid is a non-toxic, readily biodegradable, less-flammable (high fire point), high molecular weight hydrocarbon dielectric fluid.

Refer to IEEE Std C57.121™-1998 standard, "Guide for Acceptance and Maintenance of Less Flammable Hydrocarbon Fluids in Transformers." Periodic maintenance tests should be performed on the same schedule as would be used for transformers of similar application filled with conventional transformer oil.

Contact your Eaton representative for additional handling guidelines for R-Temp fluid.

### **Mixtures of R-Temp fluid and conventional transformer oil**

R-Temp fluid is fully miscible with conventional transformer oil. There is no known detrimental performance impact when R-Temp fluid is mixed with conventional transformer oil. Conversely, except for some reduction in flash and fire points, the same is true for conventional transformer oil mixed with R-Temp fluid. Conventional transformer oil

content of >3% in R-Temp fluid lowers the fire point below 300 °C. Measure the ASTM flash and fire points if the presence of conventional transformer oil is suspected. If flash or fire points fall below the minimum values required, refilling may be required.

### **Envirotran® transformers**

Eaton's Cooper Power series Envirotran® transformers are filled with Envirotemp™ FR3™ fluid. Envirotemp™ FR3™ fluid is a less-flammable (high fire point) dielectric fluid based on edible seed oils.

Periodic maintenance should be performed on the same schedule as would be used for transformers of similar application filled with conventional transformer oil. Basic recommended tests for Envirotemp™ FR3™ fluid are dielectric strength, moisture content, and flash and fire points.

Envirotran transformer tanks are shipped from the factory with a dry nitrogen-filled headspace. Internal pressure should not be equalized with atmosphere by manually opening the pressure relief valve device unless access to Bay-O-Net fuses or other internal tank components is required.

### **If internal service is required**

If the tank cover or manhole/handhole must be removed for internal service, exposure time to ambient air should be minimized. Avoid exposure times greater than 24 hours. Immediately after service is completed, replace the cover or manhole/handhole. The tank headspace must then be purged and recharged with dry nitrogen. Envirotran transformers are equipped with one or two 1/4" fill valves on the upper left and/or upper right corners of the face plate and are intended for the recharging process. The following steps should be followed when purging and recharging Envirotran transformers:

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals.
2. Release internal pressure by operating pressure relief device.
3. Fill headspace with dry nitrogen through one of the 1/4" fill valves to a pressure of 2-3 psig.
4. Release internal pressure by operating pressure relief device.
5. Refill headspace with dry nitrogen through one of the 1/4" fill valves to a pressure of 2-3 psig. Internal pressure must be maintained for at least four hours prior to transformer energization to verify seal integrity.

## Bay-O-Net fuse replacement

When replacing fuses in Flapper™ style Bay-O-Net fuse assemblies, refer to **Bay-O-Net Fuse Re-Fusing Instructions** in this manual. Follow the same procedure as with conventional oil-filled transformers.

## Operation

Eaton designs its transformers to operate at rated load with a temperature rise equal to or less than the temperature rise printed on the transformer's nameplate. Operating transformers in excess of IEEE Std C57.91™-2011 standard will result in accelerated loss of insulation system life. The coil insulation has been carefully made with thermally-upgraded materials to ensure long life at rated loads. Severe and prolonged overloads of mineral oil-filled transformers will result in overheating and accelerated aging of the insulation, which may lead to premature failure. PEAK™ transformers have extended life and can be operated at higher temperatures. Refer to IEEE Std C57.154™-2012 standard for details.

## Mixtures of Envirotemp™ FR3™ fluid and conventional transformer oil

Envirotemp™ FR3™ fluid is fully miscible with conventional transformer oil. There is no known detrimental performance impact when Envirotemp™ FR3™ fluid is mixed with conventional transformer oil. Conversely, except for some reduction in flash and fire points, the same is true for conventional transformer oil mixed with Envirotemp™ FR3™ fluid. Conventional transformer oil content of >7% in Envirotemp™ FR3™ fluid lowers the fire point below 300 °C. Measure the ASTM flash and fire points if the presence of conventional transformer oil is suspected. If flash or fire points fall below the minimum values required, refilling may be required. To maintain its exceptional environmental classification, mixing of Envirotemp™ FR3™ dielectric coolant with any other fluids should be avoided.

Contact your Eaton representative for additional handling guidelines for Envirotemp™ FR3™ fluid.

## Sampling insulating liquid

Before sampling the insulating liquid, verify that the tank is grounded. De-energize the transformer from a remote upstream source. Ground the bushings and terminals.

Refer to ASTM D923 "Standard Practices for Sampling Electrical Insulating Liquids" for sampling techniques.

A sample of the liquid should be taken when the liquid temperature is equal to or greater than the surrounding air to avoid condensation of moisture on the liquid.

Containers used for sampling liquid should be clean and dry large mouth glass bottles. Make sure that the liquid being sampled is representative of the liquid in the unit. Sufficient liquid must first be drawn off to ensure that the sample will be from the bottom of the tank, and not the liquid stored in the sampling pipe

## Testing insulating liquid

For the dielectric strength of the insulating liquids, follow the technique as specified by ASTM D877, "Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes."

If the dielectric strength of the liquid drops below 26 kV, it should be filtered until it tests at 26 kV or better.

## Filtering insulating liquid

Conventional transformer oil, R-Temp, or Envirotemp™ FR3™ fluids can be filtered by means of a filter press. The filter press is effective for removing all types of foreign matter, including finely divided carbon and small amounts of moisture. The purifier equipment consists of a specifically proportioned filter press, a positive volume gear pump, driving motor, combined drip pan and mixing tank, necessary piping, valves, strainer, gauges and drying oven. Follow manufacturer's instructions for purifier equipment operation.

Filtration should be continued until the dielectric test of the insulating liquid is 26 kV or better.

When filtering R-Temp or Envirotemp™ FR3™ fluid, the filtering equipment must be free of contaminants and other liquids. The presence of other liquids may alter the physical and electrical characteristics of R-Temp or Envirotemp™ FR3™ fluid. This could result in a reduction of fire point.

## Lowering insulating liquid level

1. Verify that tank is grounded. De-energize transformer from a remote upstream source. Ground all bushings and terminals.
2. If cover removal is required, remove cover as outlined in **Tank Cover Removal and Installation** section of this manual.
3. Prepare a clean, dry storage container to receive liquid.
4. Use pumps and hoses that have not been contaminated by contact with dissimilar liquids. Use a metal or non-rubber hose. Oil dissolves the sulfur found in rubber and will prove harmful to conductor material.
5. Attach pump intake line to drain valve on transformer tank.
6. Place output line nozzle on bottom of storage container. Do not permit liquid to splash into receiving container. Splashing will introduce air and moisture into liquid.
7. Do not lower liquid below top of core clamp unless absolutely necessary. Exposing coils may allow moisture to contaminate coil insulation.

## Restoring insulating liquid level

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### CAUTION

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**It may be necessary to add extra liquid to the storage container from a reserve supply to replace the small quantity lost in the pump and lines and to prevent aeration of replacement liquid.**

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If it is necessary to drain and refill the transformer, special care should be taken to avoid the entrapment of gas bubbles in the system. Sufficient time should be allowed between refilling and energization of the transformer to be sure that any gas bubbles created during the process have been dissipated.

1. Pump from bottom of temporary storage tank. Do not permit intake line to draw in air, since air bubbles will lower dielectric integrity of insulating system.
2. To prevent aeration at hose output, locate hose output below liquid surface
3. Pump slowly. If tank cover is not attached to tank, fill transformer to fill line marked on inside of transformer faceplate. If the tank cover is attached to tank, liquid level gauge may be read directly. On transformers that are not gauge-equipped, liquid level should be filled to bottom edge of liquid level plug hole (see Figure 3).

## Applicable standards

1. ASTM D92, "Standard Test Method for Flash and Fire Points by Cleveland Open Cup."
2. ASTM D877, "Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes."
3. ASTM D923, "Standard Practices for Sampling Electrical Insulating Liquids."
4. IEEE Std C57.106™-2002 standard, "Guide For Acceptance and Maintenance of Insulating Oil in Equipment."
5. IEEE Std C57.121™-1998 standard, "Guide for Acceptance and Maintenance of Less Flammable Hydrocarbon Fluids in Transformers."

## Spare parts and service

We suggest that one spare set of gaskets for manhole/ handhole and any gasket-type bushings be kept on hand. Other renewal parts may be ordered through your Eaton representative. When ordering parts, describe to your Eaton representative the maintenance being performed or the problem experienced. Also, tell the Eaton representative the complete transformer catalog number and serial number listed on the transformer nameplate.

## Preventative maintenance instructions

### WARNING

**Hazardous voltage. Can cause severe injury, death, or damage to equipment. De-energize transformer from a remote upstream source before opening cabinet and doing cabinet interior inspection or maintenance. Check that all transformer terminals and bushings have zero voltage. Ground transformer following industry accepted safe grounding practices.**

If any issues are found regarding the below, contact PS-WarrantyServices@Eaton.com for assistance on transformers under warranty. Additionally, these reports must be available upon request to maintain warranty period.

#### Transformer Exterior Maintenance

| Items to Inspect             | Points to be Checked   | Remedial Action   | Frequency |
|------------------------------|--|---|-----------|
| Exterior Surfaces            | Inspect for evidence of tampering, battered metal, gouges, etc. Check for any damage that would allow the entrance of wires or other metallic devices.                           | Any such damage should be repaired immediately.                                       | Annual    |
| Paint or Protective Coatings | Inspect for scratches or weathering.   | Any such damage should be touched up immediately.                                     | Annual    |
| Tank Leaks                   | Check tank exterior for signs of a leak.   | Any such leaks should be repaired immediately.  | Annual    |
| General Location             | Check the area around the transformer for stored tools, materials, equipment or debris.  | Anything on or against the transformer should be removed.                             | Annual    |
| General Location             | Walk completely around unit and listen for abnormal noises; should be a steady hum without intermittent rattling   | Any such abnormal noises should be reported and investigated.                         | Annual    |
| Pad                          | Verify that pad has not tilted resulting in a transformer that is more than 5° from horizontal.  | If pad support is compromised or out of level greater than 5°, repair it immediately. | Annual    |
| Nameplates                   | Abnormal or unexpected fading of nameplates or decals.   | Contact your Eaton representative for replacement nameplates and decals as necessary. | Annual    |
| Unusual Odors                | Smells of fluid or burning. This could be indicative of an unseen leak under the base. Also, inspect the concrete around the perimeter of the transformer base for oil spotting. | Any such abnormal odors should be reported and investigated.                          | Annual    |

#### Cabinet Interior Maintenance

| Items to Inspect    | Points to be checked   | Remedial Action   | Frequency |
|---------------------|--|---|-----------|
| Gauges and Controls | Check for proper operation.  | Repair or replace damaged or defective equipment.   | Annual    |
| Equipment Leaks     | Inspect drain cocks, plugs, fuse mountings, and switches. Look for evidence of insulating liquid seepage around tank-wall gaskets, seals, etc.   | Repair as required. Replacement of gaskets or seals in the tank wall may require that the tank be opened and the insulating liquid lowered to the appropriate level. For instruction on opening the tank and for draining and replacing the insulating liquid, refer to the <b>Insulating Liquid Maintenance</b> section.                                 | Annual    |
| Tank Pressure       | Check that pressure/vacuum gauge does not remain at zero for an extended period of time. It is preferable that a given unit not cycle between negative and positive pressures on a daily basis. Commissioning pressures have been documented in a separate paper based on the top fluid temperature. Any observed readings lower than -2 psig or greater than +7 psig indicate a condition that can and should be corrected. | If the pressure/vacuum gauge remains at zero for an extended period of time this may be evidence of air leakage in and out of the tank. A leak test should be performed by adding nitrogen to the airspace and observing for loss of pressure over an interval of a minimum of 12 hours. If the pressure is lost, locate the leak and repair immediately. | Annual    |

| <b>Items to Inspect</b> | <b>Points to be checked</b>   | <b>Remedial Action</b>   | <b>Frequency</b> |
|-------------------------|---|--|------------------|
| Dielectric Fluid Level  | Check dielectric fluid level gauge. Note that the fluid level gauge has a notation as to the expected level when the unit has an average internal fluid temperature of 25 °C. A reading above this zone is normal when at full operating temperature and does not indicate that the transformer is operating at a temperature higher than the nameplate rating.   | If the dielectric fluid level is below the nominal level, check transformer for signs of a leak. If a leak is observed, repair immediately. If no leak is observed, add oil to bring level to nominal operating level. | Annual           |
| Fluid Temperature       | Check liquid temperature gauge for elevated temperature. Reset the drag hand if one exists. Compare temperature to that of similar units. Note that the maximum top fluid temperature as noted by the draghand is a function of the maximum loading on the hottest day. A rule of thumb for a typical maximum reading would be nameplate rated temperature rise minus 10 °C plus the maximum ambient peak experienced in the area.<br><br>Example: 65 °C - 10 °C + 40 °C = 95 °C. Similar units should be within 3 °C of each other at the same location. | If temperature is elevated compared to other similar transformers, have unit serviced immediately to determine source of elevation.  | Annual           |
| Fusing                  | If bayonet fuses have been extracted, fluid might be present from that activity and may not be indicative of a leak.  |  | Annual           |
| Cable Connections       | If there are signs of overheating, check for loose connections or discolored spades (paddles). The tin plating will achieve a rainbow coloring if a particular terminal is experiencing an over temperature condition.  | Tighten any loose connections immediately. Any damage or discoloration that is observed should be addressed immediately by a qualified technician.   | Annual           |
| Bushings                | Check condition of the HV and LV bushings. Observe for any indication of dirt, breakage, general damage, heat damage or flashover. Note that excess dielectric grease from the separable dead front connectors can liquefy from the heat and appear like an internal fluid leak.  | If the bushings are dirty, clean them immediately. Any damage that is observed should be addressed immediately by a qualified technician.  | Annual           |
| Cubicle Padlock         | Check that all cubicles are locked.   | Replace any missing locks immediately.   | Annual           |
| LV Bushing Cantilever   | Check for excessive cable weight or stiff cable conductors putting upward or downward pressure on the bushings due to pad settling.   | Immediately adjust cable/conductor position to eliminate pressure.   | Annual           |
| Pressure Relief Valve   | Check for dirt, debris and operation.   | Replace immediately if damage. Clean if dirty or clogged with debris.  | Annual           |
| Lightning Arresters     | Check for damage or breakage and an intact and tight ground connection.   | Replace damaged arresters and tighten or secure any loose ground connections.  | Annual           |

### **Dissolved Gas Analysis**

| <b>Items to Inspect</b> | <b>Points to be checked</b>   | <b>Remedial Action</b>   | <b>Frequency</b> |
|-------------------------|---|--|------------------|
| Oil Sample              | Take an oil sample and send it to a third party tester to check dissolved gas levels. | Compare dissolved gas analysis results to the baseline result. Look for abrupt changes in dissolved gas levels. Any abrupt changes should be investigated immediately. | Annual           |



**Eaton**  
1000 Eaton Boulevard  
Cleveland, OH 44122  
United States  
Eaton.com

**Eaton's Cooper Power Systems  
Division**  
2300 Badger Drive  
Waukesha, WI 53188  
United States  
Eaton.com/cooperpowerseries

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For Eaton's Cooper Power series three-  
phase pad-mounted transformer product  
information call 1-877-277-4636 or visit:  
[www.eaton.com/cooperpowerseries](http://www.eaton.com/cooperpowerseries).



## 505ITM Series Test Certificate

Date

Customer Order No.

Qualitrol Order No.

Serial No.

Model No. ITM505-

- 505ITM manufactured according to specifications
- Passed hi-pot test
- Installed input modules calibrated and tested
- Analog outputs calibrated and tested
- Configured according to manufacturing order
- RS232, RS485 and USB communications ports tested
- Passed functionality test
- Customer configuration and calibration files transferred to disk
- Passed visual inspection

|   |
|---|
| ✓ |
| ✓ |
| ✓ |
| ✓ |
| ✓ |
| ✓ |
| ✓ |
| ✓ |
| ✓ |
| ✓ |

Cell Associate Initials:

# Qualitrol 505ITM Configuration Table

|                       |                   |                 |             |             |
|-----------------------|-------------------|-----------------|-------------|-------------|
| Model Number:         | 505ITM            |                 |             |             |
| Serial Number:        | 50259589-01       |                 |             |             |
| Manufacture Date:     | 02/01/17          |                 |             |             |
| Revision Level:       | 1.003000          |                 |             |             |
| System Update Date:   | 02/01/17          |                 |             |             |
| <b>Input Modules:</b> | <b>1</b>          | <b>2</b>        | <b>3</b>    | <b>4</b>    |
| Enabled:              | yes               | yes             | yes         | yes         |
| Type:                 | RTD, Pt, 100 Ohms | CT, Temperature | undefined   | undefined   |
| Name:                 | TOP OIL           | WINDING         | ?           | ?           |
| Units:                | C                 | C               |             |             |
| Offset:               | 1840              | 54              | 1820        | 1820        |
| Gain:                 | 99.775632         | 31.430000       | 99.950000   | 99.950000   |
| Scaling enabled:      | no                | no              | no          | no          |
| Scaling low:          | -40.000000        | -40.000000      | -40.000000  | -40.000000  |
| Scaling high:         | 120.000000        | 19960.000000    | -40.000000  | -40.000000  |
| RTD temp adder:       | 1                 | 1               | 1           | 1           |
| CT Ratio 1:           | 1200.000000       | 1200.000000     | 1200.000000 | 1200.000000 |
| CT Ratio 2:           | 5.000000          | 5.000000        | 5.000000    | 5.000000    |
| CT type:              | 0                 | 0               | 0           | 0           |
| Simple Delta T:       | 15.000000         | 15.000000       | 15.000000   | 15.000000   |
| Simple Cal Cur:       | 5.000000          | 5.000000        | 5.000000    | 5.000000    |
| Simple Time Constant: | 6                 | 6               | 6           | 6           |
| Oil Rise[0]:          | 40.000000         | 40.000000       | 40.000000   | 40.000000   |
| Oil Rise[1]:          | 40.000000         | 40.000000       | 40.000000   | 40.000000   |
| Oil Rise[2]:          | 40.000000         | 40.000000       | 40.000000   | 40.000000   |
| Oil Rise[3]:          | 40.000000         | 40.000000       | 40.000000   | 40.000000   |
| Oil Time Constant[0]  | 90                | 90              | 90          | 90          |
| Oil Time Constant[1]: | 90                | 90              | 90          | 90          |
| Oil Time Constant[2]: | 90                | 90              | 90          | 90          |
| Oil Time Constant[3]: | 90                | 90              | 90          | 90          |
| Exponent[0]           | 10                | 10              | 10          | 10          |
| Exponent[1]:          | 10                | 10              | 10          | 10          |
| Exponent[2]:          | 10                | 10              | 10          | 10          |
| Exponent[3]:          | 10                | 10              | 10          | 10          |
| CT clamp rating:      | 10                | 10              | 10          | 10          |



# Qualitrol 505ITM Configuration Table

| <b>Relays:</b>            | <b>1</b>    | <b>2</b>    | <b>3</b>   | <b>4</b>  |
|---------------------------|-------------|-------------|------------|-----------|
| Enabled:                  | yes         | yes         | yes        | yes       |
| Controlled:               | max 2 4     | max 2 4     | max 2 4    | max 2 4   |
| Failsafe:                 | no          | no          | no         | no        |
| Actuation direction:      | down        | down        | down       | down      |
| Test lockout:             | no          | no          | no         | yes       |
| Exerciser:                | no          | no          | no         | no        |
| Seasonal Setpoint:        | no          | no          | no         | no        |
| Ambient Forecast:         | no          | no          | no         | no        |
| Time delay:               | no          | no          | no         | no        |
| Bank switching:           | no          | no          | no         | no        |
| Dual Setpoint on:         | no          | no          | no         | no        |
| Low lockout:              | no          | no          | no         | no        |
| Setpoint 1:               | 70.000000   | 90.000000   | 105.000000 | 80.000000 |
| Setpoint 2:               | 90.000000   | 120.000000  | 130.000000 | 0.000000  |
| Setpoint 3:               | 0.000000    | 0.000000    | 0.000000   | 0.000000  |
| Setpoint 4:               | 0.000000    | 0.000000    | 0.000000   | 0.000000  |
| Hysteresis 1:             | 15.000000   | 5.000000    | 2.000000   | 10.000000 |
| Hysteresis 2:             | 15.000000   | 5.000000    | 2.000000   | 0.000000  |
| Hysteresis 3:             | 0.000000    | 0.000000    | 0.000000   | 0.000000  |
| Hysteresis 4:             | 0.000000    | 0.000000    | 0.000000   | 0.000000  |
| Seasonal Setpoint:        | 0.000000    | 0.000000    | 0.000000   | 0.000000  |
| Switching Bank:           | 1           | 1           | 1          | 1         |
| Actuation Counter         | 2           | 2           | 2          | 2         |
| Rate of change period     | 0           | 0           | 0          | 0         |
| <b>Relay Exerciser:</b>   |             |             |            |           |
| Exercise Run Time:        | 10          |             |            |           |
| Exercise Start Time:      | 8           |             |            |           |
| Exercise Cycle Time:      | 7           |             |            |           |
| Low Temperature Module:   | 256         |             |            |           |
| Low Temperature Setpoint: | 50          |             |            |           |
| System Relay:             | failsafe    |             |            |           |
| <b>Current Loops:</b>     |             |             |            |           |
| Enabled:                  | yes         | yes         |            |           |
| Controlled:               | diff A(1-1) | diff A(1-1) |            |           |
| Type:                     | 0/1         | 0/1         |            |           |
| 0/1 offset:               | 833         | 827         |            |           |
| 0/1 gain:                 | 341.000000  | 33.000000   |            |           |
| 4/20 offset:              | 3226        | 3221        |            |           |
| 4/20 gain:                | 0.000000    | 0.000000    |            |           |
| <b>Differentials:</b>     |             |             |            |           |
| Enabled:                  | no          | no          | 3          | 4         |
| Comparison:               | 0           | 0           | no         | no        |
|                           |             |             | 0          | 0         |

|                             |             |  |  |  |
|-----------------------------|-------------|--|--|--|
| <b>Translife:</b>           | <b>1</b>    |  |  |  |
| Forecast Config:            | 33760       |  |  |  |
| Forecast Hours 1:           | 0           |  |  |  |
| Forecast Hours 2:           | 0           |  |  |  |
| Forecast Hours 3:           | 0           |  |  |  |
| Forecast Hours 4:           | 0           |  |  |  |
| Forecast Hours 5:           | 0           |  |  |  |
| Forecast Hours 6:           | 0           |  |  |  |
| Forecast Hours 7:           | 0           |  |  |  |
| Forecast Hours 8:           | 0           |  |  |  |
| Forecast Hours 9:           | 0           |  |  |  |
| Forecast Hours 10:          | 0           |  |  |  |
| Forecast Hours 11:          | 0           |  |  |  |
| Forecast Hours 12:          | 0           |  |  |  |
| Forecast Setpoint 1:        | 80.000000   |  |  |  |
| Forecast Setpoint 2:        | 90.000000   |  |  |  |
| Forecast Setpoint 3:        | 100.000000  |  |  |  |
| Forecast Time 1:            | 99.900000   |  |  |  |
| Forecast Time 2:            | 99.900000   |  |  |  |
| Forecast Time 3:            | 99.900000   |  |  |  |
| Forecast Present Life Rate: | 0.000000    |  |  |  |
| Forecast Hour Life Rate:    | 0.000000    |  |  |  |
| Forecast Day Life Rate:     | 0.000000    |  |  |  |
| Forecast Life Consumption:  | 0           |  |  |  |
| Forecast Remaining Life:    | 20.000000   |  |  |  |
| Forecast Life variable A:   | -11.269000  |  |  |  |
| Forecast Life variable B:   | 6328.800000 |  |  |  |
| Transformer Lifespan:       | 20          |  |  |  |
| Forecast Operating Hours:   | 0           |  |  |  |
| Forecast Ambient Mod:       | 255         |  |  |  |
| Forecast Unity Temp:        | 110         |  |  |  |

| <b>Communications:</b>      | <b>USB</b> | <b>RS232</b> | <b>RS485 MAIN</b> | <b>RS485 Aux</b> |
|-----------------------------|------------|--------------|-------------------|------------------|
| Baud:                       | 4          | 19200        | 9600              | 19200            |
| Data bits:                  |            |              | 8                 | 8                |
| Stop bits:                  |            |              | 1                 | 1                |
| Parity:                     |            |              | none              | none             |
| Address Slave:              |            |              | 3                 | 1                |
| Address Master:             |            |              | 1                 | 1                |
| Protocol:                   |            |              | 3                 | 1                |
| Duplex Config:              |            |              | Full ( 4-wire)    |                  |
| <b>Heater:</b>              |            |              |                   |                  |
| Option:                     | installed  |              |                   |                  |
| Function:                   | enabled    |              |                   |                  |
| Setpoint:                   | 0          |              |                   |                  |
| Hysteresis:                 | 5          |              |                   |                  |
| <b>Display:</b>             |            |              |                   |                  |
| Intensity:                  | 114        |              |                   |                  |
| Contrast:                   | 254        |              |                   |                  |
| <b>Seasonal Setpoint:</b>   |            |              |                   |                  |
| Seasonal Start Date:        | 06/01      |              |                   |                  |
| Seasonal End Date:          | 09/01      |              |                   |                  |
| Exceeded Hours:             | 12         |              |                   |                  |
| Threshold Value:            | 30         |              |                   |                  |
| Measurement Period:         | 120        |              |                   |                  |
| Setpoint Temperature Shift: | 0          |              |                   |                  |
| Forecast Module:            | 1          |              |                   |                  |



# Power-Style™



## QED-2 Switchboards / Tableros de distribución tipo autoportado QED-2 / Panneaux de commutation QED-2

### Instruction Bulletin / Boletín de instrucciones / Directives d'utilisation

80043-055-12  
05/2015

Retain for future use. / Conservar para uso futuro. / À conserver pour usage ultérieur.





# Power-Style™ QED-2 Switchboards

## Class 2700

## Instruction Bulletin

80043-055-12  
05/2015

Retain for future use.

ENGLISH



## Hazard Categories and Special Symbols

Read these instructions carefully and look at the equipment to become familiar with the device before trying to install, operate, service, or maintain it. The following special messages may appear throughout this bulletin or on the equipment to warn of hazards or to call attention to information that clarifies or simplifies a procedure.



The addition of either symbol to a “Danger” or “Warning” safety label indicates that an electrical hazard exists which will result in personal injury if the instructions are not followed.



This is the safety alert symbol. It is used to alert you to personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

### **⚠ DANGER**

**DANGER** indicates a hazardous situation which, if not avoided, **will result in** death or serious injury.

### **⚠ WARNING**

**WARNING** indicates a hazardous situation which, if not avoided, **could result in** death or serious injury.

### **⚠ CAUTION**

**CAUTION** indicates a hazardous situation which, if not avoided, **could result in** minor or moderate injury.

### **NOTICE**

**NOTICE** is used to address practices not related to physical injury. The safety alert symbol is not used with this signal word.

**NOTE:** Provides additional information to clarify or simplify a procedure.

## Please Note

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

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## Section 1—Introduction

This manual contains instructions for the proper installation, operation, and maintenance of Power-Style™ QED-2 switchboard equipment manufactured by Schneider Electric. Engineering, installation, and operating staff supervisors should familiarize themselves with this manual and become acquainted with the appearance and characteristics of each piece of equipment mounted or contained in the switchboard.

These instructions and procedures apply to Power-Style QED-2 switchboard installations by Schneider Electric. When special features or non-standard components are incorporated in the switchboard, detailed instructions for these components are included in the instruction material holder.

**NOTE:** There are references to Series 2 switchboards in several places in this instruction bulletin. To determine if the QED-2 switchboard is a Series 2 model, check the rating nameplate located on the front cover. If the switchboard is a Series 2 model, the nameplate indicates that. If it is not a Series 2 model, there is not a Series designation.

### Inspection and Packaging

Every Power-Style QED-2 switchboard is carefully inspected and packaged at the assembly plant. Construction of the switchboard is checked, both structurally and electrically, for compliance with all specifications, codes, and standards. After a complete inspection, the switchboard is prepared for shipment. Each section is shipped separately for easier handling before installation. The factory order number, an identification number, and the shipping weights are plainly marked on each shipping section.

### Document Replacement

Contact your local Schneider Electric representative to replace lost or damaged wiring diagrams and instruction sheets. Use the factory order number as a reference.

## Section 2—Safety Precautions

### **⚠ DANGER**

#### **HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E or CSA Z462.
- This equipment must be installed and serviced only by qualified personnel.
- Perform such work only after reading and understanding all of the instructions contained in this bulletin.
- Turn off all power supplying this equipment before working on or inside equipment.
- Before performing visual inspections, tests, or maintenance on this equipment, disconnect all sources of electric power. Assume all circuits are live until they are de-energized, tested, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of backfeeding.
- Always use a properly rated voltage sensing device to confirm power is off.
- Practice lock-out/tag-out procedures according to OSHA requirements.
- Handle this equipment carefully and install, operate, and maintain it correctly in order for it to function properly. Neglecting fundamental installation and maintenance requirements may lead to personal injury, as well as damage to equipment or other property.
- Carefully inspect your work area and remove any tools and objects left inside the equipment.
- Replace all devices, doors, and covers before turning on power to this equipment.
- All instructions in this manual assume that the customer has taken these measures before performing maintenance or testing.

**Failure to follow these instructions will result in death or serious injury.**

## Section 3—Receiving, Handling, and Storing

### Receiving

Upon receipt, check the packing list against the equipment received to ensure the order and shipment are complete. Also upon receipt, immediately inspect switchboard sections for any damage that occurred in transit. If damage is found or suspected, file a claim with the carrier immediately and notify the nearest Schneider Electric representative.

### Handling

#### ⚠ WARNING

##### SPECIAL HANDLING REQUIREMENTS

- Do not lay the equipment on its front or sides.
- Lay equipment only on its back when special handling is required.
- Do not ship the equipment lying down.

**Failure to follow these instructions can result in serious injury or equipment damage.**

Ensure that proper equipment, such as an overhead crane, is available at the installation site to handle the switchboard. This equipment helps avoid injury to personnel and damage to the switchboard.

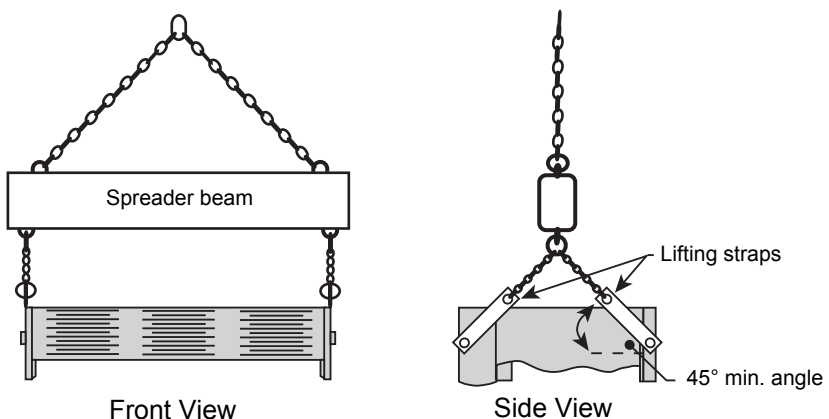
The shipping weight of each shipping section is marked on the packing list. Verify the lifting capacity of the equipment being used to handle the switchboard in accordance with the shipping weight of each shipping section. Keep the switchboard upright during handling.

Schneider Electric recommends using an overhead crane, lifting straps, and cables or chains to handle the switchboard. This method and alternative handling methods are discussed in this section.

### Handling with Lifting Straps

Schneider Electric provides lifting straps as standard equipment for NEMA Type 1 switchboard shipping sections rated 3,000 A or less. Instruction labels on each shipping section include drawings and written instructions outlining the proper use of the lifting straps (Figure 1). Use rigid spreaders or a spanner bar to provide vertical lift on the lifting straps. This helps avoid damage to the frame or finish.

**Figure 1 – Lifting with an Overhead Crane, Lifting Straps, and Cables or Chains**



Follow these instructions to handle the switchboard:

1. Use load-rated cables or chains with safety hooks or shackles. Do not pass cables or chains through holes in lifting straps.
2. Use a load-rated spreader beam to prevent structure damage. Rig so that the minimum angle between the lifting cables or chains and equipment top is 45 degrees.

Follow these instructions for laying equipment on its back:

1. Remove shipping skid and equipment back covers.
2. Use overhead cranes, lifting straps, and cables or chains for laying equipment on its back.
3. Rate of drop or pickup for laying equipment on its back is four feet per minute or less.
4. Reverse the procedure to stand the equipment in its upright position.
5. Reinstall back covers.

The warning label (Figure 2) is attached to both the front and rear of the switchboard.

**Figure 2 – Warning Label, Rainproof Switchboards**



## Handling without Lifting Straps

Lifting straps are not furnished on shipping sections rated more than 3,000 A, or on rainproof switchboards. Use rollers, slings, or other means to handle the shipping sections. The handling label (Figure 3) is affixed to each of these sections.

**Figure 3 – Handling Instruction Label, Switchboards without Lifting Straps**

⚠ **WARNING / ADVERTENCIA / AVERTISSEMENT**

Do not pass cables or chains through lift holes. Use only load rated cables or chains with safety hooks or shackles.

No haga pasar cables ni cadenas por los agujeros de levantamiento. Utilice sólo cables o cadenas adecuados para la carga con argollas o ganchos de seguridad.

Ne faites pas passer de câbles ou chaînes par les trous de levage. Utilisez uniquement des câbles ou chaînes classés pour supporter la charge, munis de crochets ou manilles de sécurité.

Load rated spreader bar  
Barra separadora adecuada para la carga  
Entretoise classée pour supporter la charge

Sling rigging  
Montaje de eslinga  
Arrimage de élingues

### TOP HEAVY LOAD HAZARD OF TIPPING

- This equipment must be moved by a sling, chain or rollers.
- Stabilize the shipping section to prevent tipping.
- Do not work under, around or on this equipment while elevated or moving.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

### CARGA PESADA EN LA PARTE SUPERIOR PELIGRO DE QUE SE CAIGA LA CARGA

- Este equipo debe moverse con una eslinga, cadena o rodillos.
- Estabilice la sección de embarque para evitar voltearla.
- No trabaje debajo, alrededor o sobre el equipo mientras se está elevando o moviendo.

**El incumplimiento de estas instrucciones puede causar la muerte, lesiones serias o daño al equipo.**

### CHARGE INSTABLE RISQUE DE RENVERSEMENT DE CHARGE

- Cet appareil doit être déplacé à l'aide d'une élingue, d'une chaîne ou de roulettes.
- Stabilisez la section de transport afin d'éviter qu'il ne bascule.
- Ne travaillez pas en dessous, autour ou sur cet appareil pendant qu'il est soulevé ou déplacé.

**Si ces directives ne sont pas respectées, cela peut entraîner la mort, des blessures graves ou des dommages matériels.**

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**▲ WARNING****TOP HEAVY LOAD—HAZARD OF TIPPING**

- Stabilize the shipping section to reduce the possibility of tipping.
- Consult with a certified rigging and lifting expert for any situation not covered in these instructions.

**Failure to follow these instructions can result in death or serious injury.**

When elevating a shipping section not equipped with lifting straps, use an overhead crane equipped with either of the following:

- A chain coupled to a sling rigging
- A wire cable with safety hooks and shackles

Wrap the sling completely around the switchboard and shipping stringers.

**NOTE:** A forklift is an alternative method of handling the switchboard. Always check the fork lengths to ensure that the forks extend under the entire switchboard. Carefully balance the load, and always use a safety strap when handling or moving a switchboard with a forklift (Figure 4 on page 15).

**Storing**

When storing the switchboard before installation, cover the top and openings of the equipment during the construction period to protect the switchboard from dust and debris.

If a switchboard is not installed and energized immediately, store it in a clean, dry space with a consistent temperature to prevent condensation. Store the switchboard indoors, if possible. Preferably, store it in a heated building with adequate air circulation and protect it from dirt, fumes, water, and physical damage. Storing the switchboard outdoors can cause harmful condensation inside the switchboard.

**NOTE:** Install portable electric heaters of approximately 250 watts per vertical section in both indoor-type and rainproof-type switchboard enclosures for adequate protection during storage.

Before energizing the space heaters, remove all loose packing or flammable materials inside the switchboard. Outdoor switchboards are not weather-resistant until completely and properly installed; treat them the same as indoor switchboards until after installation.

Figure 4 – Forklift Safety Label

**⚠ WARNING**

**HAZARD OF EQUIPMENT DAMAGE**  
 • Secure to forklift with safety strap.  
**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

**⚠ ADVERTENCIA**

**PELIGRO DE DAÑO AL EQUIPO**  
 • Sujete al montacargas con la correa de seguridad.  
**El incumplimiento de estas instrucciones puede causar la muerte, lesiones serias o daño al equipo.**

**⚠ AVERTISSEMENT**

**RISQUE DE BLESSURES OU DE DOMMAGES MATÉRIELS**  
 • Fixer au chariot élévateur avec une sangle de sécurité.  
**Si ces directives ne sont pas respectées, cela peut entraîner la mort ou des blessures graves ou des dommages matériels.**

**Remove label after installation.  
 Retire la etiqueta después de la instalación.  
 Enlever l'étiquette après l'installation.**

**Special Handling Requirements**  
 Do not lay the equipment on its front or sides. Doing so will damage unit.  
 Lay equipment only on its back when special handling is required.  
 See Instruction Bulletin for special handling instructions for laying equipment on its back.  
 Equipment is NOT to be shipped lying down.  
**Failure to follow these instructions can result in death, serious injury or equipment damage.**

**Requisitos especiales de manejo**  
 No coloque el equipo sobre su frente o lados ya que podría dañarse la unidad.  
 Coloque el equipo sobre su parte posterior solamente cuando sea necesario manejarlo de manera especial.  
 Consulte el boletín para obtener las instrucciones especiales de manejo para colocar el equipo sobre su parte posterior.  
 El equipo NO deberá transportarse acostado.  
**El incumplimiento de estas instrucciones puede causar la muerte, lesiones serias o daño al equipo.**

**Exigences de manutention spéciales**  
 Ne couchez pas l'appareil sur sa face avant ou sur les côtés. Faire ainsi l'endommagerait.  
 Couchez l'appareil sur le dos uniquement lorsqu'une manutention spéciale est nécessaire.  
 Consultez les directives d'utilisation pour les instructions de manutention spéciales pour coucher l'appareil sur le dos.  
 N'expédiez PAS l'appareil sur son dos.  
**Si ces directives ne sont pas respectées, cela peut entraîner la mort ou des blessures graves ou des dommages matériels.**

## Section 4—Installation

Correct installation of Power-Style QED-2 switchboards is essential for proper operation of all switchboard components. Study the associated instruction books and all drawings carefully. In most cases, all drawings are sent to the purchaser before a switchboard is shipped to enable adequate planning.

**NOTE:** The top of the switchboard will not support the weight of the installer.

### Location

Find the designated area on the building floor plan where the switchboard will be installed. The location chosen for installation should provide working clearances complying with Section 110-26 of the National Electrical Code® (NEC®) or Section 2-308 of the Canadian Electrical Code (CEC) Part 1.

- Front-accessible switchboards require field connections, including mains, branches, ground bus, and neutral bus, to be accessible and maintainable from the front.
- For switchboards having rear ventilation, allow a minimum 1/2-in. (13 mm) clearance between the rear of the switchboard and the wall for proper ventilation. Equipment drawings identify switchboards requiring rear or side access.
- Switchboards that require rear access for installation, field connections, or maintenance (such as filter replacement), require 30 in. (762 mm) of working space per NEC 110-26.
- If the switchboard is in a wet location or outside of the building, enclose it in an outdoor enclosure or equipment to prevent moisture or water from entering and accumulating within the enclosure. Outdoor-rated switchboards drain to the rear, so there must be at least a 1/2-in. (13 mm) clearance between the rear of the switchboard and a wall or other obstruction for proper drainage.

### Foundation Preparation

The floor or foundation must be strong enough to support the weight of the switchboard without sagging. The surrounding floor area should gently slope toward a drain.

**NOTE:** For seismic qualifications, read the section “Anchoring for Seismic Qualifications” on page 20 before pouring the floor or foundation.

Power-Style QED-2 switchboards are assembled on true and level floors at the assembly plant. To ensure correct bus bar alignment, the mounting pad or final installation site must be smooth and level. If parallel steel floor channels are imbedded for mounting the switchboard, take extra care to ensure the floor channels are level over their entire length to avoid distortion of the switchboard structure. Each channel should be level with the finished floor.

When pouring the foundation, make provisions for conduits entering the switchboard from below and carrying the incoming and/or outgoing cables, control wiring, and ground cable. The bottom view in the equipment drawing shows the available conduit area for correct layout.

Conduits should project above the finished floor by about 2 in. (51 mm). However, to simplify moving the shipping sections into place, install the conduits flush with the concrete and, after the sections are in their final position, add the appropriate extension sleeves. Otherwise, raising the shipping section on timbers or lifting it by a crane to

clear the conduit hubs will be necessary. Before pouring the foundation, consider installing additional conduits for future circuits.

## Switchboard Preparation

Remove dirt and debris from the foundation and surrounding area before moving the switchboard into final position.

After the switchboard has been moved to its final installation site, take each shipping section off its shipping stringers. For switchboards greater than 24 in. (610 mm) deep, the center base channel can be removed.

Remove all packing materials. If the switchboard is equipped with a bottom closure plate in each vertical section, remove and retain the plates for reuse. When bottom closure plates are furnished, the customer must make any holes necessary for conduit entering the bottom of the switchboard. After making the holes, reinstall the closure plate.

## General Installation

### **NOTICE**

#### **HAZARD OF EQUIPMENT DAMAGE**

Level and align adjacent shipping sections with one another. Ensure proper alignment of horizontal main through bus and proper splice bus connections.

**Failure to follow these instructions can result in equipment damage.**

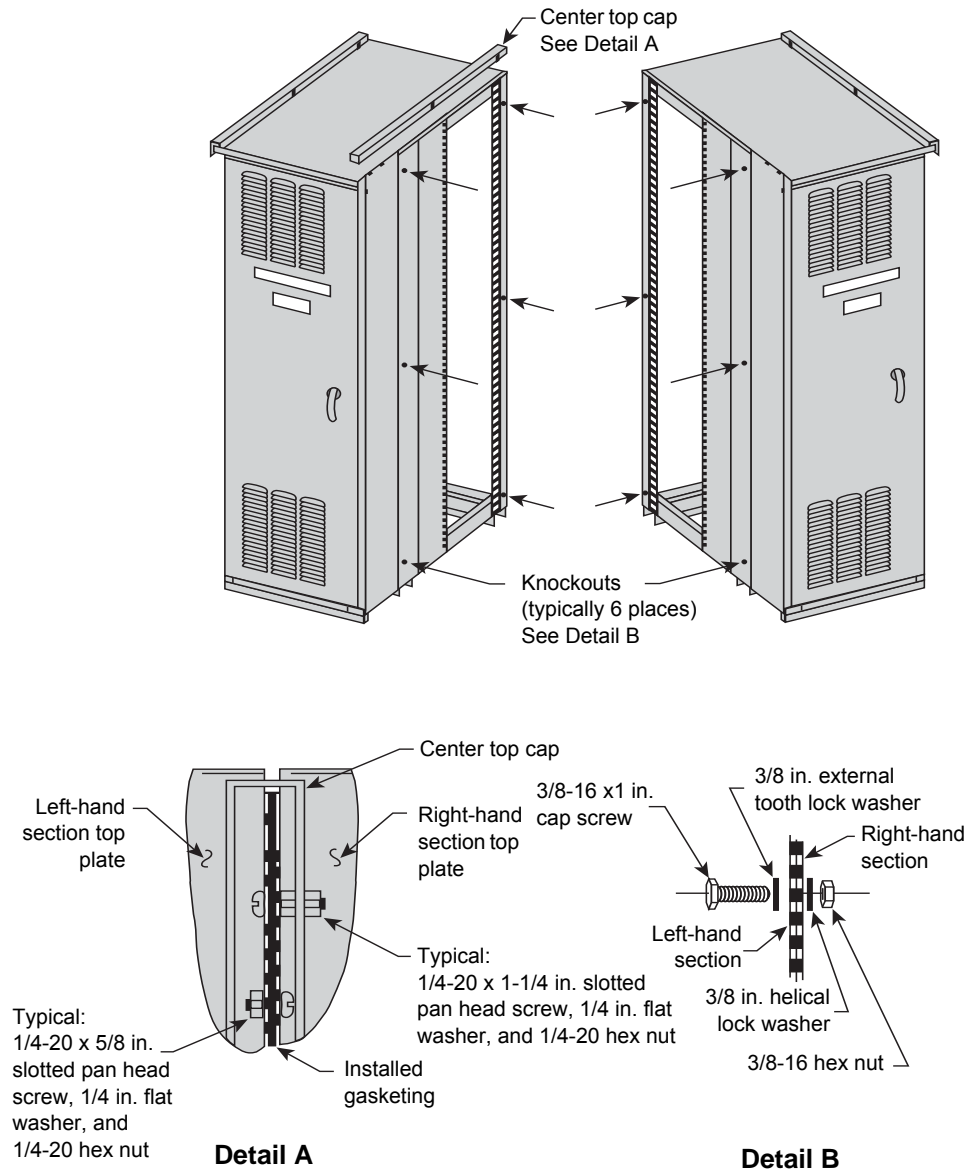
Install the switchboard into its final position by leveling progressively each section and bolting the frames together, if separated. Position shipping sections as follows:

1. Maneuver each shipping section into the desired position using the procedures under “Handling” on page 11.
2. Carefully lower the section over the conduit stubs to comply with the “available conduit area” as shown in the bottom view of the equipment drawings. Otherwise, there might not be sufficient cable bending space.
3. Level the shipping section.
4. After installation of each section is complete, make the through bus splice connection to the preceding section before installing the next section.

## Joining Shipping Sections—Outdoor Switchboards

1. Remove the center top cap (Figure 5) from the left-hand section, and retain all hardware for reuse.

**Figure 5 – Joining Adjacent Sections—Outdoor Switchboards**



2. When possible, open or remove the front and rear doors and panels, providing access to bolt adjacent shipping sections together.
3. Remove three 0.5-in. (13 mm) diameter knockouts from the front vertical corner channel and three from the rear vertical corner channel (a total of six per frame side) as indicated by the arrows in Figure 5.
4. Position each adjacent section, carefully leveling it and aligning it with the previous section. If lifting straps are provided, completely remove them from

the sides being bolted together so the sections can be joined flush. The only gasket required between sections is provided on the roof flange.

**NOTE:** If lifting strap removal is not required to join sections, leave the lifting strap on the switchboard. Verify that the bolt is tight to maintain NEMA Type 3R integrity.

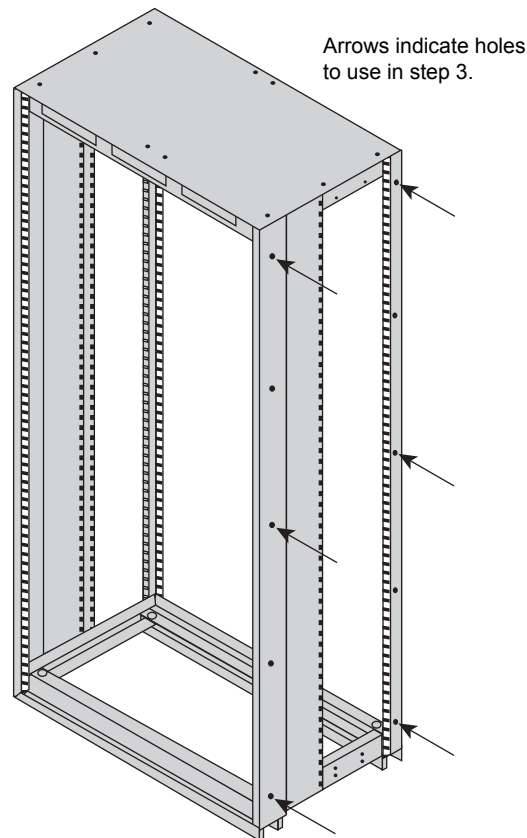
5. Six bolts (3/8-16 x 1 in.) are provided. Place them through the holes created in step 3 to join adjacent sections.
6. Make the through bus splice connections to the preceding section.
7. Replace the center top cap removed in step 1.
8. Replace and secure the front and rear doors and panels removed in step 2.

### Joining Shipping Sections—Indoor Switchboards

1. Position each adjacent section, carefully leveling and aligning it with the previous section. If lifting straps are provided, completely remove them from the sides being bolted together so the sections can be joined flush.

**NOTE:** Leave the other lifting straps on the switchboard if their removal is not required to join adjacent sections flush.

**Figure 6 – Indoor Switchboards**



2. Open or remove the front and rear doors and panels, providing access to bolt adjacent shipping sections together.
3. Six bolts (3/8-16 x 1 in.) are provided. Place the bolts through the existing holes in the front and rear vertical corner channels to join adjacent sections (Figure 6).
4. Make the through bus splice connections to the preceding section.
5. Replace and secure all front and rear doors and panels removed in step 2.

## Anchoring for Seismic Qualifications

QED-2 equipment that is seismically certified has been qualified to the site-specific seismic requirements of the listed model building codes and/or standards. Optional construction features may be required, depending on the location of the installation and the particular code and/or standard of interest. Seismic certificates of compliance are provided with all seismically certified QED-2 equipment. To maintain the validity of this certification, the installation instructions provided in this bulletin must be followed.

### Responsibility for Mitigation of Seismic Damage

For the purposes of the model building codes, QED-2 equipment are considered nonstructural building components. Equipment capacity was determined from triaxial seismic shake table test results as defined in the International Code Council Evaluation Service (ICCES) Acceptance Criteria for Seismic Qualification Testing of Nonstructural Components (AC156). Unless otherwise indicated, an equipment importance factor of 1.5 ( $I_p = 1.5$ ) was used, indicating that equipment functionality was verified before and after shaker table seismic simulation testing. This importance factor is indicative of critical facilities where maximizing the probability of post event functionality is a priority. The Building Seismic Safety Council (BSSC) recognizes AC 156 as an appropriate methodology in the 2003 National Earthquake Hazard Reduction Program (NEHRP) Commentary (FEMA 450 Part 2). The National Institute of Building Sciences established the BSSC in 1979 to develop and promote regulatory provisions for earthquake risk mitigation at the national level.

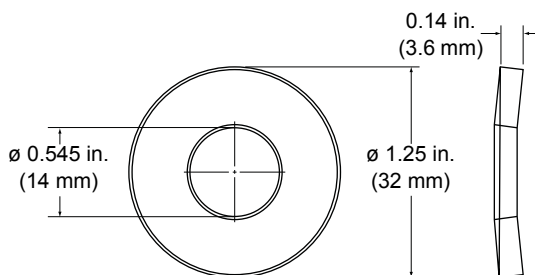
Incoming and outgoing cable and conduit must also be considered as related but independent systems. They must be designed and restrained to withstand the forces generated by the seismic event without increasing the load transferred to the equipment. For applications where seismic hazard exists, bottom entry and/or exit of cable and conduit is preferred. This system must be able to transfer the loads created by a seismic event to the load-bearing path of the building structural system.

### Maintaining Seismic Certification

Seismic qualification of nonstructural components by Schneider Electric is just one link in the total chain of responsibility required to maximize the probability that the equipment will be intact and functional after a seismic event. During a seismic event, the equipment must be able to transfer the loads that are created through the mounting pad and anchorage to the load-bearing path of the building structural system. The structural civil engineer or design engineer of record is responsible for detailing the equipment connection and anchorage requirements for the given installation. The installer and manufacturers of the anchorage restraint system are responsible for assuring that the mounting requirements are met. Schneider Electric is not responsible for the specification and performance of these systems.

## Anchoring QED-2 Equipment for Seismic Applications

**Figure 7 – Belleville Washer**



Formed base channels run the width of the section. The channels and connecting braces provide a minimum 0.75-in. (19 mm) diameter hole for fastening the section to the floor. To anchor the QED-2 switchboard to the floor properly, use all four mounting locations for NEMA Type 1 enclosures less than 36 in. deep, all six mounting locations for 36–70 in. deep enclosures, and six of the eight mounting locations for enclosures greater than 70-in. deep (see Figure 8 on page 23).

Use 0.5 in. (13 mm) diameter anchor bolts (Grade 5 minimum, provided by others) for the installation of equipment. Use one 1.25 in. (32 mm) outer diameter Grade 5 Belleville washer (provided by others; see Figure 7) under the head of each bolt or anchor nut. To develop the full strength of the anchor, torque the hardware to the value specified by the anchor manufacturer, or as recommended in the seismic restraint detailing supplied by the Structural Civil Engineer of record for the project (see Figure 9 on page 24).

Additionally, each NEMA Type 1 enclosed section includes four top-located hard points for attaching two upper lateral braces (braces and hardware supplied by others) to the QED-2 structure for top structural restraint (see Figures 10 and 11 on page 25).

Top structural restraint is required for all QED-2 equipment installed:

- where the site-specific 0.2 second spectral ground motion exceeds 2.67 g (as determined from the code-referenced ground motion maps or the site-specific seismic hazard engineering study), or
- when displacement at the top of the equipment cannot be tolerated, or
- for all QED-2 corner sections used for seismic applications.

To develop the full strength of the upper structural anchor, install and torque the hardware as specified by the anchor manufacturer or the seismic restraint detailing supplied by the Structural Civil Engineer of record for the project.

**NOTE:** Anchoring hardware is not furnished with the QED-2 equipment.

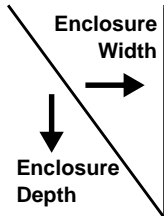
After the QED-2 switchboard and adjacent equipment are properly joined and the entire structure is bolted to the floor, install the incoming service conductors and load side cables. During an earthquake, the top of the QED-2 switchboard can move in any direction. Any top incoming cables must accommodate this motion. Do not use the QED-2 enclosure (particularly the top) to mount exterior equipment.



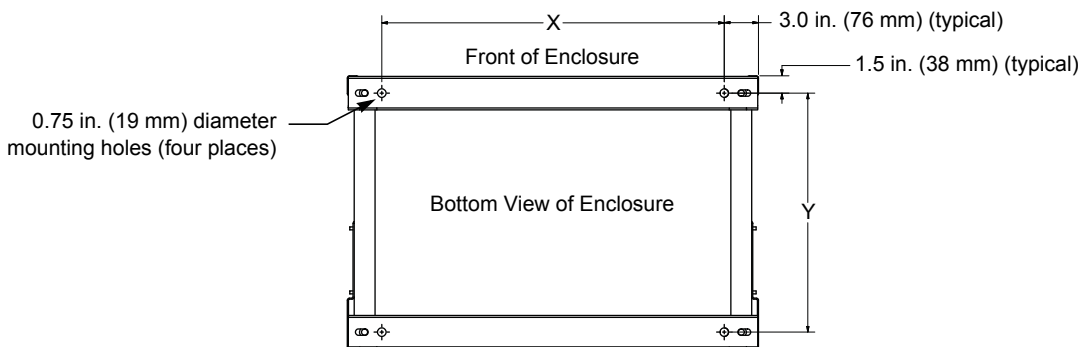
**Base Anchoring**

- To anchor the switchboard to the floor properly, use all of the designated 0.75 in. (19 mm) diameter mounting hole locations as illustrated in Figure 8 on page 23. The enclosure dimensions corresponding to Figure 8 are listed in Table 1.

**Table 1 – Enclosure X, Y, Z Dimensions in Inches (mm)**

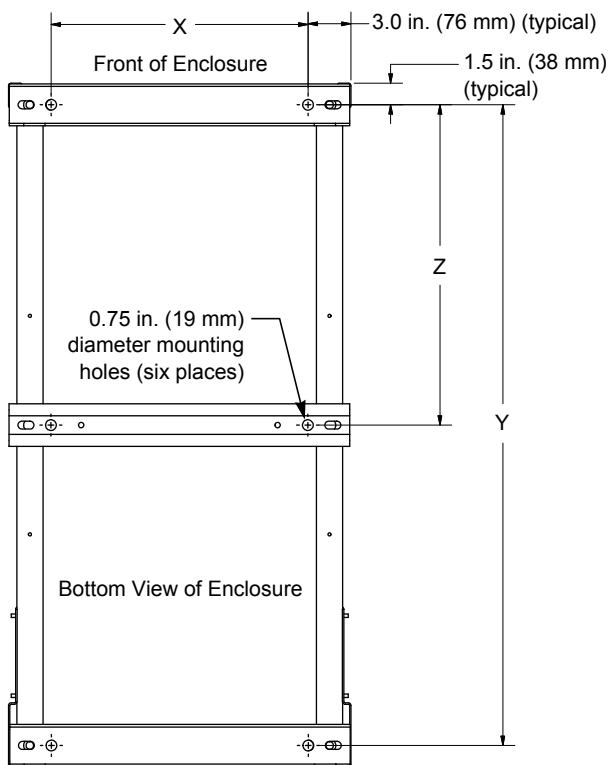
| <br>Enclosure Width<br>Enclosure Depth | 12 in.<br>(305 mm)  | 24 in.<br>(610 mm)   | 30 in.<br>(762 mm)   | 36 in.<br>(914 mm)   | 42 in.<br>(1067 mm)  | 48 in.<br>(1219 mm)   | 54 in.<br>(1372 mm)   |
|---|---|--|--|--|--|---|---|
|   | <b>24 in.<br/>(610 mm)</b>  | X = 6 (152)<br>Y = 21 (533)  | X = 18 (457)<br>Y = 21 (533)   | X = 24 (610)<br>Y = 21 (533)   | X = 30 (762)<br>Y = 21 (533)   | X = 36 (914)<br>Y = 21 (533)  | X = 42 (1067)<br>Y = 21 (533)   |
| <b>36 in.<br/>(914 mm)</b>  | X = 6 (152)<br>Z = 16.5 (419)<br>Y = 33 (838)   | X = 18 (457)<br>Z = 16.5 (419)<br>Y = 33 (838)   | X = 24 (610)<br>Z = 16.5 (419)<br>Y = 33 (838)   | X = 30 (762)<br>Z = 16.5 (419)<br>Y = 33 (838)   | X = 36 (914)<br>Z = 16.5 (419)<br>Y = 33 (838)   | X = 42 (1067)<br>Z = 16.5 (419)<br>Y = 33 (838)   | X = 48 (1219)<br>Z = 16.5 (419)<br>Y = 33 (838)   |
| <b>48 in.<br/>(1219 mm)</b>   | X = 6 (152)<br>Z = 22.5 (572)<br>Y = 45 (1143)  | X = 18 (457)<br>Z = 22.5 (572)<br>Y = 45 (1143)  | X = 24 (610)<br>Z = 22.5 (572)<br>Y = 45 (1143)  | X = 30 (762)<br>Z = 22.5 (572)<br>Y = 45 (1143)  | X = 36 (914)<br>Z = 22.5 (572)<br>Y = 45 (1143)  | X = 42 (1067)<br>Z = 22.5 (572)<br>Y = 45 (1143)  | X = 48 (1219)<br>Z = 22.5 (572)<br>Y = 45 (1143)  |
| <b>54 in.<br/>(1372 mm)</b>   | X = 6 (152)<br>Z = 25.5 (648)<br>Y = 51 (1295)  | X = 18 (457)<br>Z = 25.5 (648)<br>Y = 51 (1295)  | X = 24 (610)<br>Z = 25.5 (648)<br>Y = 51 (1295)  | X = 30 (762)<br>Z = 25.5 (648)<br>Y = 51 (1295)  | X = 36 (914)<br>Z = 25.5 (648)<br>Y = 51 (1295)  | X = 42 (1067)<br>Z = 25.5 (648)<br>Y = 51 (1295)  | X = 48 (1219)<br>Z = 25.5 (648)<br>Y = 51 (1295)  |
| <b>60 in.<br/>(1524 mm)</b>   | X = 6 (152)<br>Z = 28.5 (724)<br>Y = 57 (1448)  | X = 18 (457)<br>Z = 28.5 (724)<br>Y = 57 (1448)  | X = 24 (610)<br>Z = 28.5 (724)<br>Y = 57 (1448)  | X = 30 (762)<br>Z = 28.5 (724)<br>Y = 57 (1448)  | X = 36 (914)<br>Z = 28.5 (724)<br>Y = 57 (1448)  | X = 42 (1067)<br>Z = 28.5 (724)<br>Y = 57 (1448)  | X = 48 (1219)<br>Z = 28.5 (724)<br>Y = 57 (1448)  |
| <b>72 in.<br/>(1829 mm)</b>   | X = 6 (152)<br>Z <sub>1</sub> = 28.5<br>Z <sub>2</sub> = 40.5 (1029)<br>Y = 69 (1753) | X = 18 (457)<br>Z <sub>1</sub> = 28.5 (724)<br>Z <sub>2</sub> = 40.5 (1029)<br>Y = 69 (1753) | X = 24 (610)<br>Z <sub>1</sub> = 28.5 (724)<br>Z <sub>2</sub> = 40.5 (1029)<br>Y = 69 (1753) | X = 30 (762)<br>Z <sub>1</sub> = 28.5 (724)<br>Z <sub>2</sub> = 40.5 (1029)<br>Y = 69 (1753) | X = 36 (914)<br>Z <sub>1</sub> = 28.5 (724)<br>Z <sub>2</sub> = 40.5 (1029)<br>Y = 69 (1753) | X = 42 (1067)<br>Z <sub>1</sub> = 28.5 (724)<br>Z <sub>2</sub> = 40.5 (1029)<br>Y = 69 (1753) | X = 48 (1219)<br>Z <sub>1</sub> = 28.5 (724)<br>Z <sub>2</sub> = 40.5 (1029)<br>Y = 69 (1753) |

**Figure 8 – Base Channel Floor Anchor Bolt Locations**

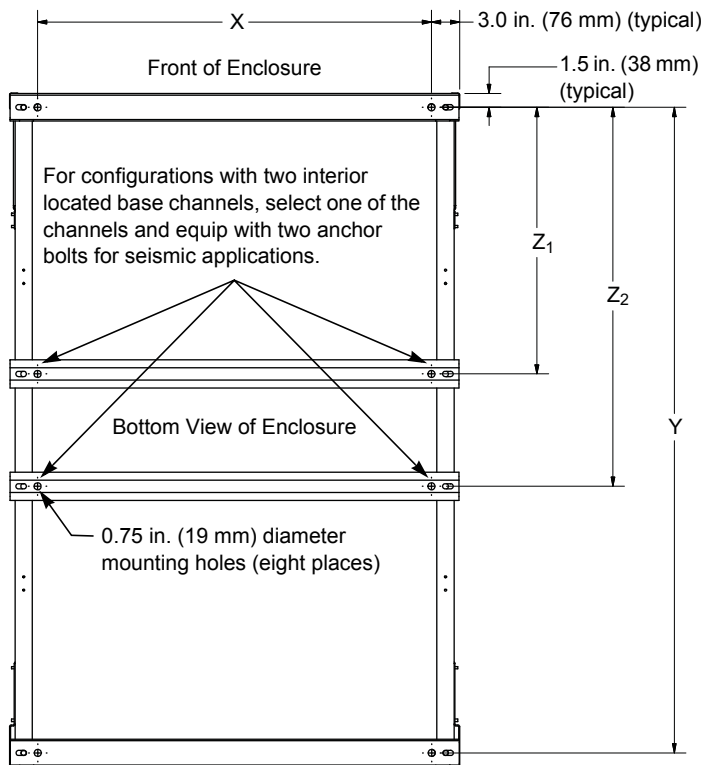


**Enclosures < 36 in. Deep**

**NOTE:** See Table 1 on page 22 for X, Y, Z dimensional values.



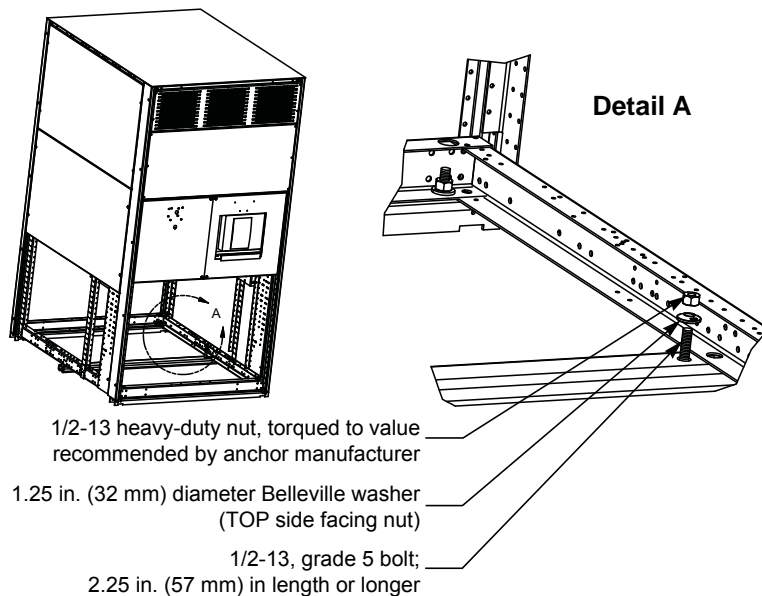
**Enclosures 36–70 in. Deep**



**Enclosures > 70 in. Deep**

- Depending on the frame size (see Figure 8 on page 23), use either four or six 1/2-13 Grade 5 bolts in the locations shown in Figure 9.

**Figure 9 – Base Channel Mounting Hardware**



**NOTE:** Base channel mounting hardware detail shown for reference purposes only. Anchoring hardware is not furnished with the switchboard. Covers and internal hardware shown removed for illustration purposes.

- Once the switchboard is in place, secure the base channels to each bolt using a 1.25 in. (32 mm) diameter Belleville washer between a 1/2-13 hardened nut and the switchboard frame as illustrated in Figure 9.

**NOTE:** The “TOP” side of the Belleville washer must be facing the nut.

- Torque each nut to the value recommended by the anchor manufacturer to develop the full strength of the anchor.

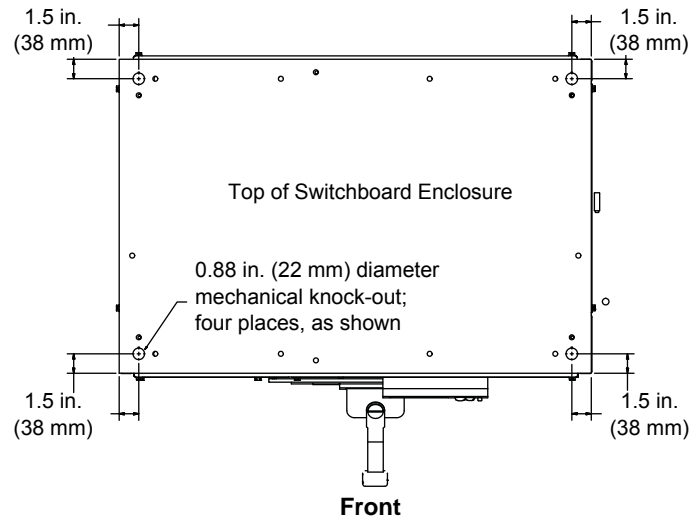
### Top Anchoring/Restraint

For installation at locations with an  $S_s$  greater than 2.67 g (as determined from the current version of the International Building Code), or where displacement cannot be tolerated at the top of the switchboard during a seismic event, use top restraints attached to the equipment hard points.

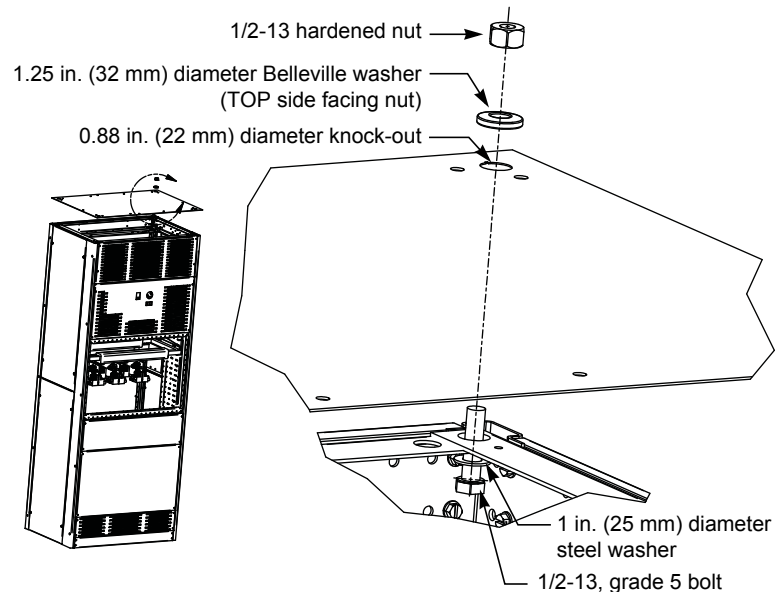
**NOTE:** Anchoring hardware is not furnished with the switchboard.

- The four 0.88-in. (22 mm) diameter mechanical knock-outs shown in Figure 10 on page 25 serve as hard points for application of a top restraint system.

**NOTE:** By code, it is the responsibility of the Building Design Professional to determine the top restraint methodology for the intended building application.

**Figure 10 – Top Anchor Hard-Point Locations**

2. Detach the top plate from the main switchboard enclosure. Retain the screws.
3. Remove the four 0.88 in. (22 mm) diameter mechanical knock-outs as directed by the Building Design Professional.
4. With the knock-outs removed, reattach and re-secure the top plate to the enclosure using the screws removed in Step 2.
5. Attach the top restraint system using a 1/2-13, Grade 5 bolt, a 1 in. (25 mm) diameter steel washer, a 1.25 in. (32 mm) diameter Belleville washer, and a hardened 1/2-13 nut as shown in Figure 11.

**Figure 11 – Top Anchor Mounting Hardware**

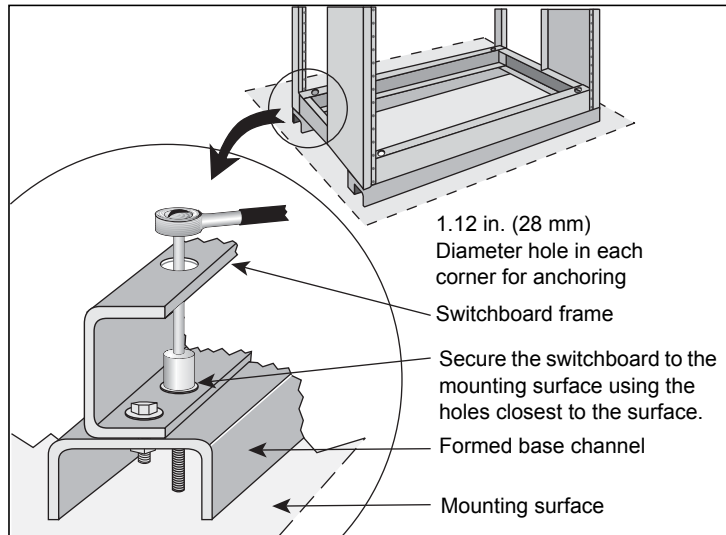
6. After all switchboard sections are properly joined and the entire structure is properly anchored, install the incoming service conductors and load side cables.
7. Do not use the switchboard enclosure (particularly the top) to mount exterior equipment, except for conduit.

## Anchoring the Switchboard

Although sections are freestanding, a hard bump or shifting movement can result in damage to the splice joints between sections and conduit hubs connected to the sections. Therefore, each vertical section must be anchored to the floor.

Formed base channels run the width of the shipping section. The channels have 1.12-in. (28 mm) diameter holes for fastening the section to the floor (Figure 12). Anchor each section to the floor with 1/2-in. (Grade 2 minimum) bolts with flat washers and anchors suitable for installation of electrical equipment (not furnished).

**Figure 12 – Switchboard Base Channels**



After all switchboard sections are properly joined and the entire structure is bolted to the floor, install the incoming service conductors and load side cables.

**NOTE:** If the switchboard consists of only one shipping section, proceed to “Grounding and Bonding” on page 28.

## Through Bus Splice Connections

### **⚠ DANGER**

#### **HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

Do not install through bus splice connectors with the switchboard energized.

**Failure to follow these instructions will result in death or serious injury.**

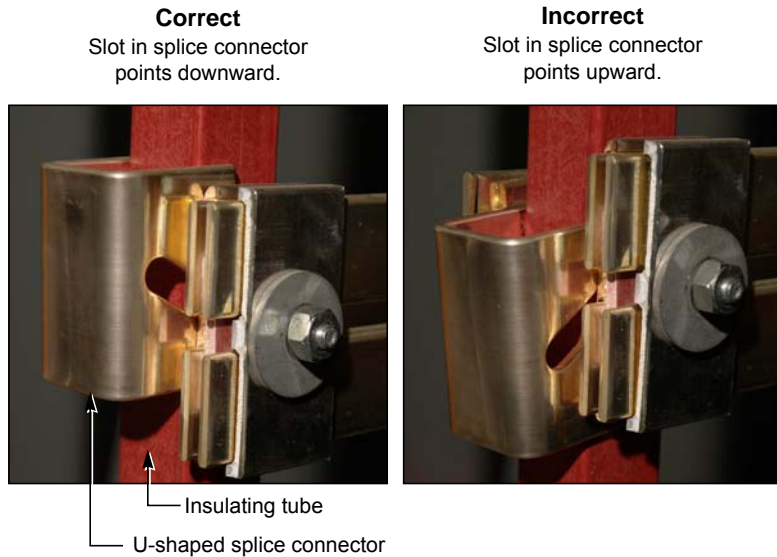
Through bus splice connectors and/or hardware, along with installation instructions, are provided with each shipping split. Follow the installation instructions, and torque splice bolts to the value given in “Section 9—Torque Values for Electrical Connections” on page 53.

If through bus bars are wrapped with an insulative material, cover the splice connections with the material provided.

For splice connections with bus on the front and rear of an insulating tube, ensure the U-shaped, copper connector is centered around the tube. Figure 13 on page 27 shows the proper orientation of the connector.

**NOTE:** The U-shaped connector will fit snugly against the insulating tube when installed correctly. It is pulled away from the insulating tube in Figure 13 to show the orientation of the connector slot.

**Figure 13 – Proper Orientation of U-shaped Splice Connector**

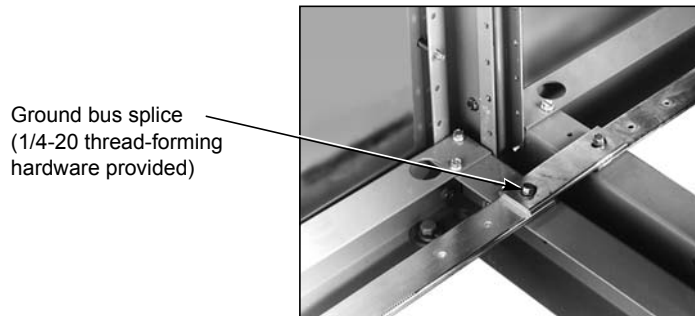


**Ground Bus Splice Connections**

Align and secure the ground bus splice connection between shipping sections. Torque connections to 100 lb-in (11 N•m) (Figure 14 or 15).

**NOTE:** Proper installation is essential for equipment ground-fault systems.

**Figure 14 – Ground Bus Splice Connection**



**Figure 15 – Series 2 Ground Bus Splice Connection**



## Grounding and Bonding

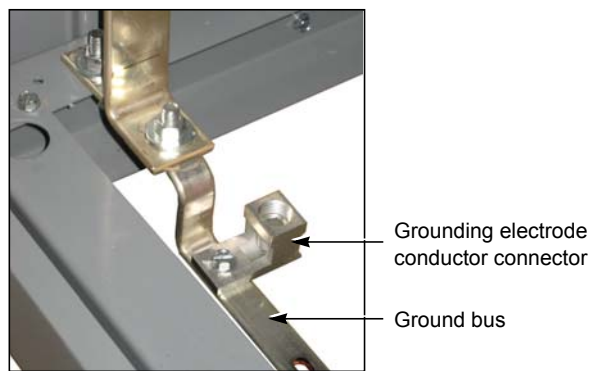
### Service Equipment— Grounded System

**NOTE:** A system is “grounded” if it is grounded at any point ahead of the switchboard, whether the grounded conductor (neutral) is carried through to the loads, or not.

For solidly *grounded* systems used as either service equipment or as a main switchboard on a separately derived system:

1. Run a grounding electrode conductor from the grounding electrode at the installation site to the grounding electrode conductor connector (ground lug) located on the switchboard ground bus (or on the neutral bus, if so indicated on the equipment drawing) (Figure 16). Select the material and size of this grounding electrode conductor to comply with Sections 250-62 and 250-66 of the NEC or Sections 10-204 and 10-206 of the 1998 CEC, and install it as specified in Section 250-64 of the NEC or Section 10-908 of the 1998 CEC.

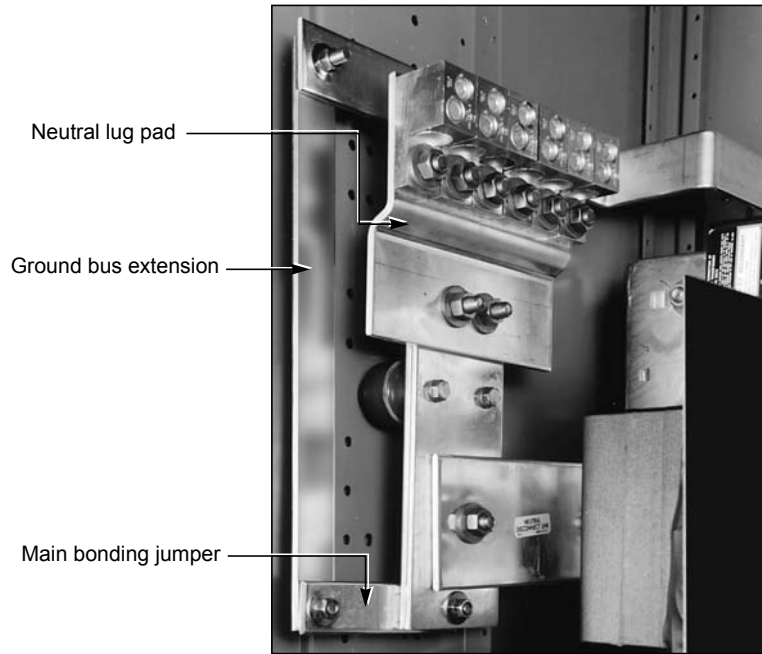
**Figure 16 – Grounding Electrode Connector**



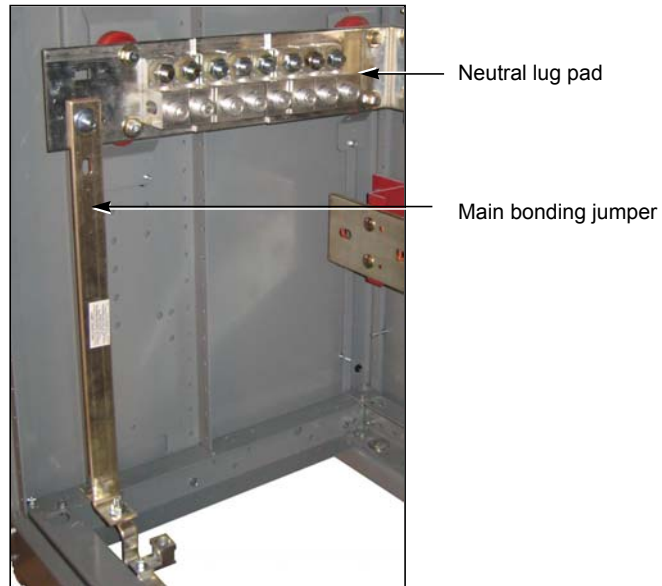
2. Install the main bonding jumper between the neutral bus and the ground bus (Figure 17 or 18 on 29). For torque values, refer to “Section 9—Torque Values for Electrical Connections” on page 53.

**NOTE:** If the switchboard is fed from multiple sources (for example, double-ended systems), there may be two or more main bonding jumpers to install.

**Figure 17 – Main Bonding Jumper**



**Figure 18 – Series 2 Main Bonding Jumper**



In Canada, a main bonding jumper bus or cable is provided between the neutral bus and ground bus. When the bonding jumper must be disconnected (for example, for a Megger® test), remove the main bonding jumper bus or cable lug with cable from the neutral bus. This is normally located near the line neutral lugs. Secure the main bonding jumper bus or cable and lug to maintain the required distance from phases and neutral.

**NOTE:** If the switchboard is fed from multiple sources (for example, a double-ended system like a main-tie-main), there may be two or more main bonding jumpers installed.



**Service Equipment—  
Ungrounded System**

For *ungrounded* systems used as either service equipment, or as a main switchboard on a separately derived system:

1. Run a grounding electrode conductor from the grounding electrode at the installation site to the grounding electrode conductor connector (ground lug) located on the switchboard ground bus (Figure 16 on page 28).
2. Select the material and size of this grounding electrode conductor to comply with Sections 250-62 and 250-66 of the NEC or Sections 10-700 and 10-702 of the 1998 CEC, and install it as specified in Section 250-64 of the NEC or Section 10-204 of the 1998 CEC.

**Not Service Equipment**

For either *grounded or ungrounded* systems, when a switchboard is not used as service equipment nor as a main switchboard on a separately derived system:

Use equipment grounding conductors sized according to Section 250-122 of the NEC or Section 10-206 of the 1998 CEC to connect the switchboard frame and ground bus to the service ground.

**High-Impedance Grounded  
Neutral Systems**

For high-impedance grounded neutral systems:

Ground the system following the instructions provided with the system grounding equipment and in compliance with Section 250-36 of the NEC. Confirm that the switchboard frame and ground bus are bonded in accordance with Section 250-102 of the NEC.

**Busway Connections**

Schneider Electric switchboards are manufactured with two different styles of busway connections. Qwik Flange™ is used on indoor switchboards only.

The other type of busway connection is the “dummy” flanged end. This type is used on some indoor switchboards, but primarily on outdoor units. The dummy flanged end must be removed to allow actual busway flanged end installation. Either the dummy or actual busway flanged end must be in place before energizing the switchboard.

**NOTE:** Do not use the switchboard to support the weight of the busway connection. Support busway independently. When busway is installed, make sure no areas of the roof are bowed downward. This will help prevent pooling of water.

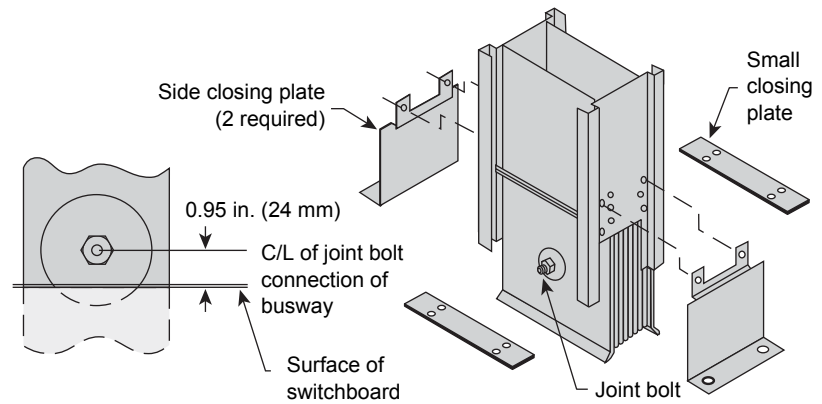
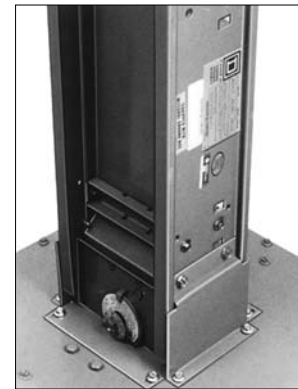
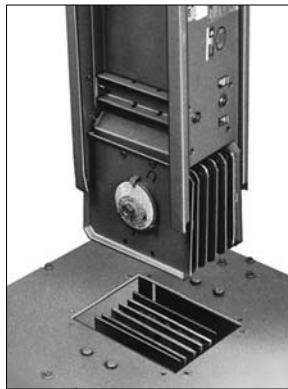
**Busway Connection—NEMA  
Type 1 (Indoor) Only  
(Qwik Flange™)****⚠ DANGER****HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

Turn off all power supplying the switchboard and busway before installing connections.

**Failure to follow these instructions will result in death or serious injury**

Follow the instructions in this section to make Qwik Flange busway connections (see Figures 19 and 20 on page 31):

1. Remove any protective covering from the opening in the switchboard.
2. Slip the busway joint into the switchboard connectors.
3. Check the joint bolt alignment; the center line (C/L) of the joint bolt to the switchboard surface should be 0.95 in. (24 mm) (Figure 19 on page 31).
4. Attach the side closing plates using two 5/16-in. bolts (provided). When installed properly, the holes in the side closing plates align with the holes in both the switchboard and busway.

**Figure 19 – Qwik Flange Installation****Figure 20 – Qwik Flange**

5. Use an 18-in. (457 mm) or longer wrench to torque the joint bolt until the outer break-away head twists off. Do not allow the break-away bolt head or red warning disc to drop into the switchboard.
6. Slip the remaining two small closing plates into position by aligning with the holes in the switchboard. Use the four 1/4-20 screws provided to secure the equipment.
7. Confirm proper phasing of the installed busway before energizing.

**Busway Connections—  
NEMA Type 1  
(Non-Qwik Flange) and  
NEMA Type 3R**

If this style of connection for busway is furnished, the busway “dummy” flanged end must be removed before installing busway (Figure 21 on page 32).

**⚠ DANGER**

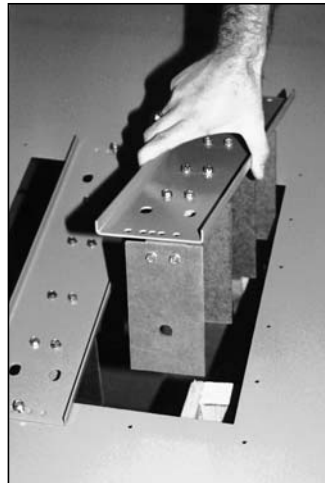
**HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

Turn off all power supplying the switchboard and busway before installing connections.

**Failure to follow these instructions will result in death or serious injury.**

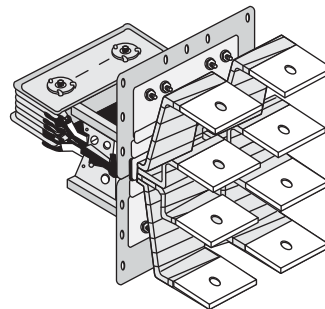
1. From inside the switchboard, remove the 1/2-in. bolts that fasten the switchboard bus to the busway dummy nonmetallic flanges. Retain all hardware for reuse.
2. Remove all screws securing the busway dummy flanged end to the switchboard enclosure.
3. Remove the busway dummy flanged end (Figure 21).

**Figure 21 – Removing the Busway Dummy Flanged End**



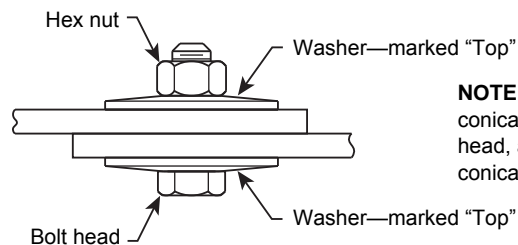
4. Install the actual busway flanged end to the switchboard bus connectors provided in the switchboard (Figure 22). Insert the flanges between the switchboard bus connectors so that the mounting holes in the collar of the flanged end align with the pre-drilled holes in the switchboard enclosure.

**Figure 22 – Flanged-End Connections**



- Line up the holes in the bus bar flanges, and reinstall the 1/2-in. (13 mm) hardware that was removed in step 1 on page 32 and as shown in Figure 23.

**Figure 23 – Reinstalling the 1/2-In. (13 mm) Hardware**



**NOTE:** The convex side (marked "Top") of one conical washer should be against the bolt head, and the convex side of the second conical washer should be against the hex nut.

- Torque the bolts inserted in step 5 as indicated in "Section 9—Torque Values for Electrical Connections" on page 53.
- Assemble the busway collar to the switchboard enclosure with the screws provided.
- Ensure that the busway integral ground is connected to the switchboard ground bus.
- Confirm busway phasing before energizing.

## Conduit Area

- Locate and terminate all conduit in the switchboard enclosure in the "available conduit area" designated on the equipment drawing.

**NOTE:** On switchboards greater than 24 in. (610 mm) deep, the center base channel can be removed for additional conduit area. **Exception:** Do not remove any base channels when seismic restraint is required.

- Install the conduit properly. Use hubs, locknuts, and bushings to protect the cables and prevent condensation on the conduit from entering the switchboard.

**NOTE:** If top entry, do not use the top of the switchboard to support the weight of the conduit. Support the conduit independently. When conduit is installed, make sure no areas of the roof are bowed downward. This will help prevent pooling of water.

If bottom closure plates are furnished, the customer must remove the plates, make holes in them for any conduit entering the bottom of the switchboard, and then reinstall the plates.

Under seismic conditions, consider using top restraints if movement of the top of the switchboard is an issue.

- Bond all conduit hubs to the switchboard enclosure with approved electrical connections.

## Cable Pulling

Power-Style QED-2 switchboards are constructed to customer specifications for the cable entrance arrangement (for example, top or bottom feed). Switchboard components are arranged to give proper cable clearance and bending space for cables entering or exiting the switchboard as specified on the equipment drawing.

1. Use only cable sizes suitable for a proper fit with the corresponding lugs.
2. Pull the proper number of line side and load side cables according to the load served and the NEC or CEC.
3. Position the cables inside the switchboard so that they are not subject to physical damage.
4. Maintain the largest possible bending radii and proper clearance to bus bars and grounded parts. If any cables are lying or bearing on structural members, support them to relieve this condition or place suitable protective material at the bearing point to protect the cable insulation.
5. Be certain to run all phase conductors, including the neutral, through the same opening where cables enter or leave the switchboard, or pass through any metal that has magnetic properties. Otherwise, overheating can result. See Section 300-20(a) of NEC.
6. When instructed, brace or cable-lace the conductors.

## Cable Terminations

1. Use a proper insulation stripping tool to strip a length of insulation from the end of the cable sufficient to fit into the full length of the lug barrel. Be careful not to nick or ring the strands.
2. Thoroughly clean aluminum cable contact surfaces with a wire brush, or scrub them with an abrasive cloth to remove oxides and foreign matter.
3. Immediately apply an acceptable joint compound to the bare aluminum surfaces.
4. If compression-type lugs are furnished on any switch or circuit breaker, or as the main incoming power lugs, unbolt and remove them to create sufficient room for crimping the lugs to the cables with the crimping tool.
  - a. Insert the cable into the lug barrel and, using the crimping tool, make the specified number of crimps per the recommendations of the manufacturer.
  - b. Wipe excess joint compound from the connector and insulation.
  - c. With the cables connected, remount the lugs onto the bus bars, switches, or circuit breakers. Torque the bolts to the values given in “Section 9—Torque Values for Electrical Connections” on page 53.
5. Set screw-type lugs may be furnished as main incoming lugs and are standard on molded case circuit breakers and QMB/QMJ/QMQB<sup>1</sup> fusible switches. Torque these lugs to, **but do not exceed**, the specified values. Torque values for circuit breaker and switch lugs are marked on these units. Torque values for other switchboard lugs are marked on the switchboard (Table 7 on page 53).

<sup>1</sup> QMQB switches are available in Canada only.

### Cable Restraint for Short-Circuit Current Rating (SCCR)

Cable restraint is recommended for lugs mounted on bus when the following conditions are met:

- Unsupported cable lengths are greater than 3.5 ft. (1 m) <sup>1</sup>

**AND**

- Cables meet the **Yes** criteria shown in Table 2.

**Table 2 – Cable Restraint Criteria**

| Cable Ampacity | Available Short Circuit Fault Current (RMS) |               |                |               |
|----------------|---|---------------|----------------|---------------|
|                | < 65 kA                                     | 65 to < 85 kA | 85 to < 150 kA | 150 to 200 kA |
| ≤ 800 A        | No  | Yes           | Yes            | Yes           |
| 1200 A         | No  | No            | Yes            | Yes           |
| 1600 A         | No  | No            | Yes            | Yes           |
| 2000 A         | No  | No            | Yes            | Yes           |
| 2500 A         | No  | No            | No             | Yes           |
| 3000 A         | No  | No            | No             | Yes           |
| ≥ 4000 A       | No  | No            | No             | No            |

**OR**

- When otherwise specified.

**NOTE:** For I-Line™ circuit breakers, or if the lugs are in the circuit breaker, refer to the instruction bulletin for the specific circuit breaker.

**Figure 24 – Cable Restraint Example**



<sup>1</sup> Cable length is measured from the end of the lug to the conduit fitting through which the cable exits.

**NOTICE****HAZARD OF CABLE MOVEMENT UNDER SHORT-CIRCUIT CONDITIONS**

Restrain all cables, including neutral cables, in the switchboard installation when the conditions stated on page 35 are met.

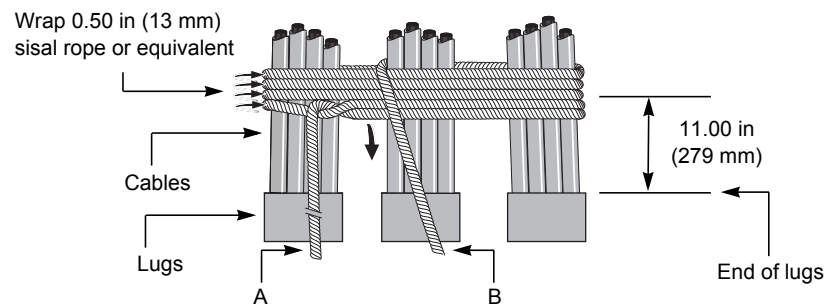
**Failure to follow these instructions can result in equipment damage.**

When cable restraints are required, perform the following steps.

**NOTE:** Wrap cables using 1/2-in. (13 mm) diameter sisal rope, 3/8-in. (9.5 mm) diameter nylon rope, or equivalent.

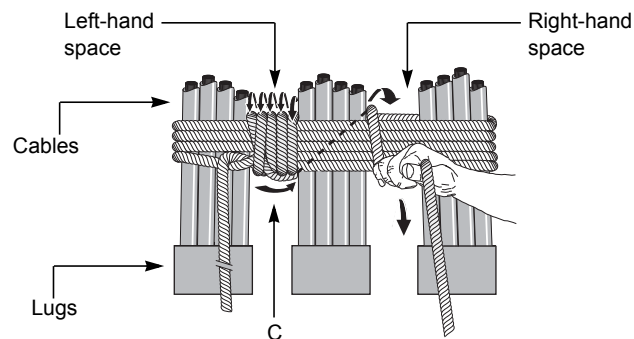
1. Begin wrapping the cables (Figure 25) a maximum distance of 11 in. (279 mm) from the end of the lugs. Continue to wrap the cables on 11-in. (279 mm) center(s) up to the point where the cables leave the enclosure.
  - a. Wrap the cables four (4) times as shown, leaving 3 ft. (1 m) of excess rope at the first end (A).
  - b. Pull the rope (B) taut.

**Figure 25 – Wrapping Cables (neutral cables not shown)**



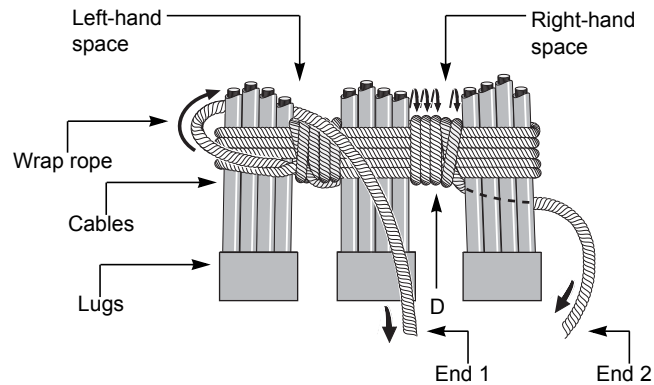
2. Wrap the rope several times (Figure 26) until the space between the cables is completely filled.
  - a. Weave the final rope loop underneath the previous loop (C).
  - b. Bring the rope through the right-hand space.
  - c. Pull the rope taut.

**Figure 26 – Wrapping the Space Between Cables**



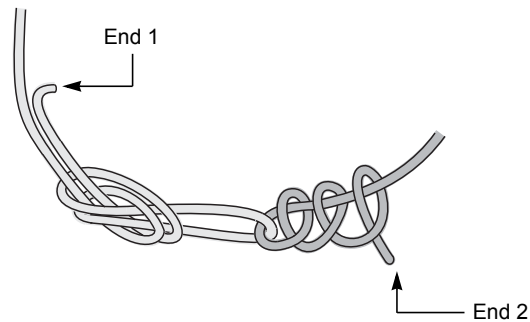
3. Wrap the rope several times until the space between the cables (Figure 27) is completely filled.
  - a. Weave the final rope loop underneath the previous rope loop (D).
  - b. Pull the rope taut.

**Figure 27 – Finish Wrapping the Space Between Cables**



4. Tie the rope ends (1) and (2) together (Figure 28) until they are taut. Cut off excess rope, and tape ends to prevent fraying.

**Figure 28 – Tying Rope Ends Together**



5. Recheck torques of wire binding screws after securing the cables.

**NOTE:** Refer to the torque label supplied with the switchboard for torque values.



## Section 5—Pre-energizing Checkout Procedure

Conduct a complete inspection **before** the switchboard is energized to ensure that all components function and operate properly. **Complete every step of the checkout procedure listed before energizing the switchboard.**

1. Check all field-installed bus bar connections. Torque values are listed in “Section 9—Torque Values for Electrical Connections” on page 53.
2. Check all accessible connections for tightness.
3. Check all factory- and field-installed lug terminations for tightness.
4. Check the rigidity of all bus bar supports.
5. Check the switchboard enclosure for dents or other damage that reduces electrical clearances inside the switchboard.
6. Remove all foam blocks, or other temporary cushioning or retaining material, from the electrical devices.
7. Manually open and close all switches, circuit breakers, and other operating mechanisms, checking for correct alignment and free operation.
8. Operate all electrically operated switches, circuit breakers, and other devices equipped with remote operators (not under load). An auxiliary source of control power may be necessary to accomplish this.
9. Check all relays, meters, and instrumentation to verify that all field-installed wiring connections are made properly and that the devices function properly.
10. Current transformers (CTs) supplied for customer use require connection to a metering device load before energizing. Verify that the metering device load is properly connected, including main switchboard connections to remote equipment.
11. All CT circuits supplied by Schneider Electric for customer metering use are shorted for shipment. Remove shorting terminal screws on shorting terminal blocks or jumpers and store in the block.
12. Factory-installed circuit breakers may have an adjustable magnetic or electronic trip which is factory set to the lowest setting. To provide coordinated operation during a fault, adjust the trip as outlined in the instruction manual provided with the circuit breaker. All poles are adjusted simultaneously, using a screwdriver, by the single setting.
13. If ground-fault protection is furnished on type BP switch, adjust the relay to the desired ground current pickup setting. The relay is shipped from the factory at the lowest setting of 120 A for the relay. Relay pickup range is from 120–1,200 A for the relay.

**NOTE:** For molded case circuit breakers, refer to “Section 11—Reference Publications” on page 56 for circuit breaker information.

14. Check the torque on all bolts of the fuses mounted in Bolt-Loc™ switches, 21–30 lb-ft (28–41 N•m), and in QMB/QMJ/QMQB<sup>1</sup> switches (as marked on the device).

<sup>1</sup> QMQB switches are available in Canada only.

**NOTICE****HAZARD OF EQUIPMENT DAMAGE**

Do not pry open or spread the fuse mounting clips. Doing so can cause a loose connection, resulting in overheating.

**Failure to follow these instructions can result in equipment damage.**

15. Examine fuse clip contact pressure and contact means (QMB/QMJ/QMQB<sup>1</sup> fusible switches). If there is any sign of looseness, contact Schneider Electric Services at 1-888-778-2733 (US) or 1-800-565-6699 (Canada). Loose fuse clips can result in overheating.
16. Check all QMB/QMJ/QMQB<sup>1</sup> fusible switches, verifying that the proper fuses with the required interrupting rating and continuous current rating are installed. Do not use renewable link fuses in Square D™ brand fusible switches.
17. Verify that all grounding connections are correctly made. If the switchboard is used as a service entrance, double check to see that the main bonding jumper is connected (Figure 17 on page 29).

**⚠ CAUTION****HAZARD OF EQUIPMENT DAMAGE OR INJURY**

- Remove the long-time rating plug before electrical insulation testing a circuit breaker that has a label stating “Warning: Disconnect Plug Before Dielectric Test.”
- Some Micrologic™ trip units are not rated for voltages that would occur during electrical resistance insulation testing.
- Open all control and metering disconnects from the control circuits.

**Failure to follow these instructions can result in injury or equipment damage.**

18. Conduct an electrical insulation resistance (Megger®) test to ensure that the switchboard is free from short circuits and undesirable grounds.
  - a. Open all control power and metering disconnects or remove the fuses from the control circuits.
  - b. Disconnect the neutral connection at any surge protective device or other electronic device before performing the electrical insulation resistance test; reconnect to the device after the test.
  - c. With the neutral isolated from the ground and the power switches and circuit breakers open, conduct electrical insulation tests from phase-to-phase, phase-to-ground, phase-to-neutral, and neutral-to-ground.
  - d. If the resistance reads less than one megohm while testing with the branch circuit devices in the open position, the system may be unsafe and should be investigated.
  - e. Consult Schneider Electric Services at 1-888-778-2733 (US) or 1-800-565-6699 (Canada) to help correct any problems.
19. After completing the electrical insulation resistance test, replace all control power fuses that were removed and close power disconnects that were opened.
20. Check all field-installed wiring. Make certain it is clear of all live parts, and when instructed, secured to withstand fault currents.

21. Verify that all control wiring between sections is connected.
22. Vacuum to remove any dust, scrap wire, or other debris.

## **NOTICE**

### **HAZARD OF EQUIPMENT DAMAGE**

Do not use an air hose to blow out the switchboard. Dust can settle inside relays and overcurrent devices, causing overheating and improper operation.

**Failure to follow these instructions can result in equipment damage.**

23. Replace all covers and barriers; check for any pinched wires, and close doors. Make certain all enclosure parts are aligned properly and securely fastened.

## **Ground Fault Protection Systems**

Paragraph 230-95(c) of the National Electrical Code requires that all equipment ground-fault protection systems be tested when first installed. If the circuit breaker has equipment ground-fault protection installed, test it at this time.

1. Make sure the trip unit is powered. The trip unit is powered if:
  - The circuit breaker is closed or bottom fed and has more than 100 V of load voltage on two phases (P or H trip unit only).
  - The full-function or hand-held test kit is connected and on.
  - The 24 Vdc external power supply is connected.
  - An external voltage tap is installed and voltage of more than 100 V is present on two phases (P or H trip unit only).
2. If the system is a radial (single-ended) system, press the ground-fault Push-to-Test button. The circuit breaker trips, and the trip unit ground-fault indicator light comes on.
3. Record results on the ground fault system test log.

**NOTE:** If a complete check of the ground-fault system is necessary, use primary injection testing. If the system is multiple source and/or requires field connections at the job site, use primary injection testing.

**NOTE:** Some ground fault systems require field connections at the job site. Consult the switchboard interconnection wiring drawing for details.

## Section 6—Energizing the Switchboard

### **⚠ DANGER**

#### **HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

- Correct short-circuit conditions detected during the checkout procedures described in “Section 5—Pre-energizing Checkout Procedure” beginning on page 38.
- Qualified electrical personnel must be present when energizing this equipment for the first time.
- Follow the instructions in this section to energize the switchboard properly.

**Failure to follow these instructions will result in death or serious injury.**

1. Make sure there is not a load on the switchboard when it is energized. Turn off all downstream loads.
2. Energize the switchboard in the following sequence:
  - a. Turn on all control power disconnects before energizing the switchboard. Refer to the record drawings supplied with equipment to see if control power disconnects are supplied.
  - b. Close any open doors and/or covers.
  - c. Close all main devices.
  - d. Close each branch circuit breaker or branch fusible switch.
  - e. Proceed to each panelboard and other downstream load.
3. After all overcurrent protective devices are closed, turn on all loads (for example, lighting circuits, contactors, heaters, and motors).

## Section 7—Maintaining the Switchboard

### **⚠ DANGER**

#### **HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

- Inspect and perform preventive maintenance only on switchboards and equipment that has been de-energized and electrically isolated (unless otherwise specified). This helps ensure that accidental contact cannot be made with energized parts.
- Follow safety-related work practices as described in NFPA 70E, Part II at all times.

**Failure to follow these instructions will result in death or serious injury.**

Periodic maintenance of the switchboard includes cleaning, lubrication, and exercising component parts. The interval between maintenance checks can vary depending upon the amount of usage and environmental conditions of each installation. The maximum recommended inspection interval is one year. This definition for periodic maintenance applies throughout this manual, unless otherwise noted.

Always inspect the switchboard after a fault. (Refer to “Section 8—Adverse Circumstances”, beginning on page 50). Service bulletins for the various disconnecting and overcurrent devices mounted in the switchboard are available through your local Schneider Electric representative.

### General Inspection and Cleaning

1. Vacuum the switchboard interior to remove any dirt or dust deposits. Wipe all bus bars, insulators, cables, etc., with a clean, dry, lint-free cloth.
2. Check the switchboard interior carefully for moisture, condensation build-up, or signs of any previous wetness. Moisture can cause insulation failures and rapid oxidation of current-carrying parts. Inspect all conduit entrances and cracks between the enclosure panels for dripping leaks. Condensation in conduits can be a source of moisture and must not be allowed to drip onto live parts or insulating material. Take the necessary steps to eliminate the moisture and seal off all leaks.

### **NOTICE**

#### **HAZARD OF EQUIPMENT DAMAGE**

- Do not use an air hose to blow out the switchboard. Dust can settle inside relays and overcurrent devices, causing overheating and improper operation.
- Do not allow paint, chemicals, or petroleum-based solvents to contact plastics or insulating materials.

**Failure to follow these instructions can result in equipment damage.**

3. Inspect the switchboard for any signs of overheating. Discoloration and flaking of insulation or metal parts are indications of overheating.

**NOTE:** If overheating occurs, be sure that all conditions that caused the overheating have been corrected. Loose or contaminated connections can cause overheating.

4. Check for signs of rodent nesting in the switchboard. If required, use a good exterminating technique in the general area of the switchboard.  
**NOTE:** Do not place or use exterminating substances and chemicals inside the switchboard. Some products attract rodents.
5. Carefully inspect all devices for any visibly worn-out, cracked, or missing parts.
6. Manually open and close switches and circuit breakers several times to verify they are working properly.
7. Verify that all key interlocks and door interlocking provisions are working properly.

### Bus Bar Joints, Lug Terminations, and Insulating Materials

1. Bus bar joints are maintenance-free. Do not retighten them after the pre-energizing checkout procedure is complete.

#### **NOTICE**

##### **HAZARD OF EQUIPMENT DAMAGE**

- Do not sand or remove plating on any bus bar, splice bar, or terminal lug.
- Damage to plating can result in overheating. Replace damaged part. Contact Schneider Electric Services at 1-888-778-2733 (US) or 1-800-565-6699 (Canada).

**Failure to follow these instructions can result in equipment damage.**

2. Check all bus bar joints and terminal lugs for any pitting, corrosion, or discoloration resulting from high temperatures or subjection to high fault conditions. If any damage has occurred, replace the bus bars or lugs. If cleaning is required, use Lectra-Clean®, made by CRC.
3. Inspect all insulating materials. Before re-energizing the switchboard, replace insulators with any visible damage (such as cracks).

### General Lubrication Information

For field maintenance re-lubrication of blade/jaw components in switches 600 V and below, use BG20 High Performance Synthetic Grease from Dow Corning (Schneider Electric catalog number SWLUB). This grease is applicable for the following switches:

- Bolt-Loc
- QMB Main and Branch
- QMJ Branch
- QMQB<sup>1</sup> Main and Branch

For bus/plug-on connections, use electric joint compound, Schneider Electric catalog number PJC7201.

For Masterpact™ NW drawout connections, use only Schneider Electric catalog number S48899 Electric Joint Compound.

### Automatic Transfer Switches

Consult the documentation provided by the manufacturer for all installation, operation, and maintenance instructions for these devices.

<sup>1</sup> QMQB switches are available in Canada only.

## Bolt-Loc Bolted Pressure Contact Switch Maintenance (800–4,000 A)

Refer to the Bolt-Loc switch installation and maintenance manual for complete information (manual is shipped with the switchboard). If the manual is not available, refer to “Section 11—Reference Publications” on page 56, and contact your local Schneider Electric representative to obtain the appropriate manuals.

1. Exercise the operating mechanism at least once a year to ensure proper operation.
2. The Bolt-Loc switch is shipped from the factory properly lubricated. Periodic cleaning and lubrication of the switch is required. The maintenance interval between lubrications depends on factors such as usage and ambient conditions. The maximum recommended maintenance interval is one year for current-carrying parts and five years for operating mechanisms.

### **⚠ DANGER**

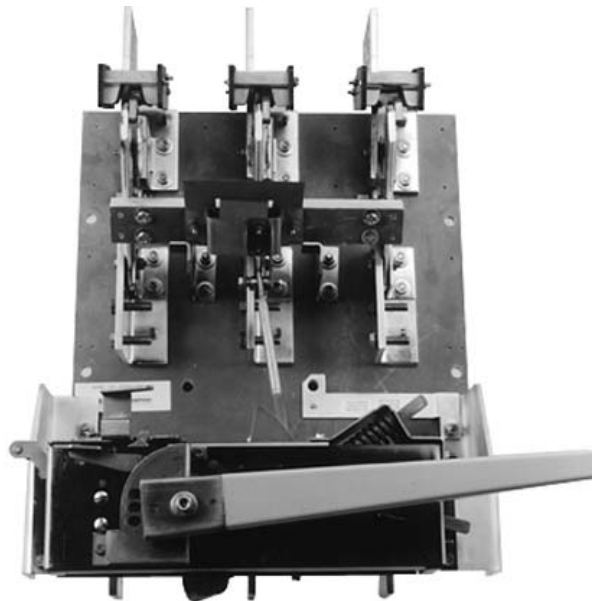
#### **HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

Always check line and load ends of the fuses for voltage before starting the replacement procedure. The Bolt-Loc switch can be part of a multiple source system in which the fuses can be energized when the Bolt-Loc switch is in the “open” position.

**Failure to follow these instructions will result in death or serious injury.**

3. To replace the fuse:
  - a. Open the switch before opening the fuse door.

**Figure 29 – Type BP Bolt-Loc Fusible Switch**



- b. Open the fuse door, releasing the interlock as described in the instructions on the door.
  - c. Observe the switch blades to confirm the switch is “open.”
  - d. Check the line and load ends of fuses for voltage using a properly rated voltage sensing device. No voltage should be present.

- e. Remove all fuses. Retain the hardware for reuse.
  - f. Using a non-abrasive cleaner such as Lectra-Clean, made by CRC, wipe clean the fuse mounting pads on the switch and the terminals of each new fuse. Check the alignment of fuse terminals before installing new fuses.
  - g. Install new fuses using the same hardware removed in Step e. Tighten to 21–30 lb-ft (28–41 N•m).
4. Close the fuse door, and check the fuse door interlock with the switch in the ON position. The fuse doors should not open using normal hand force.

## Circuit Breakers

Schneider Electric circuit breakers are designed and manufactured as sealed units requiring minimal periodic maintenance.

Exercise circuit breakers at least once a year to ensure proper operation. For general maintenance:

1. Trip the circuit breaker by pushing the Push-To-Trip or “Open” button located on the face of the circuit breaker. Refer to the appropriate circuit breaker manual for the specific location of this button.
2. Manually open and close the circuit breaker two to three times.

**Figure 30 – PowerPact™ R-Frame Circuit Breaker**



**NOTE:** Schneider Electric instruction bulletin 48049-900-0x, *Field Testing and Maintenance Guide for Thermal-Magnetic and Micrologic™ Electronic Trip Molded Case Circuit Breakers*, provides more in-depth information.



**⚠ DANGER****HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

- If adjusting circuit breaker settings, do not set the long-time trip rating at a higher ampacity than the rating of the bus bar or load cables it supplies; overheating can occur.
- Before energizing the switchboard, fill all unused I-Line circuit breaker mounting spaces with blank fillers and/or extensions as listed in Table 3.

**Failure to follow these instructions will result in death or serious injury.**

Refer to individual circuit breaker instruction manuals shipped with the switchboard for additional maintenance information, such as changing rating plugs, sensor plugs, or adjustable settings and removing circuit breakers. If the instruction manual is not available, refer to “Section 11—Reference Publications” on page 56 for the appropriate number, or contact your local Schneider Electric representative.

**Table 3 – I-Line™ Blank Fillers and Extensions**

| Item                    | Height            | Catalog No. | Branch Circuit Side | Circuit Breaker Frame   |
|-------------------------|-------------------|-------------|---------------------|---|
| <b>Blank Fillers</b>    | 1.50 in. (38 mm)  | HNM1BL      | Both Sides          | Not applicable  |
|                         | 4.50 in. (114 mm) | HNM4BL      | Both Sides          |   |
| <b>Blank Extensions</b> | 1.50 in. (38 mm)  | HLW1BL      | Wide Side           | All applications except PowerPact H/J circuit breakers with Micrologic trip unit 5/6. |
|                         | 4.50 in. (114 mm) | HLW4BL      | Wide Side           |   |
|                         | 1.50 in. (38 mm)  | HLN1BL      | Narrow Side         |   |
|                         | 4.50 in. (114 mm) | HLN4BL      | Narrow Side         |   |
|                         | 4.50 in. (114 mm) | HLN4EBL     | Narrow Side         | Only PowerPact H/J circuit breakers with Micrologic trip unit 5/6.                    |
|                         | 4.50 in. (114 mm) | HLW4EBL     | Wide Side           |   |

**NOTICE****HAZARD OF EQUIPMENT DAMAGE**

- Do not remove the protective lubricant on the plug-on connectors.
- If additional lubrication is required, apply a coating of electrical joint compound, catalog number PJC7201, to the contact surfaces of the plug-on connector.

**Failure to follow these instructions can result in equipment damage.**

3. The universal test set, catalog number UTS3, is available to test Schneider Electric Powerpact P and R circuit breakers equipped with Micrologic trip units. It runs trip unit tests automatically, with prompts to the user for initial information. Test modules for each circuit breaker frame are used to store data necessary for automatic tests. Series B Micrologic trip units require test module CBTMB, which is included in UTS3.

A pocket tester, catalog number S434206, or UTA tester, catalog number STRV00910, are available for Schneider Electric Powerpact H, J, and L circuit breakers with Micrologic trip units. These testers supply power to the Micrologic trip units and allow for settings to be adjusted through the keypad located on the circuit breaker or through a PC using the USB interface.

Masterpact NW trip units require the full-function test set, catalog number S33595, or the hand-held test set, catalog number S33594.

**NOTE:** Tests can be conducted with a circuit breaker installed in the switchboard; circuit breaker removal is not required. **The switchboard must be de-energized.**

## QMB/QMJ/QMQB<sup>1</sup> Fusible Switches

Refer to the QMB/QMJ/QMQB<sup>1</sup> instruction manual for complete maintenance information. If the instruction manual is not available, refer to “Section 11—Reference Publications” on page 56 of this manual for the appropriate number. Contact your local Schneider Electric representative to obtain the manual.

### Switch Maintenance

1. Periodically exercise the switch to ensure proper operation. This period should not exceed one year.
2. Check the cover interlock with the switch in the ON position. The cover should not open using normal hand force.
3. Inspect the switch interior for any damaged or cracked parts, and replace as necessary.
4. For fusible switch units, check the fuse mounting clips or bolted contact area for corrosion or discoloration (indicating overheating). Replace them if necessary.
5. For additional maintenance instructions, see the label on the inside of the door.

### Fuse Replacement (Fusible Switches Only)

1. Turn the switch to the OFF position before opening the door.

## **⚠ DANGER**

### **HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

Always check line and load ends of the fuses for voltage before starting the fuse replacement procedure with a properly rated voltage sensing device.

**Failure to follow these instructions will result in death or serious injury.**

2. Observe the switch blades to confirm that the switch is in the OFF position.
3. Using a properly rated voltage sensing device, verify that line and load ends of the fuse are not energized.
4. Observe all warning labels specifying the type of fuse to use. Do not substitute a non-current limiting fuse, or attempt in any way to defeat the rejection feature of the fuse clips furnished with the switch. Do not use renewable link fuses in Schneider Electric fusible switches.

## **NOTICE**

### **HAZARD OF EQUIPMENT DAMAGE**

Do not pry open or spread the fuse mounting clips. Doing so can cause a loose connection, resulting in overheating and nuisance fuse blowing.

**Failure to follow these instructions can result in equipment damage.**

<sup>1</sup> QMQB switches are available in Canada only.

## Installing QMB/QMJ/QMQB<sup>1</sup> Fusible Switches

### **⚠ DANGER**

#### **HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

- Remove power for these sections before installing or removing QMB/QMJ/QMQB<sup>1</sup> switches.
- Do not use a main as a branch unit or a branch as a main.
- All unused spaces must be filled with blank fillers before energizing the switchboard. Refer to Tables 4 and 5 for sizes and catalog numbers.

**Failure to follow these instructions will result in death or serious injury.**

**Table 4 – QMB/QMJ Fusible Switch Blank Fillers**

| Height             | Catalog No. |
|--------------------|-------------|
| 1.50 in. (38 mm)   | QMB1BLW     |
| 3.00 in. (76 mm)   | QMB3BLW     |
| 6.00 in. (152 mm)  | QMB6BLW     |
| 15.00 in. (381 mm) | QMB15BLW    |

**Table 5 – QMQB<sup>1</sup> Fusible Switch Blank Fillers**

| Height                  | Catalog No. |
|-------------------------|-------------|
| 2x: 1.375 in. (35 mm)   | QFS1        |
| 8x: 5.50 in. (140 mm)   | QFS5        |
| 10x: 6.875 in. (175 mm) | QFS6        |
| 14x: 9.625 in. (244 mm) | QFS9        |
| 24x: 16.50 in. (419 mm) | QFS16       |

### **NOTICE**

#### **HAZARD OF EQUIPMENT DAMAGE**

Do not remove the protective lubricant on the plug-on connectors.

**Failure to follow these instructions can result in equipment damage.**

1. Turn off the main power.
2. Turn the switch handle(s) to the OFF position. Align switch plug-on connectors with QMB panel vertical bus, and plug switch onto panel.
3. Place and partially tighten all unit mounting screws that mount to the QMB panel mounting rails.
4. Tighten all screws evenly. The unit mounting flange and plug-on connectors must be seated securely.

**Removing  
QMB/QMJ/QMQB<sup>1</sup> Fusible  
Switches**

1. Turn off the main power.
2. Turn switch handle(s) to the OFF position.
3. Disconnect the load wires.
4. For QMB and QMJ switches, remove mounting screws holding the switch to the mounting rail. For QMQB<sup>1</sup> switches, remove the bolts holding the switch to the line terminal.
5. Unplug the switch.

**Ground-Fault Protection Systems**

Check the terminal connections on the ground-fault protection system at least once a year for tightness and corrosion. If the system can be tested without tripping the main or branch device, directions for testing the system are in the device manual. Otherwise, testing the ground-fault protection system will trip the main or branch device to which it is connected. If the ground-fault sensor or relay is physically or electrically damaged, replace it.

If the ground-fault protection system does not operate properly and additional equipment has been connected to the installation since the last maintenance test/check, de-energize the entire system, and check for grounds on the neutral downstream from the main bonding jumper. If no downstream grounds are detected and the ground fault system is not operating properly, contact Schneider Electric Services at 1-888-778-2733 (US) or 1-800-565-6699 (Canada).

If no additions have been made to the installation and the ground-fault protection system does not operate properly, contact Schneider Electric Services at 1-888-778-2733 (US) or 1-800-565-6699 (Canada).

Refer to the ground-fault field test instruction manual for additional testing information. If the manual is not available, refer to “Section 11—Reference Publications” on page 56 of this manual to obtain the appropriate number. Contact your local Schneider Electric representative to obtain this manual.

<sup>1</sup> QMQB switches are available in Canada only.

## Section 8—Adverse Circumstances

This section includes, but is not limited to, all electrical components of the switchboard.

### **⚠ DANGER**

#### **HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

- Turn off all power supplying the switchboard before cleaning.
- Always use a properly rated voltage sensing device to confirm all power is off.
- Before energizing the switchboard, all unused circuit breaker mounting spaces must be filled.

**Failure to follow these instructions will result in death or serious injury.**

**NOTE:** Before attempting to re-energize the switchboard following adverse circumstances, contact Schneider Electric Services at 1-888-778-2733 (US) or 1-800-565-6699 (Canada) for special instructions.

### Inspection Following a Short Circuit

If a short circuit occurs, make a thorough inspection of the entire system, and verify that no damage to conductors or insulation has occurred. High mechanical and thermal stresses developed by short-circuit currents can damage conductors and insulation. Check the overcurrent-protection device that interrupted the short-circuit current for possible arcing damage.

Do not open sealed devices, such as molded case circuit breakers. Replace these devices if they are damaged. Before energizing the switchboard, all unused circuit breaker mounting spaces must be filled. For more information about these devices, refer to the appropriate instruction manual listed in “Section 11—Reference Publications” on page 56.

### Clean-up Following a Short Circuit

The insulating properties of some organic insulating materials can deteriorate during an electrical arc. If so:

1. Remove any soot or debris.
2. Replace carbon-tracked insulation.

### Water-Soaked Switchboards

Do not clean or repair a switchboard that has been exposed to large volumes of water or submerged at any time. Current-carrying parts, insulation systems, and electrical components may be damaged beyond repair. **Do not energize the switchboard.** Contact Schneider Electric Services at 1-888-778-2733 (US) or 1-800-565-6699 (Canada).

## Water-Sprayed or Splashed Switchboards (Clean Water Only)

### **⚠ DANGER**

#### **HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH**

Turn off all power supplying this equipment before working on it.

**Failure to follow these instructions will result in death or serious injury.**

### Inspection and Clean-up of Clean Water Sprayed or Splashed Switchboards

If the switchboard has been sprayed or splashed with small amounts of clean water, make a thorough inspection of the entire system, and verify that no damage to conductors or insulation has occurred. Do not open sealed devices such as molded case circuit breakers or fuses. Replace these devices if they are damaged. For more information about these devices, refer to the appropriate instruction manual listed in “Section 11—Reference Publications”.

Follow steps 1–10 only if:

- No signs of physical damage to the equipment are present.
- The switchboard has not been submerged or exposed to water for long periods of time.
- The water that has been in contact with the switchboard has not been contaminated with sewage, chemicals, or other substances that can negatively affect the integrity of the electrical equipment.
- The water that has been in contact with the switchboard has not entered any area of the enclosure that may contain wiring installed as intended and located above any live part. Specifically, inspect for water entering through conduits located above live parts.

If any one or more of these conditions have not been met, contact Schneider Electric Services at 1-888-778-2733 (US) or 1-800-565-6699 (Canada).

If **ALL** of the conditions listed have been met, proceed as follows:

1. Turn off all power supplying this equipment before working on or inside the equipment.
2. Always use a properly rated voltage sensing device to confirm all power is off.
3. Disconnect and electrically isolate the switchboard so that no contact can be made with energized parts.
4. Wipe off all moisture from the bus bars, insulators, and insulating material with a clean, dry, lint-free cloth. Do **not** use cleaning agents or water displacement sprays.
5. Prepare the switchboard for insulation resistance (Megger®) testing by disconnecting all line side supply connections and all load side cable connections to isolate the switchboard from the wiring system.

**⚠ CAUTION****HAZARD OF EQUIPMENT DAMAGE OR INJURY**

- Remove the long-time rating plug before electrical insulation testing a circuit breaker that has a label stating “Warning: Disconnect Plug Before Dielectric Test.”
- Some Micrologic trip units are not rated for voltages that would occur during electrical resistance insulation testing.
- Open all control and metering disconnects from the control circuits.

**Failure to follow these instructions can result in injury or equipment damage.**

6. Turn all circuit breakers or switches to their ON position. The switchboard must remain de-energized.
7. Use a megohmmeter with a capacity of 500–1,000 Vdc and apply voltage from:
  - a. Each phase-to-ground with circuit breaker on.
  - b. Phase-to-phase with circuit breaker on.
8. Record resistance values. Refer to “Section 10—Switchboard Insulation Resistance Chart” on page 55.
9. If resistance measurements are less than 0.5 megohm, call Schneider Electric Services at 1-888-778-2733 (US) or 1-800-565-6699 (Canada) for recommendations.
10. If resistance measurements are greater than 0.5 megohm, the equipment can be energized using the procedures listed in “Section 6—Energizing the Switchboard” on page 41.

## Section 9—Torque Values for Electrical Connections

**Table 6 – Incoming, Branch, and Neutral Lug**

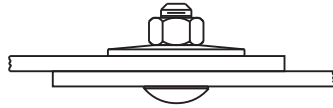
| Socket Size Across Flats | Torque Value       |
|--------------------------|--------------------|
| 1/4 in.                  | 180 lb-in (20 N•m) |
| 5/16 in.                 | 250 lb-in (28 N•m) |
| 3/8 in.                  | 340 lb-in (38 N•m) |
| 1/2 in. *                | 450 lb-in (51 N•m) |

\* Certain lugs require 620 lb-in (70 N•m) and are marked as such.

**Table 7 – Multiple Conductor Neutral and/or Ground Bar**

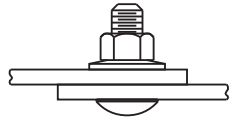
| Screw Type   | Lug Wire Range | Conductor Size     | Torque Value       |
|--------------|----------------|--------------------|--------------------|
| Slotted Head | 14–4           | 14-10 Cu, 12-10 Al | 20 lb-in (2 N•m)   |
|              |                | 8 Cu-Al            | 25 lb-in (3 N•m)   |
|              |                | 6-4 Cu-Al          | 35 lb-in (4 N•m)   |
|              | 14–1/0         | 14-8 Cu-Al         | 36 lb-in (4 N•m)   |
|              |                | 6-1/0 Cu-Al        | 45 lb-in (5 N•m)   |
| Socket Head  | 14–1/0         | All                | 100 lb-in (11 N•m) |
|              | 6–300 kcmil    | All                | 275 lb-in (31 N•m) |



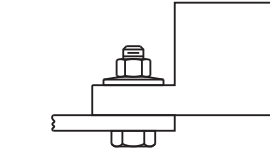


Carriage bolt  
Hex nut  
Conical washer

| Hardware Description | Torque Value              |
|----------------------|---------------------------|
| 1/2 in.              | 720–840 lb-in (81–95 N•m) |

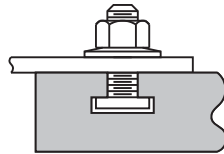


Carriage bolt  
Conical washer assembly  
Keps nut



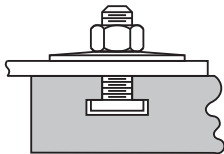
Hex head bolt  
Conical washer assembly  
Keps nut

| Hardware Description | Torque Value              |
|----------------------|---------------------------|
| 1/4 in.              | 50–75 lb-in (6–8 N•m)     |
| 5/16 in.             | 80–125 lb-in (9–14 N•m)   |
| 3/8 in.              | 175–225 lb-in (20–25 N•m) |
| 1/2 in.              | 250–350 lb-in (28–40 N•m) |



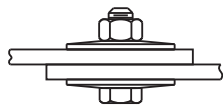
Square head (Tee) bolt  
Conical washer assembly  
Keps nut

| Hardware Description | Torque Value              |
|----------------------|---------------------------|
| 1/4 in.              | 50–75 lb-in (6–8 N•m)     |
| 3/8 in.              | 175–225 lb-in (20–25 N•m) |
| 1/2 in.              | 250–350 lb-in (28–40 N•m) |



Square head (Tee) bolt  
Conical washer

| Hardware Description | Torque Value      |  |
|----------------------|-------------------|--|
|                      | Conical Washer OD | Square Head (Tee) Bolt<br>Conical Washer |
| 3/8 in.              | 0.87 in. (22 mm)  | 250–280 lb-in (28–32 N•m)                |
|                      | 1.00 in. (25 mm)  | 130–150 lb-in (15–17 N•m)                |
| 1/2 in.              | 1.25 in. (32 mm)  | 450–550 lb-in (51–62 N•m)                |
|                      | 2.25 in. (57 mm)  |  |



Hex head bolt  
(2) Conical washers

| Hardware Description | Torque Value      |                                      |
|----------------------|-------------------|--------------------------------------|
|                      | Conical Washer OD | Hex Head Bolt<br>(2) Conical Washers |
| 5/16 in.             | 0.90 in. (23 mm)  | 145–160 lb-in (16–18 N•m)            |
| 3/8 in.              | 0.87 in. (22 mm)  | 250–280 lb-in (28–32 N•m)            |
|                      | 1.00 in. (25 mm)  | 130–150 lb-in (15–17 N•m)            |
| 1/2 in.              | 1.25 in. (32 mm)  | 720–840 lb-in (81–95 N•m)            |
|                      | 2.25 in. (57 mm)  |                                      |
|                      | 3.00 in. (76 mm)  |                                      |



## Section 11—Reference Publications

Schneider Electric publications are available through your local Schneider Electric representative. These publications include device replacement procedures and listings of spare parts to make ordering and servicing of replacement parts quick and convenient. Any maintenance procedure or device not listed, such as an I-Line interior, is not customer serviceable.

Contact your local Schneider Electric representative for information at 1-888-778-2733 in the US, or at 1-800-565-6699 in Canada. Or, refer to the Technical Library at <http://www.schneider-electric.us/> to obtain the appropriate publications.

For information about obtaining NEMA documents, write to:

National Electrical Manufacturers Association (NEMA)  
 Attention: Customer Service  
 1300 North 17th Street  
 Suite 1847  
 Rosslyn, VA 22209

| Other Reference Publications   | Publication Number     |
|--|------------------------|
| General Instructions for Proper Installation, Operation, and Maintenance of Switchboards Rated 600 V or Less | NEMA Publication PB2.1 |
| Application Guide for Ground Fault Protective Devices for Equipment  | NEMA Publication PB2.2 |
| Circuit Breakers   | NEMA Publication AB-4  |
| Enclosed and Miscellaneous Distribution Switches   | NEMA Publication KS-1  |
| Electrical Equipment Maintenance   | NFPA 70B-1999          |







**Schneider Electric USA, Inc.**

800 Federal Street  
Andover, MA 01810 USA  
888-778-2733  
[www.schneider-electric.us](http://www.schneider-electric.us)

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80043-055-12, 05/2015  
Replaces 80043-055-11, 04/2014

Replaces / Remplace S2700AB0501BP R0

## Circuit Breaker Handle Padlock Attachments Accessoires de cadenasage de manette de

| Class<br>Classe | Type<br>Type                               |
|-----------------|--|
| 2700            | 60100, 60400, 60800,<br>SL800, SL1200, QED |

Retain for future use. / À conserver pour usage ultérieur.

### INTRODUCTION

This data bulletin contains cross-references between the circuit breaker types that may be used in this type of switchboard and the padlock kit part numbers. The installation and operating instructions for each circuit breaker handle padlock attachment kit should be found with each kit.

### SAFETY PRECAUTIONS

### INTRODUCTION

Ces directives d'utilisation contiennent des références croisées entre les types de disjoncteurs qui peuvent être utilisés dans ce type de panneau de commutation et les numéros de pièces des kits de cadenas.

Les directives d'installation et de fonctionnement pour chaque kit d'accessoires de cadenasage de manette de disjoncteur doivent se trouver avec chaque kit.

### MESURES DE SÉCURITÉ

## DANGER

### HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

- Apply appropriate personal protective equipment (PPE) and follow safe electrical work practices. See NFPA 70E.
- This equipment must be installed and serviced only by qualified electrical personnel in accordance with National and Local Electrical Codes.
- Turn off all power supplying this equipment before working on or inside equipment.
- Always use a properly rated voltage sensing device to confirm power is off.
- Replace all devices, doors, and covers before turning on power to this equipment.

**Failure to follow these instructions will result in death or serious injury.**

### RISQUE D'ÉLECTROCUTION, D'EXPLOSION OU D'ÉCLAIR D'ARC

- Portez un équipement de protection personnelle (ÉPP) approprié et observez les méthodes de travail électrique sécuritaire. Voir NFPA 70E.
- L'installation et l'entretien de cet appareil ne doivent être effectués que par du personnel qualifié conformément au Code national de l'électricité (NEC; É.-U.) et aux codes locaux électriques.
- Coupez toutes les alimentations à cet appareil avant d'y travailler.
- Utilisez toujours un dispositif de détection de tension ayant une valeur nominale appropriée pour vous assurer que l'alimentation est coupée.
- Remplacez tous les dispositifs, les portes et les couvercles avant de mettre l'appareil sous tension.

**Si ces directives ne sont pas respectées, cela entraînera la mort ou des blessures graves.**



### HANDLE PADLOCK ATTACHMENT

Use the appropriate Handle Padlock Attachment kit listed below to lock the circuit breaker handle in the OFF position.

### ACCESSOIRE DE CADENASSAGE DE MANETTE

Utiliser l'accessoire de cadenassage de manette approprié indiqué ci-dessous pour verrouiller la manette en position d'arrêt (O).

| Circuit Breaker Catalogue Designation /<br>Désignation de catalogue du disjoncteur | Poles /<br>Pôles    | Handle Padlock Attachment /<br>Accessoire de cadenassage de manette   |
|--|---------------------|---|
| QO   | 1<br>2, 3<br>2<br>3 | QO1PA, QO-AS, QOB-AS, QO1HPL, QOU1PL, QOM1PA, QO1PAF, QOU1PAFLA, QOGFI1PAF, QO1PAD, QOHPL, QO1PL, QO2PAF, QOMPA, GF12PA, QOGFI2PAF, QOTHPA, QO3HT |
| FY<br>Q2, Q2-H, Q2H  | 1<br>2, 3           | HPAFYQ  |
| QB, QD, QG, QJ   | 2, 3                | QBPAF   |
| FA, FH, FD, FG, FJ<br>FC, FI   | 1, 2, 3<br>2, 3     | HPAFK<br>HPAFKF   |
| KA, KH, KC, KI   | 2, 3                | HPAFK, HPAFKF   |
| LA, LH, MA, ME, MH, MX, Q4   | 2, 3                | HPALM, HPAXLM, HPANA  |
| LC, LE, LI, LX, LXI  | 2, 3                | AHPALI  |
| NA, NC, NE, NX   | 2, 3                | HPANE   |
| PG, PK, PJ, PL, MG, MJ   | 2, 3                | S32631 or / ou S44936 <sup>a</sup><br>NJPAF   |
| RG, RJ, RK, RL   | 2, 3                | S32631 or / ou S33996 <sup>a</sup><br>NJPAF   |
| PA, PC, PH, PE, PX   | 2, 3                | PAPAF   |
| NB, NBH  | 1<br>2, 3           | 1LOB<br>2LOK  |
| FF   | 1                   | HPAFF   |
| FK   | 1<br>2, 3           | HPAKD   |
| CE   | 2, 3                | PLK1  |
| CJL  | 2, 3                | PLK3  |
| CJM  | 2, 3                | HLK4  |
| CMH  | 2, 3                | HPALM   |
| CK   | 2, 3                | 44936   |
| TH1  | 3                   | 765A754G01  |
| TH4  | 3                   | 373B591G02  |
| TH8  | 3                   | 6591C30G01  |
| Powerpact® H (HD, HG, HJ, HL) and / et Powerpact J (JD, JG, JJ, JL)                | 2,<br>3             | S29370<br>S29371, S37422  |

<sup>a</sup> When the circuit breaker is fitted with a key interlock, use handle padlock attachment:  
S44936 for the "P" frame breakers and  
S33996 for the "R" frame breakers.

<sup>a</sup> Lorsque le disjoncteur est muni d'une serrure à clé d'interverrouillage, utiliser un accessoire de cadenassage de manette :  
S44936 pour les disjoncteurs à châssis P et  
S33996 pour les disjoncteurs à châssis R

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

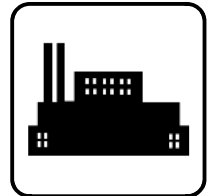
Seul un personnel qualifié doit effectuer l'installation, l'utilisation, l'entretien et la maintenance du matériel électrique. Schneider Electric n'assume aucune responsabilité des conséquences éventuelles découlant de l'utilisation de cette documentation.

**Schneider Electric USA**  
252 North Tippecanoe  
Peru, IN 46970 USA  
1-888-SquareD (1-888-778-2733)  
www.us.SquareD.com

**Schneider Electric Canada**  
19 Waterman Avenue, M4B 1 Y2  
Toronto, Ontario  
1-800-565-6699  
www.schneider-electric.ca

# Wiring Diagrams

## Industrial Generator Sets



Models:

**750-2000REOZMD**

**750-2000ROZMC**

Controllers:

Decision-Maker® 3000

Decision-Maker® 550

Decision-Maker® 6000

**KOHLER**<sup>®</sup>  
POWER SYSTEMS

**ISO 9001**  
**KOHLER**  
POWER SYSTEMS  
NATIONALLY REGISTERED

TP-6813 3/12a



This manual provides wiring diagrams for the 750-2000REOZMD and 750-2000ROZMC generator sets equipped with one of the following controllers:

- Decision-Maker® 3000 (750-1000 kW)
- Decision-Maker® 550
- Decision-Maker® 6000

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## Service Assistance

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For professional advice on generator power requirements and conscientious service, please contact your nearest Kohler distributor or dealer.

- Consult the Yellow Pages under the heading Generators—Electric.
- Visit the Kohler Power Systems website at KohlerPower.com.
- Look at the labels and stickers on your Kohler product or review the appropriate literature or documents included with the product.
- Call toll free in the US and Canada 1-800-544-2444.
- Outside the US and Canada, call the nearest regional office.

### **Headquarters Europe, Middle East, Africa (EMEA)**

Kohler Power Systems  
3 rue de Brennus  
93200 Saint Denis  
France  
Phone: (33) 1 49 178300  
Fax: (33) 1 49 178301

### **Asia Pacific**

Power Systems Asia Pacific Regional Office  
Singapore, Republic of Singapore  
Phone: (65) 6264-6422  
Fax: (65) 6264-6455

### **China**

North China Regional Office, Beijing  
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(86) 10 6518 7951  
(86) 10 6518 7952  
Fax: (86) 10 6518 7955

East China Regional Office, Shanghai  
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Fax: (86) 21 6288 0550

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Phone: (91) 80 3366208  
(91) 80 3366231  
Fax: (91) 80 3315972

### **Japan, Korea**

North Asia Regional Office  
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Phone: (813) 3440-4515  
Fax: (813) 3440-2727

### **Latin America**

Latin America Regional Office  
Lakeland, Florida, USA  
Phone: (863) 619-7568  
Fax: (863) 701-7131

# Wiring Diagrams

Use the Wiring Diagram Cross-Reference chart to determine the wiring diagram version number for a given model number and spec number. Then find that version number and the controller type on the Wiring Diagrams Reference chart to determine the wiring diagram numbers for your unit. Refer to Controller Identification for controller type identification, if necessary.

## Wiring Diagram Cross-Reference

| Generator Set Model No. | Hz | Generator Set Spec No. | Wiring Diagram Version No. |
|-------------------------|----|------------------------|----------------------------|
| 750REOZMD               | 60 | GM81540-GA9            | 1                          |
| 800REOZMD               | 60 | GM81540-GA10           | 1                          |
| 900REOZMD               | 60 | GM81540-GA11           | 2                          |
| 1000REOZMD              | 60 | GM81540-GA12           | 2                          |
| 1250REOZMD              | 60 | GM80624-GA9            | 3                          |
| 1600REOZMD              | 60 | GM80624-GA10           | 3                          |
| 1750REOZMD              | 60 | GM80624-GA11           | 3                          |
| 2000REOZMD              | 60 | GM80624-GA12           | 3                          |
| 750ROZMC                | 60 | GM81540-GA1            | 1                          |
| 750ROZMC                | 50 | GM81540-GA2            | 1                          |
| 800ROZMC                | 60 | GM81540-GA3            | 1                          |
| 800ROZMC                | 50 | GM81540-GA4            | 1                          |
| 900ROZMC                | 60 | GM81540-GA5            | 1                          |
| 900ROZMC                | 50 | GM81540-GA6            | 1                          |
| 1000ROZMC               | 60 | GM81540-GA7            | 1                          |
| 1000ROZMC               | 50 | GM81540-GA8            | 1                          |
| 1250ROZMC               | 60 | GM80624-GA1            | 3                          |
| 1250ROZMC               | 50 | GM80624-GA2            | 3                          |
| 1600ROZMC               | 60 | GM80624-GA3            | 3                          |
| 1600ROZMC               | 50 | GM80624-GA4            | 3                          |
| 1820ROZMC               | 60 | GM80624-GA5            | 3                          |
| 1820ROZMC               | 50 | GM80624-GA6            | 3                          |
| 2000ROZMC               | 60 | GM80624-GA7            | 3                          |
| 2000ROZMC               | 50 | GM80624-GA8            | 3                          |

## 750/800REOZMD and 750-1000ROZMC Wiring Diagrams Reference

| Controller Description          | Version 1   | Page |
|---------------------------------|-------------|------|
| <b>Decision-Maker® 3000</b>     |             |      |
| Point-to-Point Wiring Diagram   |             |      |
| Sheet 1                         | GM81316A-   | 48   |
| Sheet 2                         | GM81316B-   | 49   |
| Sheet 3                         | GM81316C-   | 50   |
| Schematic Diagram               |             |      |
| Sheet 1                         | ADV-8170-   | 17   |
| Accessory Connections           |             |      |
| Sheet 1                         | GM78246-    | 28   |
| <b>Decision-Maker® 550</b>      |             |      |
| Point-to-Point Wiring Diagram   |             |      |
| Sheet 1                         | GM81312A-   | 45   |
| Sheet 2                         | GM81312B-   | 46   |
| Sheet 3                         | GM81312C-   | 47   |
| Schematic Diagram               |             |      |
| Sheet 1                         | ADV-8169-   | 16   |
| Accessory Connections           |             |      |
| Sheet 1                         | GM78247A-C  | 29   |
| Sheet 2                         | GM78247C-C  | 31   |
| Sheet 3                         | GM78247D-C  | 32   |
| <b>Decision-Maker® 6000</b>     |             |      |
| Point-to-Point Wiring Diagram   |             |      |
| Sheet 1                         | GM81322A-A  | 51   |
| Sheet 2                         | GM81322B-A  | 52   |
| Sheet 3                         | GM81322C-A  | 53   |
| Sheet 4                         | GM81322D-A  | 54   |
| Sheet 5                         | GM81322E-A  | 55   |
| Sheet 6                         | GM81322F-A  | 56   |
| Schematic Diagram               |             |      |
| Sheet 1                         | ADV-8171A-A | 18   |
| Sheet 2                         | ADV-8171B-A | 19   |
| Sheet 3                         | ADV-8171C-A | 20   |
| Sheet 4                         | ADV-8171D-A | 21   |
| Accessory Connections           |             |      |
| Sheet 1                         | GM78247B-C  | 30   |
| Sheet 2                         | GM78247C-C  | 31   |
| <b>Alternator Reconnections</b> | ADV-5875D-M | 7    |

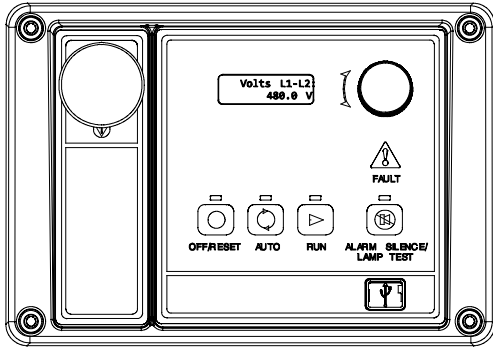
## 900/1000REOZMD Wiring Diagrams Reference

| Controller Description          | Version 2   | Page |
|---------------------------------|-------------|------|
| <b>Decision-Maker® 3000</b>     |             |      |
| Point-to-Point Wiring Diagram   |             |      |
| Sheet 1                         | GM81330A-   | 60   |
| Sheet 2                         | GM81330B-   | 61   |
| Sheet 3                         | GM81330C-   | 62   |
| Schematic Diagram               |             |      |
| Sheet 1                         | ADV-8188-   | 23   |
| Accessory Connections           |             |      |
| Sheet 1                         | GM78246-    | 28   |
| <b>Decision-Maker® 550</b>      |             |      |
| Point-to-Point Wiring Diagram   |             |      |
| Sheet 1                         | GM81329A-   | 57   |
| Sheet 2                         | GM81329B-   | 58   |
| Sheet 3                         | GM81329C-   | 59   |
| Schematic Diagram               |             |      |
| Sheet 1                         | ADV-8187-   | 22   |
| Accessory Connections           |             |      |
| Sheet 1                         | GM78247A-C  | 29   |
| Sheet 2                         | GM78247C-C  | 31   |
| Sheet 3                         | GM78247D-C  | 32   |
| <b>Decision-Maker® 6000</b>     |             |      |
| Point-to-Point Wiring Diagram   |             |      |
| Sheet 1                         | GM81331A-A  | 63   |
| Sheet 2                         | GM81331B-A  | 64   |
| Sheet 3                         | GM81331C-A  | 65   |
| Sheet 4                         | GM81331D-A  | 66   |
| Sheet 5                         | GM81331E-A  | 67   |
| Sheet 6                         | GM81331F-A  | 68   |
| Schematic Diagram               |             |      |
| Sheet 1                         | ADV-8189A-A | 24   |
| Sheet 2                         | ADV-8189B-A | 25   |
| Sheet 3                         | ADV-8189C-A | 26   |
| Sheet 4                         | ADV-8189D-A | 27   |
| Accessory Connections           |             |      |
| Sheet 1                         | GM78247B-C  | 30   |
| Sheet 2                         | GM78247C-C  | 31   |
| <b>Alternator Reconnections</b> | ADV-5875D-M | 7    |

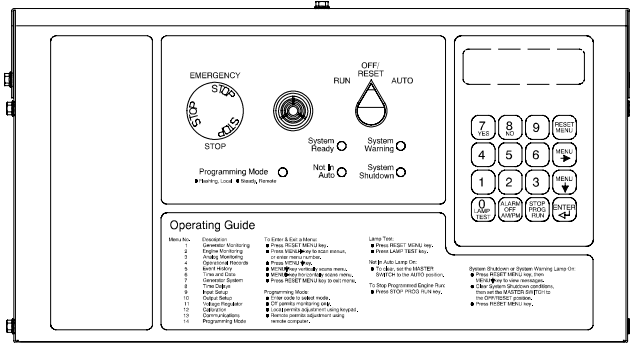
## 1250-2000REOZMD and 1250-2000ROZMC Wiring Diagrams Reference

| Controller Description                          | Version 3   | Page |
|---|-------------|------|
| <b>Decision-Maker® 550<br/>(380-600 Volt)</b>   |             |      |
| Point-to-Point Wiring Diagram                   |             |      |
| Sheet 1   | GM79396A-B  | 33   |
| Sheet 2   | GM79396B-B  | 34   |
| Sheet 3   | GM79396C-B  | 35   |
| Schematic Diagram                               |             |      |
| Sheet 1   | ADV-8027A-  | 8    |
| Sheet 2   | ADV-8027B-  | 9    |
| <b>Decision-Maker® 550<br/>(3300-4160 Volt)</b> |             |      |
| Point-to-Point Wiring Diagram                   |             |      |
| Sheet 1   | GM80025A-   | 42   |
| Sheet 2   | GM80025B-   | 43   |
| Sheet 3   | GM80025C-   | 44   |
| Schematic Diagram                               |             |      |
| Sheet 1   | ADV-8055A-  | 14   |
| Sheet 2   | ADV-8055B-  | 15   |
| <b>Decision-Maker® 550 (All)</b>                |             |      |
| Accessory Connections                           |             |      |
| Sheet 1   | GM78247A-C  | 29   |
| Sheet 2   | GM78247C-C  | 31   |
| Sheet 3   | GM78247D-C  | 32   |
| <b>Decision-Maker® 6000<br/>(380-600 Volt)</b>  |             |      |
| Point-to-Point Wiring Diagram                   |             |      |
| Sheet 1   | GM79397A-A  | 36   |
| Sheet 2   | GM79397B-A  | 37   |
| Sheet 3   | GM79397C-A  | 38   |
| Sheet 4   | GM79397D-A  | 39   |
| Sheet 5   | GM79397E-A  | 40   |
| Sheet 6   | GM79397F-A  | 41   |
| Schematic Diagram                               |             |      |
| Sheet 1   | ADV-8028A-A | 10   |
| Sheet 2   | ADV-8028B-A | 11   |
| Sheet 3   | ADV-8028C-A | 12   |
| Sheet 4   | ADV-8028D-A | 13   |
| Accessory Connections                           |             |      |
| Sheet 1   | GM78247B-C  | 30   |
| Sheet 2   | GM78247C-C  | 31   |
| <b>Alternator Reconnections</b>                 | ADV-5875D-M | 7    |

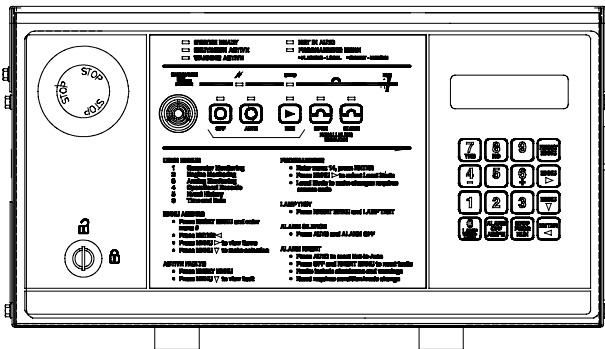
# Controller Identification



## Decision-Maker® 3000 Controller



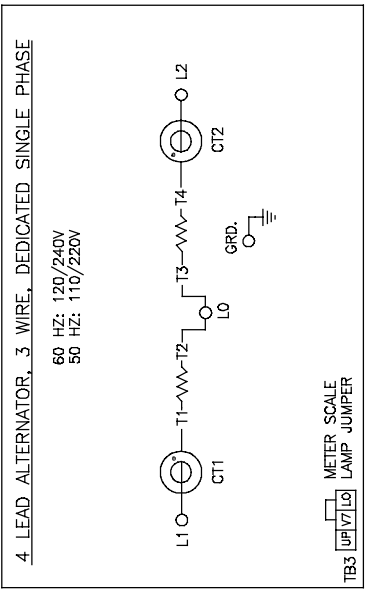
## Decision-Maker® 550 Controller



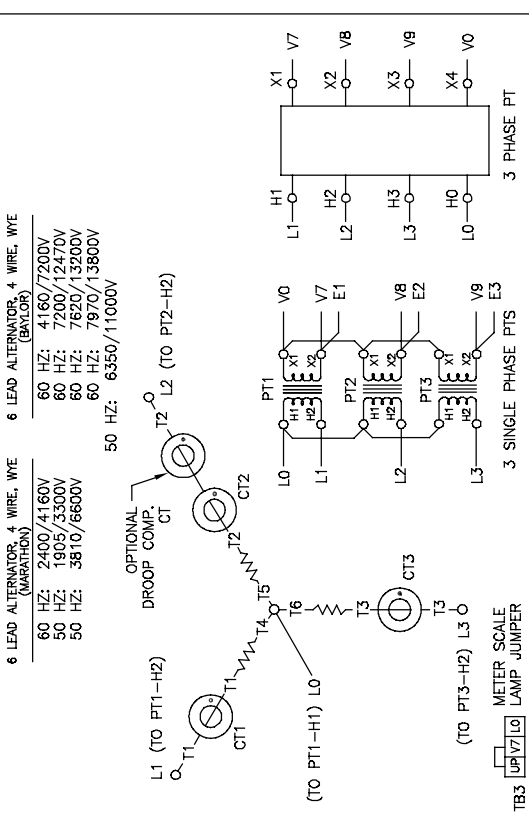
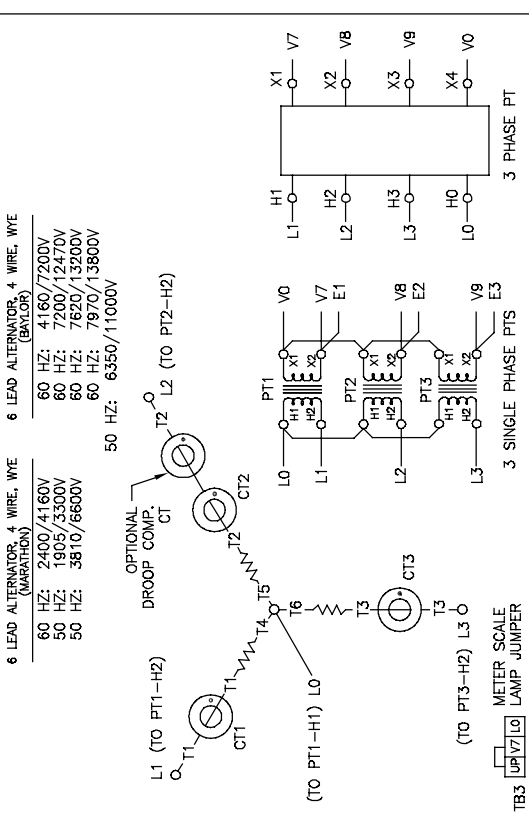
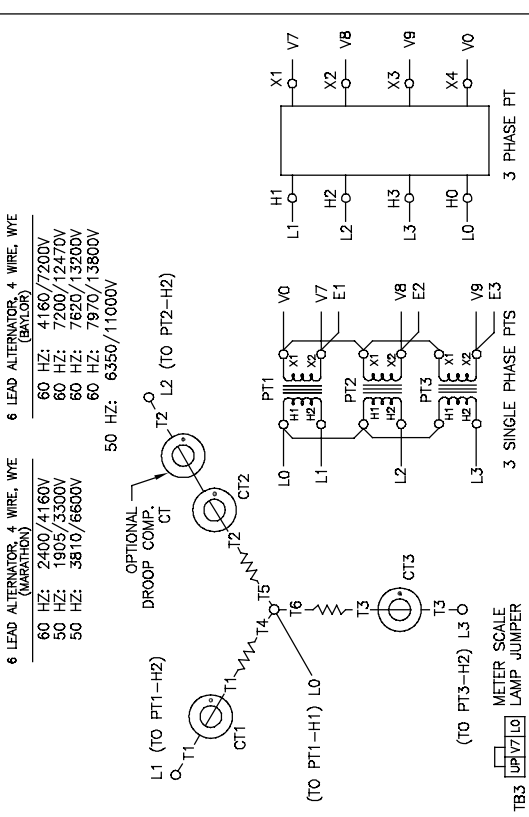
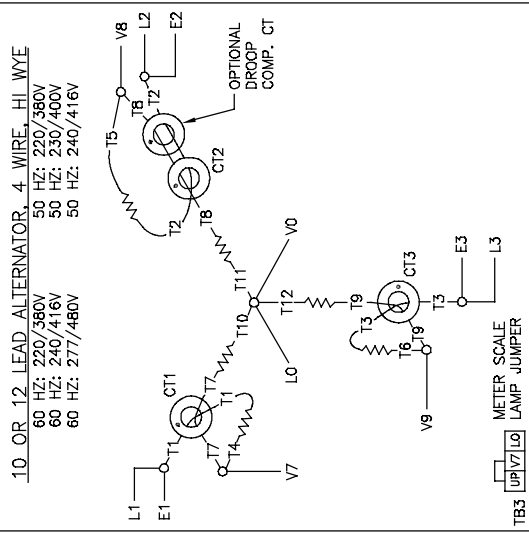
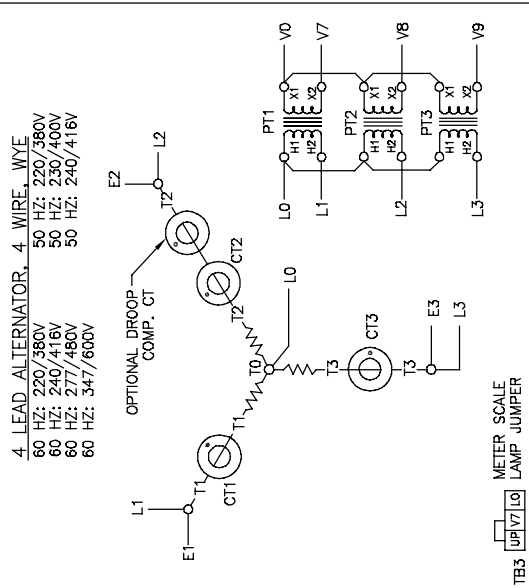
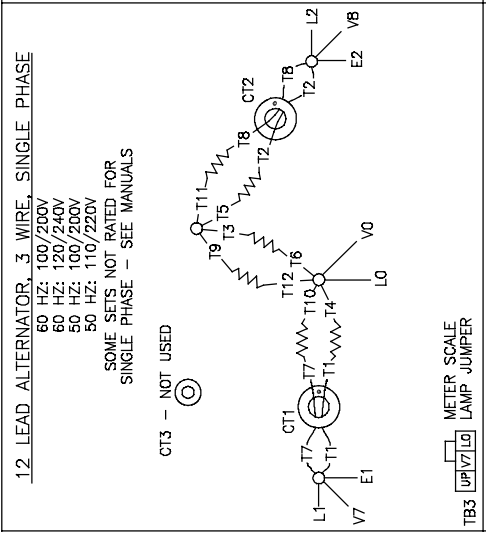
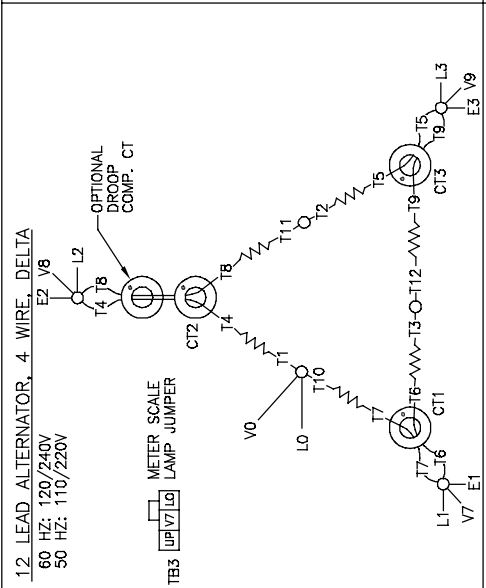
## Decision-Maker® 6000 Controller

| REV | DATE     | REVISION  | BY  |
|-----|----------|---|-----|
| H   | 9-25-08  | (A-1) SHEET 4 OF 4 WAS SHEET 3 OF 3 [77613]                       | CRS |
| J   | 4-30-08  | SPECTRUM & SOME VOIDED AND REMOVED SEE SHEETS 1, 2, AND 3 [86250] | SEM |
| K   | 9-9-08   | SEE SHEET 2 [86307]   | SEM |
| L   | 11-19-08 | SEE SHEET 3 [86648]   | CRS |
| M   | 8-29-10  | (G.D.-1 & -2) SINGLE PHASE GENERATOR CONNECTIONS                  | CRS |
|     |          | ADDED [88870]   | DPS |

SINGLE PHASE GENERATOR CONNECTIONS



3 PHASE GENERATOR CONNECTIONS



PHASE ROTATION  
 A B C  
 L1 L2 L3

NOTES:  
 ON 10 LEAD GENERATORS, LEADS T10, T11 & T12 ARE ALL BROUGHT OUT TOGETHER AND LABELED "TO".  
 CURRENT TRANSFORMER DOT OR "H1" TOWARD GENERATOR.  
 CURRENT TRANSFORMERS NOT USED ON ALL SETS.

| UNLESS OTHERWISE SPECIFIED - | DATE    | BY  |
|------------------------------|---------|-----|
| 3) TERMINALS TO BE USED      | 5-27-04 | DPS |
| 4) WIRE GAUGE                | 5-27-04 | DPS |
| 5) WIRE TYPE                 | 5-27-04 | DPS |
| 6) WIRE COLOR                | 5-27-04 | DPS |
| 7) WIRE LENGTH               | 5-27-04 | DPS |
| 8) WIRE BUNDLE               | 5-27-04 | DPS |
| 9) WIRE MARKING              | 5-27-04 | DPS |
| 10) WIRE IDENTIFICATION      | 5-27-04 | DPS |
| 11) WIRE LABELING            | 5-27-04 | DPS |
| 12) WIRE TAPPING             | 5-27-04 | DPS |
| 13) WIRE SPLICING            | 5-27-04 | DPS |
| 14) WIRE BUNDLING            | 5-27-04 | DPS |
| 15) WIRE PROTECTING          | 5-27-04 | DPS |
| 16) WIRE LABELING            | 5-27-04 | DPS |
| 17) WIRE IDENTIFICATION      | 5-27-04 | DPS |
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| 31) WIRE IDENTIFICATION      | 5-27-04 | DPS |
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| 98) WIRE LABELING            | 5-27-04 | DPS |
| 99) WIRE IDENTIFICATION      | 5-27-04 | DPS |
| 100) WIRE LABELING           | 5-27-04 | DPS |

**KOHLER CO.**  
 POWER SYSTEMS  
 10000 W. 100th Ave., Suite 100, Denver, CO 80231  
 303.440.1000  
 FAX: 303.440.1001  
 WWW.KOHLER.COM

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DATE: 5-27-04  
 DRAWN: JPS  
 CHECKED: JPS  
 APPROVED: JPS

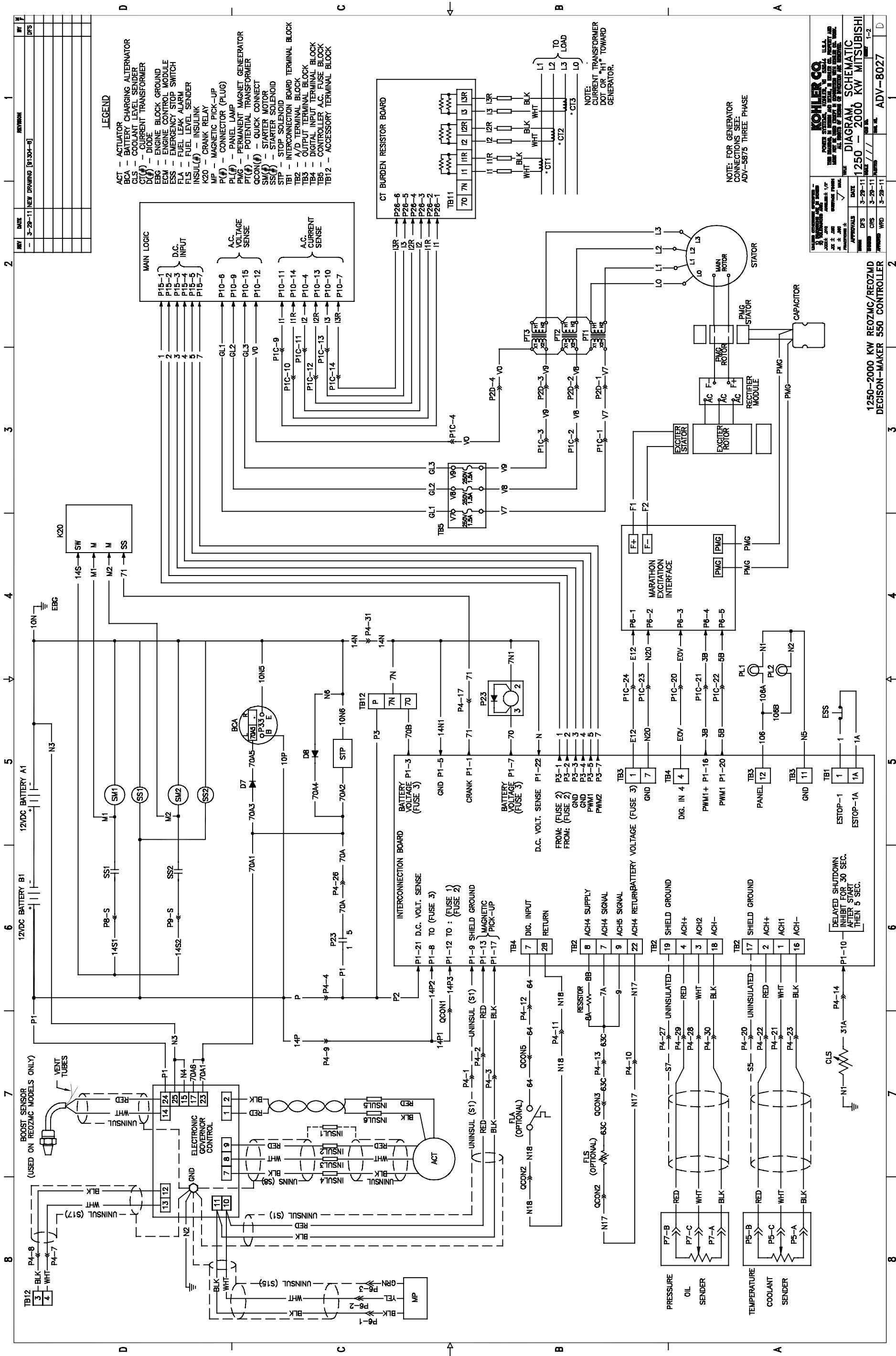
SCALE: NONE  
 SHEET: 4-4

DIAGRAM, RECONNECTABLE

REV. NO. ADV-5875

MARATHON ALTERNATORS





**REVISION**

| REV | DATE    | DESCRIPTION           | BY | CHK |
|-----|---------|-----------------------|----|-----|
| 1   | 3-29-11 | NEW DRAWING [B1304-B] |    | DPS |

**LEGEND**

- ACT - ACTUATOR
- BCA - BATTERY CHARGING ALTERNATOR
- CLS - COIL LEVEL SENDER
- CTB - CURRENT TRANSFORMER
- D(1) - DIODE
- EBC - ENGINE BLOCK GROUND
- ECM - ENGINE CONTROL MODULE
- ESS - EMERGENCY STOP SWITCH
- FLA - FUEL LEAK ALARM
- FLS - FUEL LEVEL SENDER
- INSUL(1) - INSULINK
- K20 - CRANK RELAY
- MP - MAGNETIC PICK-UP
- P(1) - CONNECTOR (PLUG)
- PL(1) - PANEL LAMP
- PMG - PERMANENT MAGNET GENERATOR
- PT(1) - POTENTIAL TRANSFORMER
- QCON(1) - QUICK CONNECT
- SM(1) - STARTER MOTOR
- SS(1) - STOP SOLENOID
- STP - STOP SOLENOID
- TB1 - INTERCONNECTION BOARD TERMINAL BLOCK
- TB2 - A/D TERMINAL BLOCK
- TB3 - OUTPUT TERMINAL BLOCK
- TB4 - DIGITAL INPUT TERMINAL BLOCK
- TB6 - CONTROLLER A.C. FUSE BLOCK
- TB12 - ACCESSORY TERMINAL BLOCK

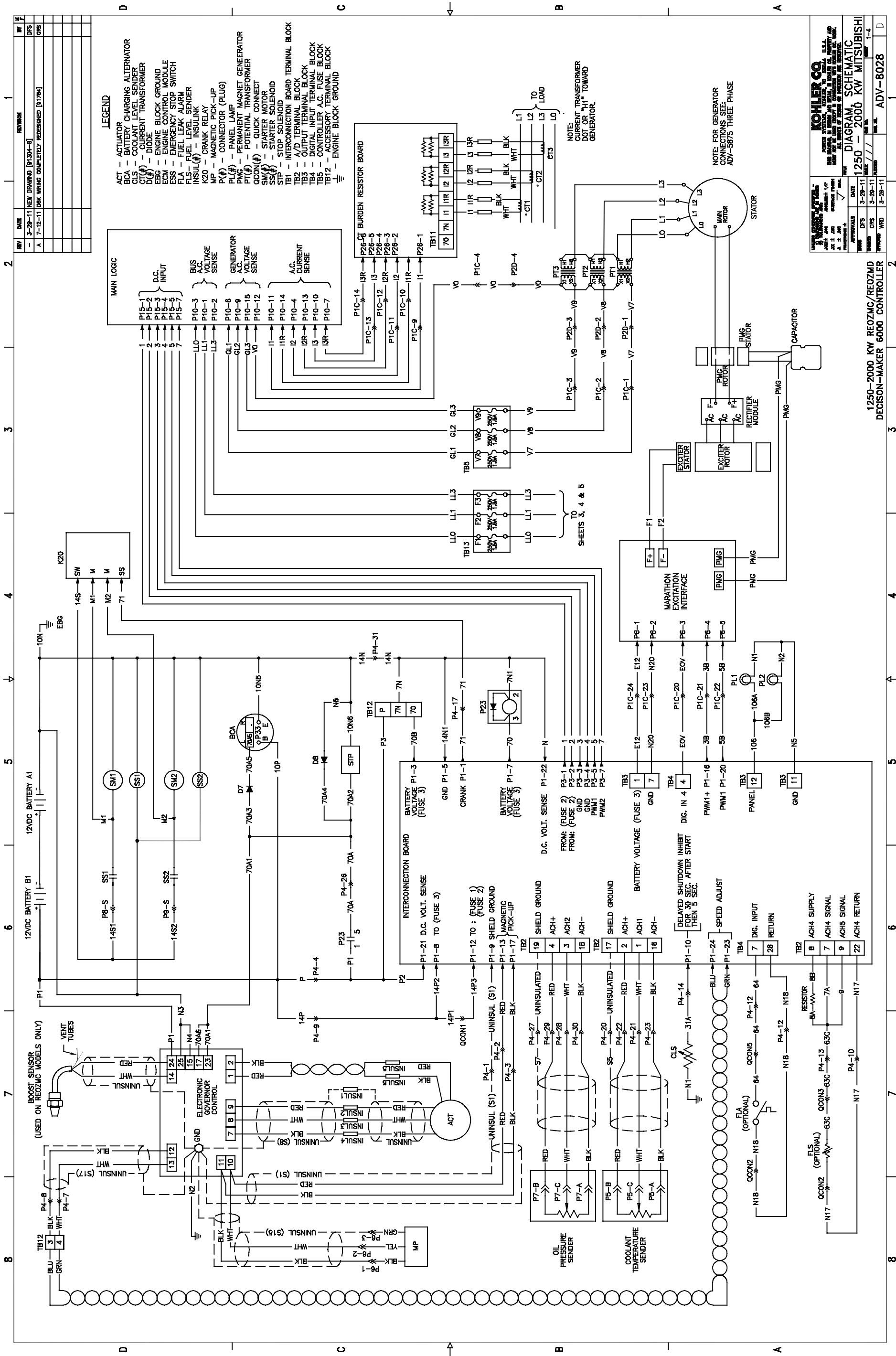
NOTE: FOR GENERATOR CONNECTIONS SEE: ADV-5875 THREE PHASE

**1250-2000 KW REOZMC/REOZMD DECISION-MAKER 550 CONTROLLER**

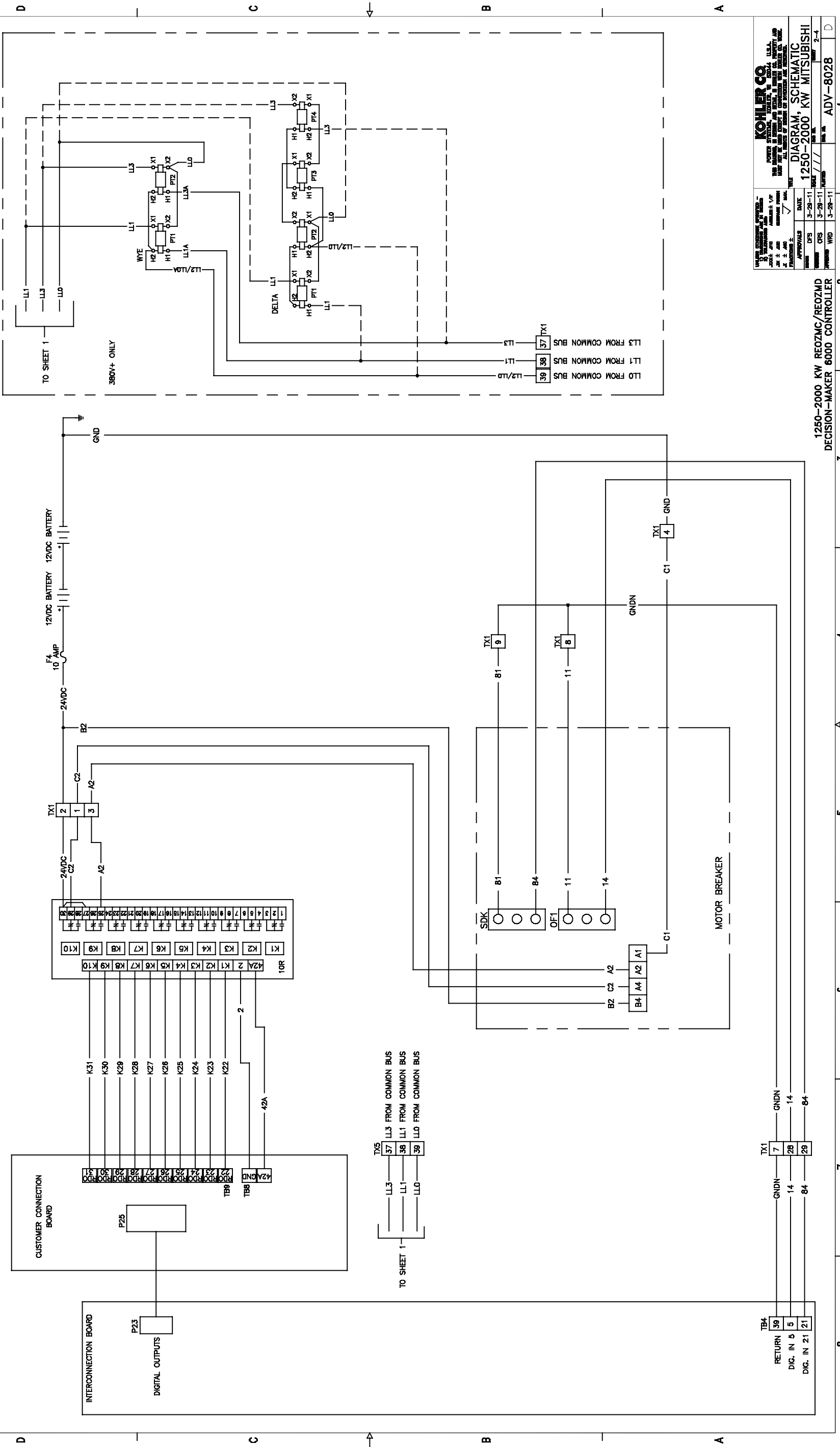
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| CRS       | 3-29-11 | 1   |    |     |
| WRD       | 3-29-11 | 1   |    |     |

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 1250-2000 KW REOZMC/REOZMD DECISION-MAKER 550 CONTROLLER  
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**DIAGRAM SCHEMATIC**  
**1250 - 2000 KW MITSUBISHI**





| REV | DATE    | REVISION                                 | BY | CHK |
|-----|---------|--|----|-----|
| -   | 3-29-11 | NEW DRAWING [P1304-8]                    |    | DFE |
| A   | 7-12-11 | DRG WIRING COMPLETELY REDESIGNED [P1784] |    | CRS |
|     |         |  |    |     |
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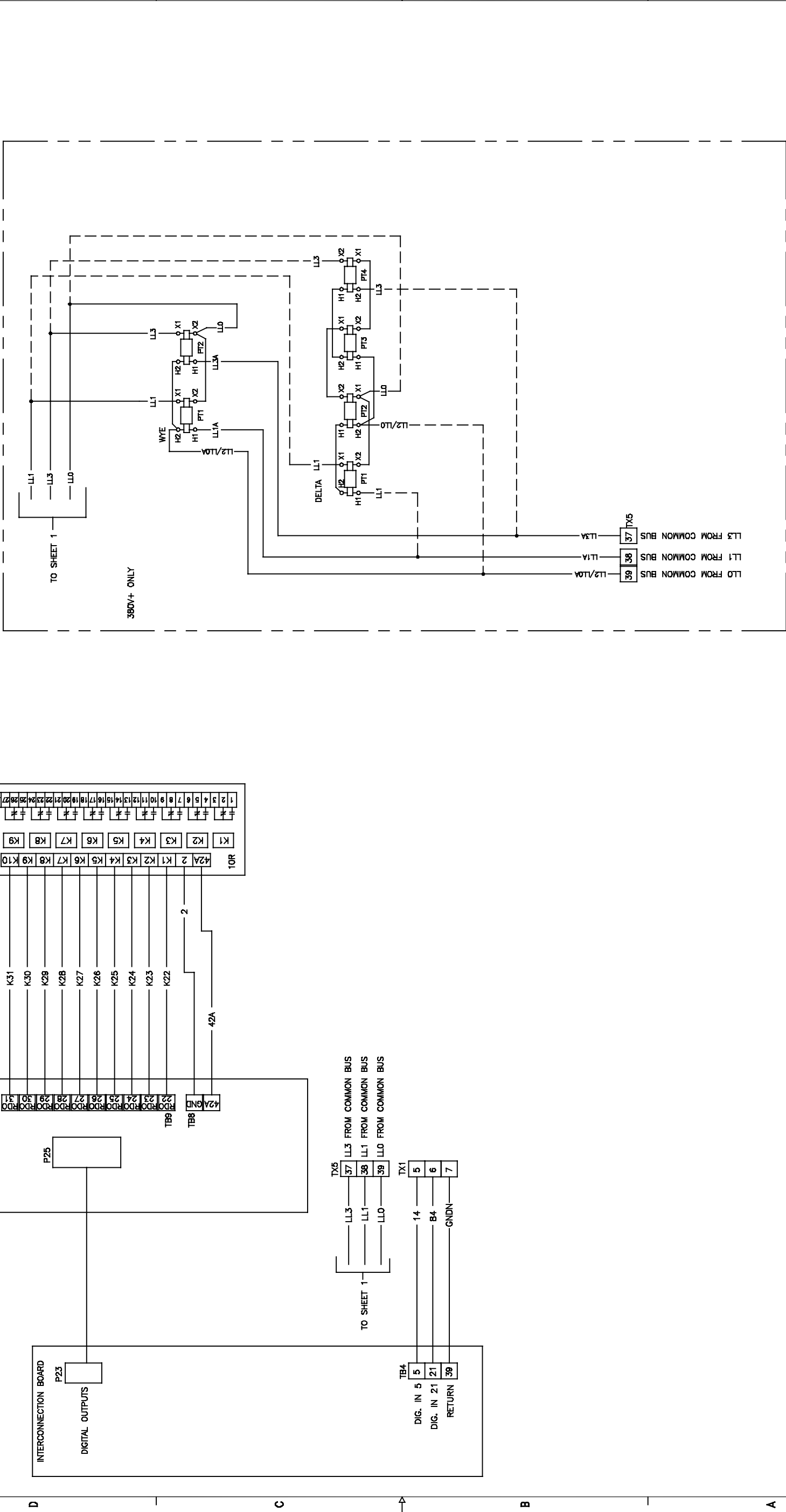
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| DESIGNED  | 3-29-11 | 1:1   | 2-4       | 2-4          |
| CHECKED   | 3-29-11 |       |           |              |
| APPROVED  | 3-29-11 |       |           |              |

1250-2000 KW REOZMC/REOZMD  
 DECISION-MAKER 6000 CONTROLLER  
 ADV-8028

| NO. | DESCRIPTION         | TERMINAL | WIRE GAUGE | WIRE COLOR |
|-----|---------------------|----------|------------|------------|
| 1   | LL3 FROM COMMON BUS | 37       |            |            |
| 2   | LL1 FROM COMMON BUS | 38       |            |            |
| 3   | LL0 FROM COMMON BUS | 39       |            |            |
| 4   | TX1                 | 4        |            |            |
| 5   | TX1                 | 8        |            |            |
| 6   | TX1                 | 9        |            |            |
| 7   | TX1                 | 7        |            |            |
| 8   | TX1                 | 14       |            |            |
| 9   | TX1                 | 28       |            |            |
| 10  | TX1                 | 84       |            |            |
| 11  | TX1                 | 29       |            |            |
| 12  | TX1                 | 14       |            |            |
| 13  | TX1                 | 84       |            |            |
| 14  | TX1                 | 14       |            |            |
| 15  | TX1                 | 84       |            |            |
| 16  | TX1                 | 14       |            |            |
| 17  | TX1                 | 84       |            |            |
| 18  | TX1                 | 14       |            |            |
| 19  | TX1                 | 84       |            |            |
| 20  | TX1                 | 14       |            |            |
| 21  | TX1                 | 84       |            |            |
| 22  | TX1                 | 14       |            |            |
| 23  | TX1                 | 84       |            |            |
| 24  | TX1                 | 14       |            |            |
| 25  | TX1                 | 84       |            |            |
| 26  | TX1                 | 14       |            |            |
| 27  | TX1                 | 84       |            |            |
| 28  | TX1                 | 14       |            |            |
| 29  | TX1                 | 84       |            |            |
| 30  | TX1                 | 14       |            |            |
| 31  | TX1                 | 84       |            |            |
| 32  | TX1                 | 14       |            |            |
| 33  | TX1                 | 84       |            |            |
| 34  | TX1                 | 14       |            |            |
| 35  | TX1                 | 84       |            |            |
| 36  | TX1                 | 14       |            |            |
| 37  | TX1                 | 84       |            |            |
| 38  | TX1                 | 14       |            |            |
| 39  | TX1                 | 84       |            |            |
| 40  | TX1                 | 14       |            |            |
| 41  | TX1                 | 84       |            |            |
| 42  | TX1                 | 14       |            |            |
| 43  | TX1                 | 84       |            |            |
| 44  | TX1                 | 14       |            |            |
| 45  | TX1                 | 84       |            |            |
| 46  | TX1                 | 14       |            |            |
| 47  | TX1                 | 84       |            |            |
| 48  | TX1                 | 14       |            |            |
| 49  | TX1                 | 84       |            |            |
| 50  | TX1                 | 14       |            |            |
| 51  | TX1                 | 84       |            |            |
| 52  | TX1                 | 14       |            |            |
| 53  | TX1                 | 84       |            |            |
| 54  | TX1                 | 14       |            |            |
| 55  | TX1                 | 84       |            |            |
| 56  | TX1                 | 14       |            |            |
| 57  | TX1                 | 84       |            |            |
| 58  | TX1                 | 14       |            |            |
| 59  | TX1                 | 84       |            |            |
| 60  | TX1                 | 14       |            |            |
| 61  | TX1                 | 84       |            |            |
| 62  | TX1                 | 14       |            |            |
| 63  | TX1                 | 84       |            |            |
| 64  | TX1                 | 14       |            |            |
| 65  | TX1                 | 84       |            |            |
| 66  | TX1                 | 14       |            |            |
| 67  | TX1                 | 84       |            |            |
| 68  | TX1                 | 14       |            |            |
| 69  | TX1                 | 84       |            |            |
| 70  | TX1                 | 14       |            |            |
| 71  | TX1                 | 84       |            |            |
| 72  | TX1                 | 14       |            |            |
| 73  | TX1                 | 84       |            |            |
| 74  | TX1                 | 14       |            |            |
| 75  | TX1                 | 84       |            |            |
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| 78  | TX1                 | 14       |            |            |
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| 81  | TX1                 | 84       |            |            |
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| 88  | TX1                 | 14       |            |            |
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| 94  | TX1                 | 14       |            |            |
| 95  | TX1                 | 84       |            |            |
| 96  | TX1                 | 14       |            |            |
| 97  | TX1                 | 84       |            |            |
| 98  | TX1                 | 14       |            |            |
| 99  | TX1                 | 84       |            |            |
| 100 | TX1                 | 14       |            |            |



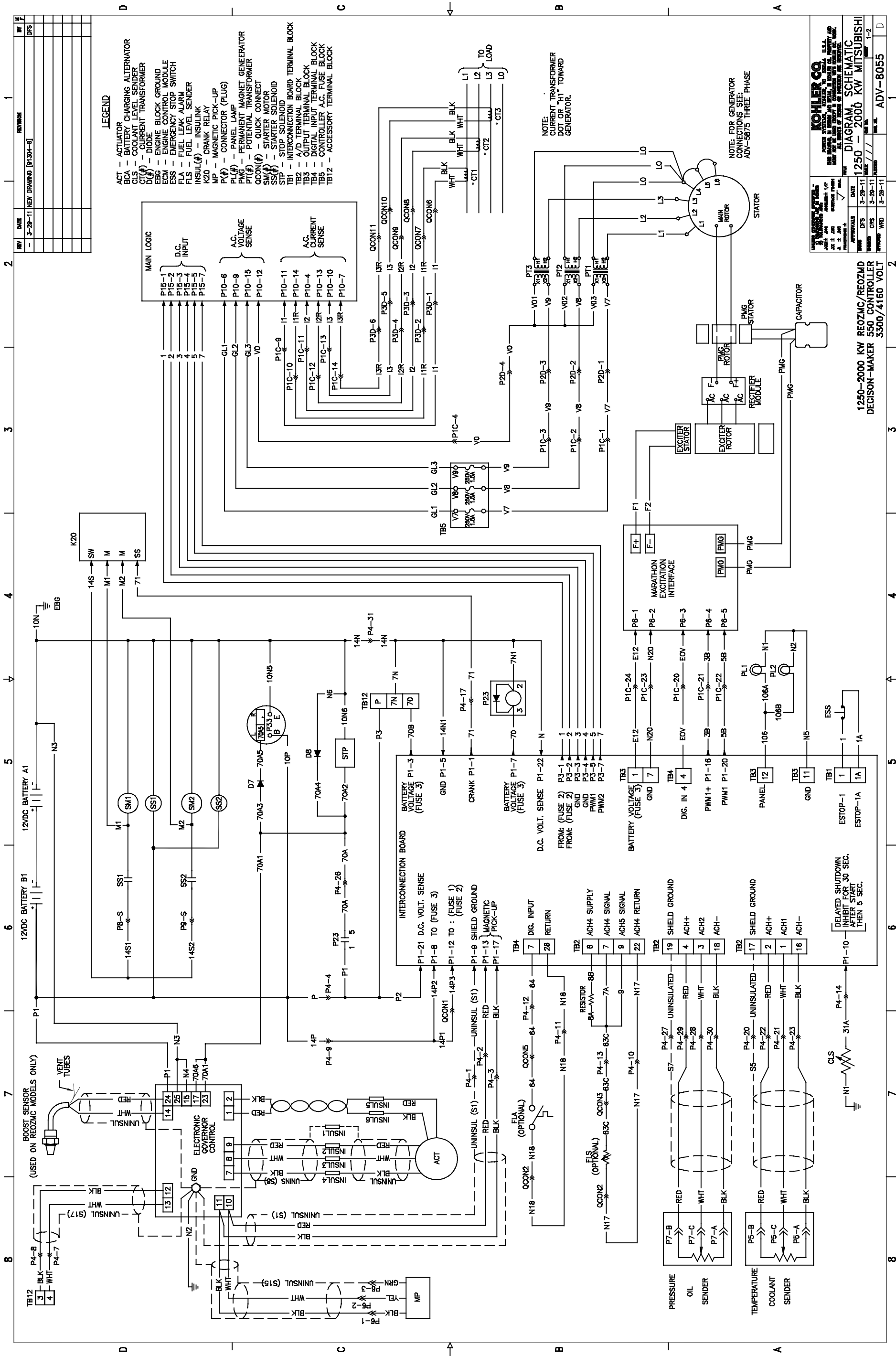
| REV | DATE    | REVISION                                 | BY | CHK |
|-----|---------|--|----|-----|
| -   | 3-29-11 | NEW DRAWING [01304-B]                    |    | DJS |
| A   | 7-12-11 | DRK WIRING COMPLETELY REDESIGNED [07764] |    | DJS |
|     |         |  |    |     |
|     |         |  |    |     |
|     |         |  |    |     |



| APPROVALS |     | DATE    | BY | CHK |
|-----------|-----|---------|----|-----|
| DESIGNED  | DJS | 3-29-11 |    | DJS |
| CHECKED   | DJS | 3-29-11 |    | DJS |
| APPROVED  | WRD | 3-29-11 |    | DJS |

1250-2000 KW REDZNC/REDZMD  
DECISION-MAKER 6000 CONTROLLER

| KOHLER CO. U.S.A. |      | DIAGRAM, SCHEMATIC |            |
|-------------------|------|--------------------|------------|
| 3                 | 100% | 1250-2000 KW       | MITSUBISHI |
| ADV-8028          |      |                    |            |



- LEGEND**
- ACT - ACTUATOR
  - BCA - BATTERY CHARGING ALTERNATOR
  - CLS - COOLANT LEVEL SENDER
  - CT1 - CURRENT TRANSFORMER
  - CT2 - DIODE
  - CT3 - DIODE
  - EBG - ENGINE BLOCK GROUND
  - ECM - ENGINE CONTROL MODULE
  - ESS - EMERGENCY STOP SWITCH
  - FLA - FUEL LEAK ALARM
  - FLS - FUEL LEVEL SENDER
  - INSUL(#)- INSULINK
  - K20 - CRANK RELAY
  - MP - MAGNETIC PICK-UP
  - PK(#)- CONNECTOR (PLUG)
  - PL(#)- PANEL LAMP
  - PMG - PERMANENT MAGNET GENERATOR
  - PT(#)- POTENTIAL TRANSFORMER
  - QCON(#)- QUICK CONNECT
  - SM(#)- STARTER MOTOR
  - SS(#)- STOP SOLENOID
  - STP - STOP SOLENOID
  - TB1 - INTERCONNECTION BOARD TERMINAL BLOCK
  - TB2 - A/D TERMINAL BLOCK
  - TB3 - OUTPUT TERMINAL BLOCK
  - TB4 - DIGITAL INPUT TERMINAL BLOCK
  - TB5 - CONTROLLER A.C. FUSE BLOCK
  - TB12 - ACCESSORY TERMINAL BLOCK

| REV | DATE    | REVISION              | BY | CHK |
|-----|---------|-----------------------|----|-----|
| -   | 3-29-11 | NEW DRAWING [B1304-B] |    |     |
|     |         |                       |    |     |
|     |         |                       |    |     |
|     |         |                       |    |     |
|     |         |                       |    |     |

| APPROVALS | DATE    | BY | CHK |
|-----------|---------|----|-----|
| DESIGNED  | 3-29-11 |    |     |
| DRAWN     | 3-29-11 |    |     |
| CHECKED   | 3-29-11 |    |     |
| APPROVED  | 3-29-11 |    |     |

1250-2000 KW REOZMC/REOZMD  
 DECISION-MAKER 550 CONTROLLER  
 3300/4160 VOLT

**DIAGRAM, SCHEMATIC**  
 1250 - 2000 KW MITSUBISHI

NOTE: CURRENT TRANSFORMER  
 DOT OR "H" TOWARD  
 GENERATOR.

NOTE: FOR GENERATOR  
 CONNECTIONS SEE:  
 ADV-5875 THREE PHASE

DELAYED SHUTDOWN  
 INHIBIT FOR 30 SEC.  
 AFTER START  
 THEN 5 SEC.

FROM: (FUSE 2) P3-1  
 FROM: (FUSE 2) P3-2  
 GND P3-3  
 GND P3-4  
 PWM1 P3-5  
 PWM2 P3-7

BATTERY VOLTAGE (FUSE 3)  
 GND P1-5  
 14N1

CRANK P1-1  
 71  
 P4-17

BATTERY VOLTAGE (FUSE 3)  
 P1-7  
 70  
 P23

D.C. VOLT. SENSE P1-22  
 N  
 7N1

FROM: (FUSE 2) P3-1  
 FROM: (FUSE 2) P3-2  
 GND P3-3  
 GND P3-4  
 PWM1 P3-5  
 PWM2 P3-7

BATTERY VOLTAGE (FUSE 3)  
 GND P1-5  
 14N1

CRANK P1-1  
 71  
 P4-17

BATTERY VOLTAGE (FUSE 3)  
 P1-7  
 70  
 P23

D.C. VOLT. SENSE P1-22  
 N  
 7N1

FROM: (FUSE 2) P3-1  
 FROM: (FUSE 2) P3-2  
 GND P3-3  
 GND P3-4  
 PWM1 P3-5  
 PWM2 P3-7

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 GND P3-4  
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 FROM: (FUSE 2) P3-2  
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 GND P3-4  
 PWM1 P3-5  
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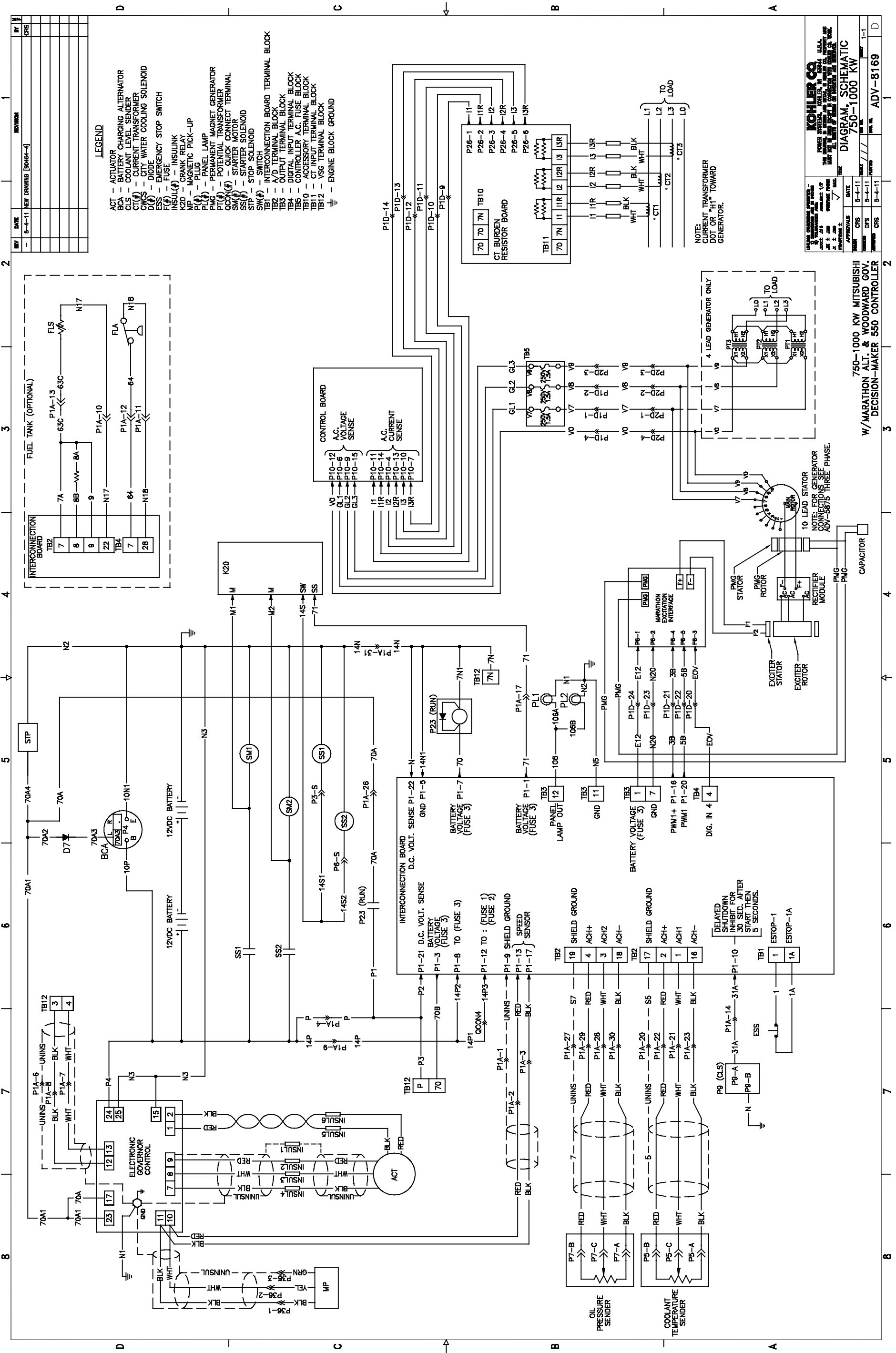
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 GND P1-5  
 14N1

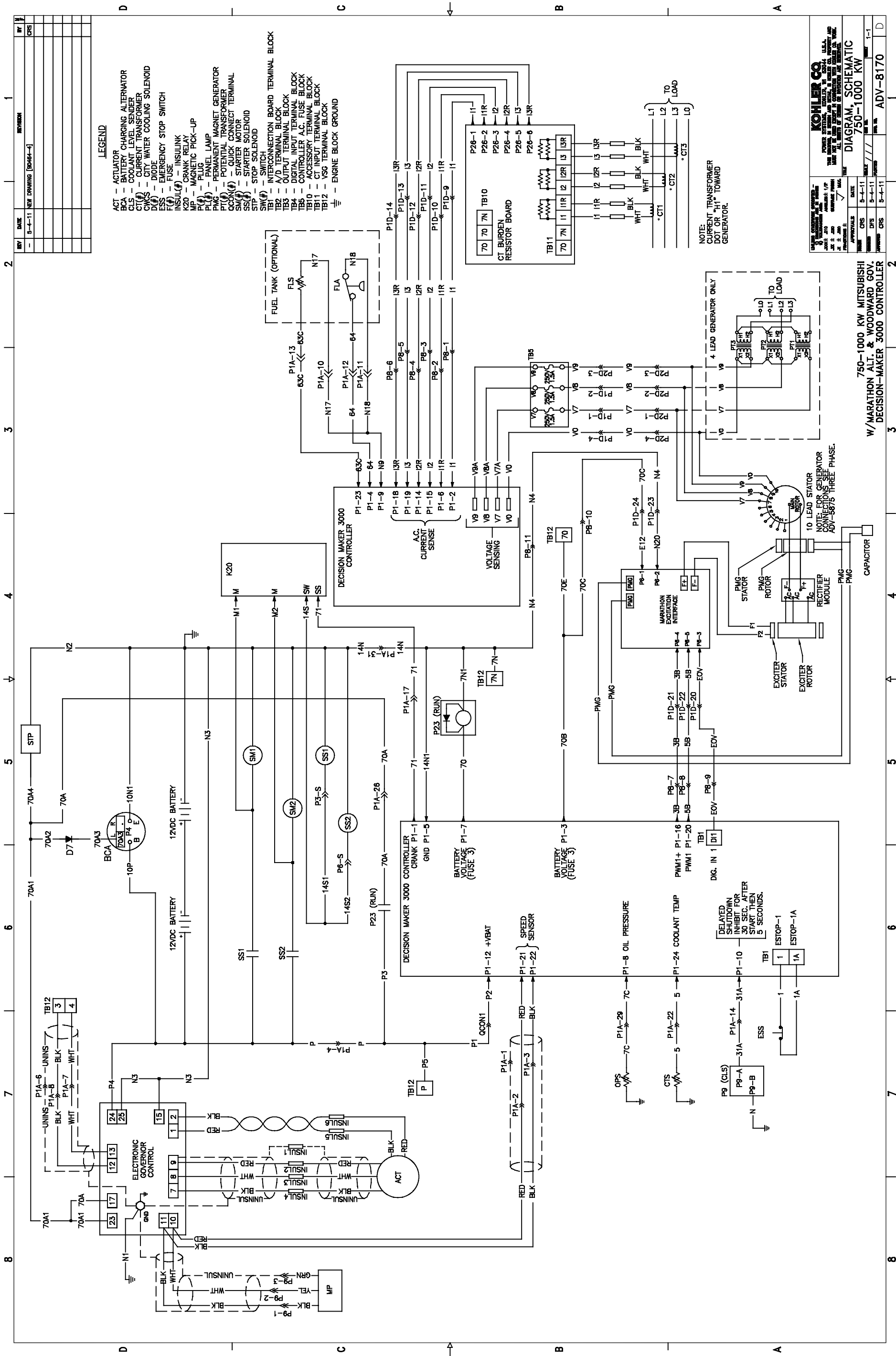
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 71  
 P4-17

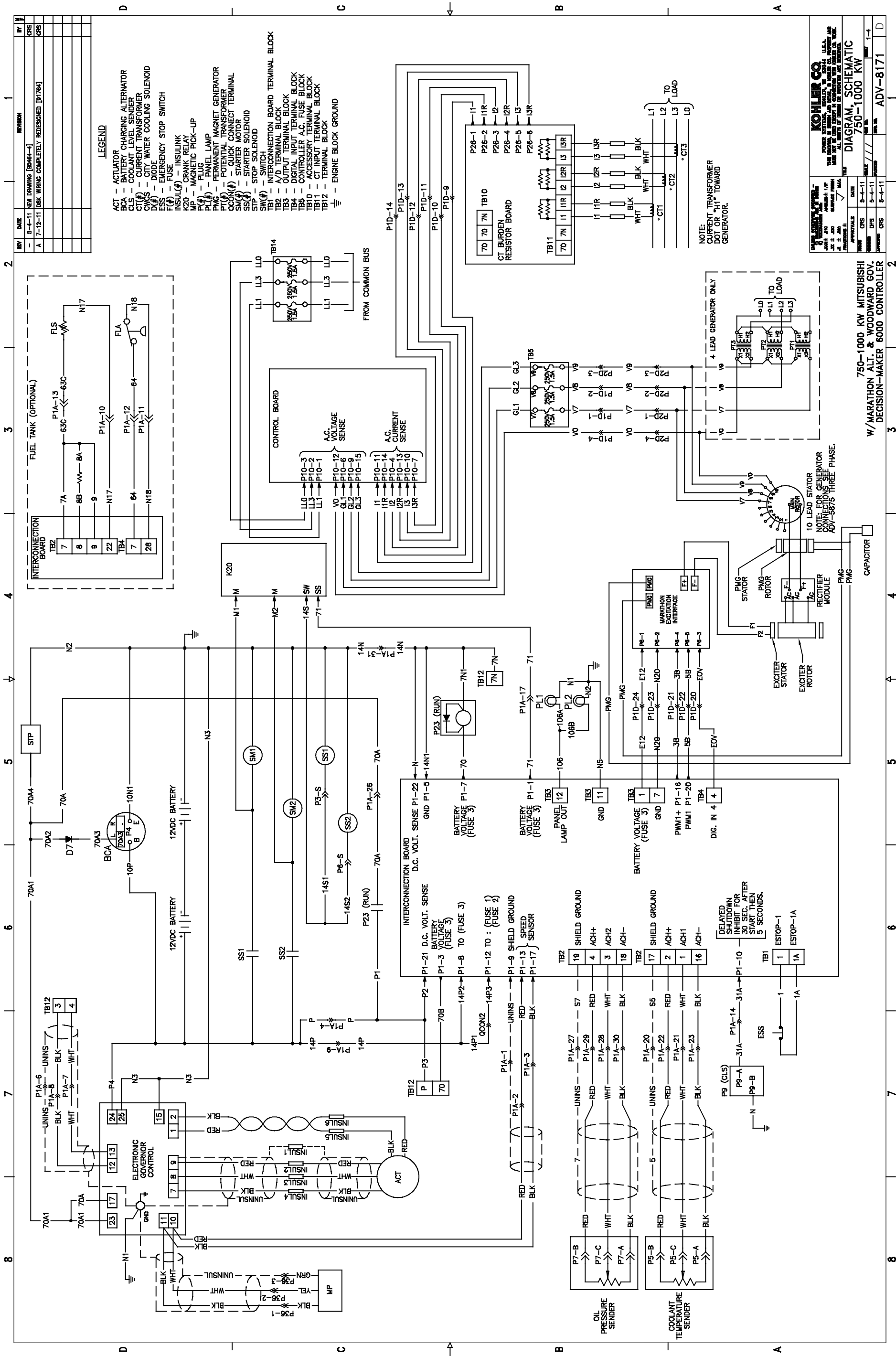
BATTERY VOLTAGE (FUSE 3)  
 P1-7  
 70  
 P23











**LEGEND**

- ACT - ACTUATOR
- BCA - BATTERY CHARGING ALTERNATOR
- CLS - COOLANT LEVEL SENDER
- CT(F) - CURRENT TRANSFORMER
- CWS - CITY WATER COOLING SOLENOID
- D(F) - DIODE
- ESS - EMERGENCY STOP SWITCH
- F(F) - FUSE
- INSUL(L) - INSULINK
- K20 - CRANK RELAY
- MP - MAGNETIC PICK-UP
- PL(F) - PLUG
- PL(L) - PANEL LAMP
- PMG - PERMANENT MAGNET GENERATOR
- PT(F) - POTENTIAL TRANSFORMER
- QCON(F) - QUICK CONNECT TERMINAL
- SS(F) - STARTER MOTOR
- SS(L) - STARTER SOLENOID
- STP - STOP SOLENOID
- SW(F) - SWITCH
- TB(F) - INTERCONNECTION BOARD TERMINAL BLOCK
- TB(L) - A/V TERMINAL BLOCK
- TB3 - OUTPUT TERMINAL BLOCK
- TB4 - DISTAL INPUT TERMINAL BLOCK
- TB5 - CONTROLLER A.C. FUSE BLOCK
- TB10 - ACCESSORY TERMINAL BLOCK
- TB11 - CT INPUT TERMINAL BLOCK
- TB12 - TERMINAL BLOCK
- ≡ - ENGINE BLOCK GROUND

| REV | DATE    | REVISION                                 | BY  |
|-----|---------|--|-----|
| -   | 9-4-11  | NEW DRAWING [0646-4]                     | CRS |
| A   | 7-12-11 | 10K WIRING COMPLETELY REDESIGNED [07174] | CRS |

| APPROVALS                | DATE   |
|--------------------------|--------|
| DESIGNED BY: [Signature] | 5-4-11 |
| CHECKED BY: [Signature]  | 5-4-11 |
| APPROVED BY: [Signature] | 5-4-11 |

**KOHLER CO.**  
 POWER GENERATION DIVISION  
 1000 WEST 10TH AVENUE  
 MILWAUKEE, WISCONSIN 53217  
 ALL RIGHTS RESERVED  
**DIAGRAM, SCHEMATIC**  
**750-1000 KW**

750-1000 KW MITSUBISHI  
 W/MARATHON ALT. & WOODWARD GOV.  
 DECISION-MAKER 6000 CONTROLLER

NOTE: CURRENT TRANSFORMER  
 DOT OR "H" TOWARD  
 GENERATOR.

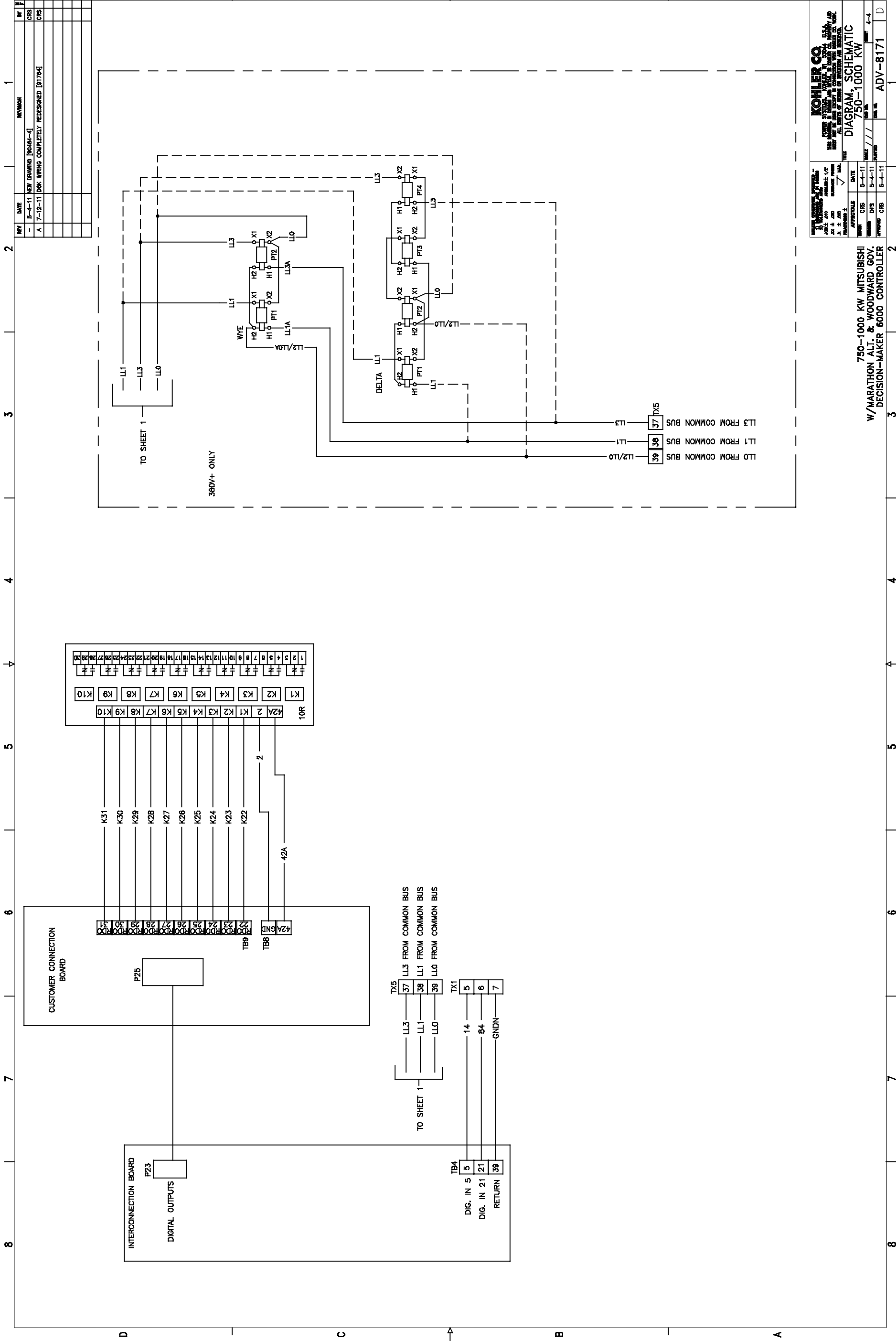
NOTE: FOR GENERATOR  
 CONNECTIONS SEE  
 ADV-5875 THREE PHASE

DELATED SHUTDOWN  
 INHIBIT FOR  
 30 SEC. AFTER  
 START THEN  
 5 SECONDS.

ADV-8171







**KOHLER CO. U.S.A.**

1000 WEST 10TH AVENUE, DENVER, CO. 80202, U.S.A.

TELEPHONE: 303-733-1000 FAX: 303-733-1001

WWW.KOHLER.COM

ALL RIGHTS OF TRADE OR INTELLECTUAL PROPERTY RESERVED.

DATE: 5-4-11

SCALE: 1/2"

PROJECT: ADV-8171

REV: 4-4

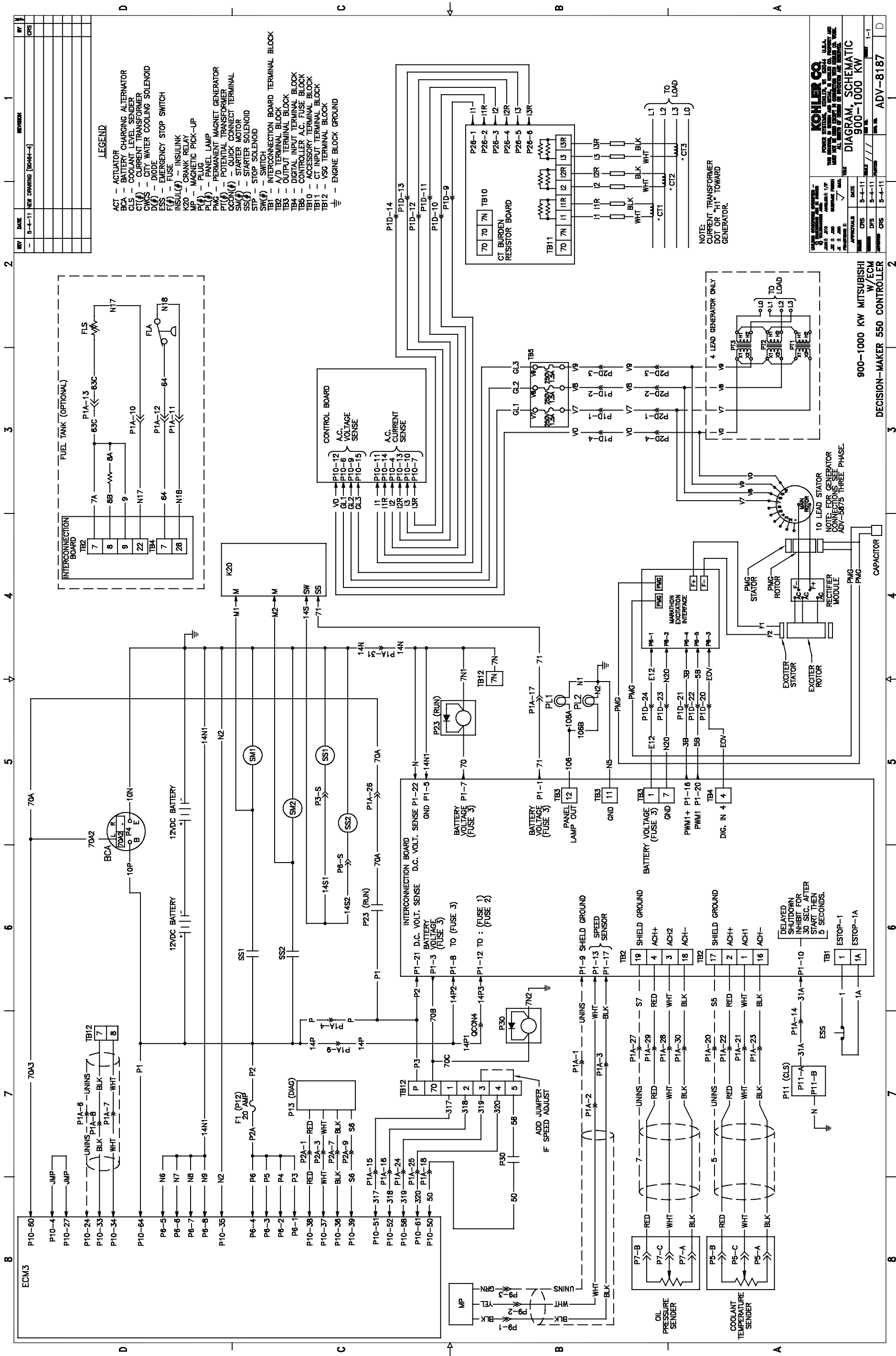
APPROVALS:

| APPROVALS | DATE   |
|-----------|--------|
| DESIGNED  | 5-4-11 |
| CHECKED   | 5-4-11 |
| APPROVED  | 5-4-11 |

**750-1000 KW MITSUBISHI**

**W/MARATHON ALT. & WOODWARD GOV.**

**DECISION-MAKER 6000 CONTROLLER**



**LEGEND**

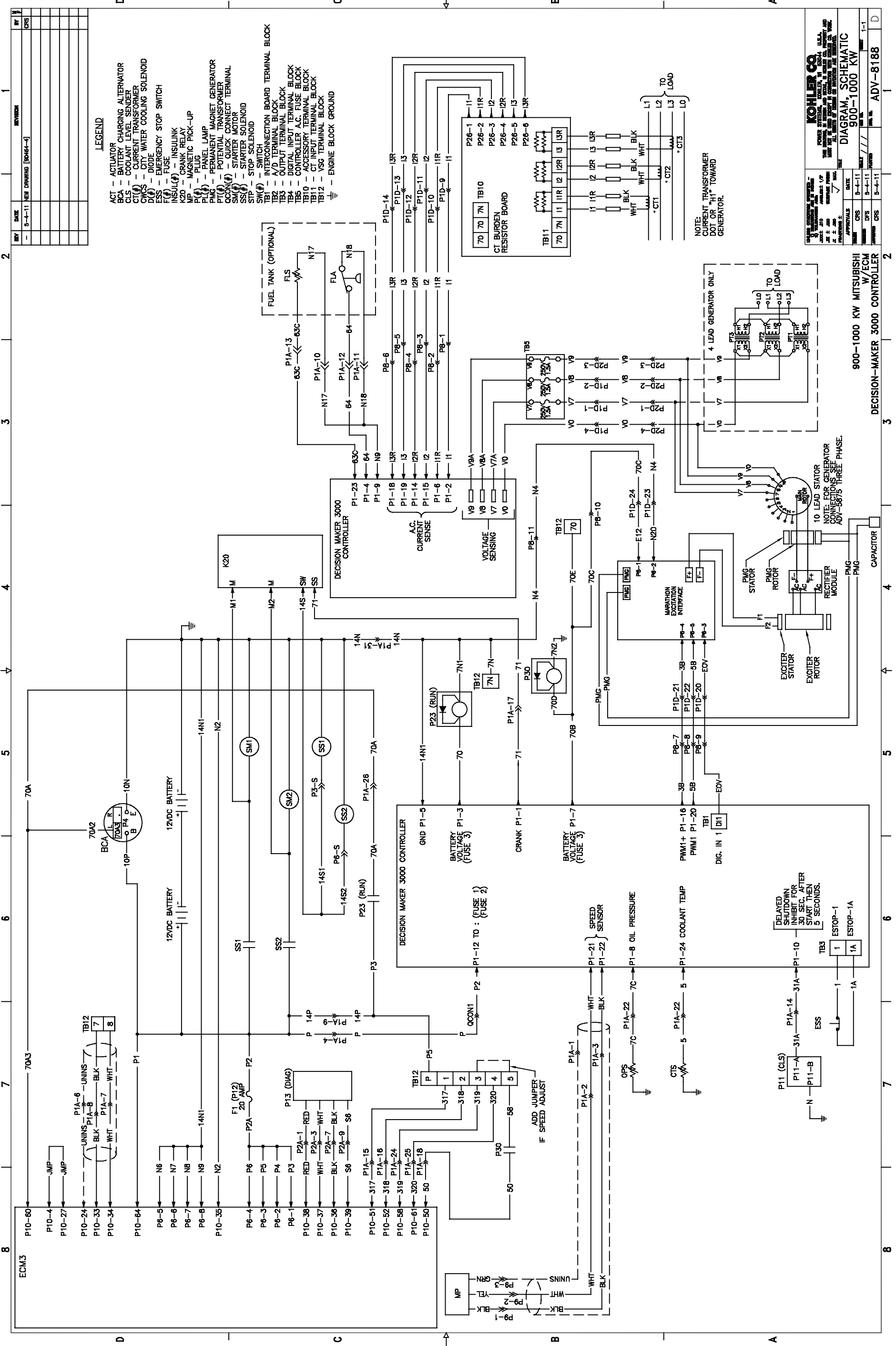
- ACT - ACTUATOR
- BCA - BATTERY CHARGING ALTERNATOR
- CLS - COOLANT LEVEL SENDER
- CT(F) - CURRENT TRANSFORMER
- CWS - CITY WATER COOLING SOLENOID
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- SW(F) - INTERCONNECTION BOARD TERMINAL BLOCK
- TB1 - A/V TERMINAL BLOCK
- TB2 - OUTPUT TERMINAL BLOCK
- TB3 - DISTAL INPUT TERMINAL BLOCK
- TB4 - CONTROLLER A.C. FUSE BLOCK
- TB5 - ACCESSORY TERMINAL BLOCK
- TB10 - CT INPUT TERMINAL BLOCK
- TB11 - VSG TERMINAL BLOCK
- TB12 - ENGINE BLOCK GROUND

| REV | DATE   | REVISION              | BY  |
|-----|--------|-----------------------|-----|
| -   | 5-4-11 | NEW DRAWING [50464-4] | CRS |

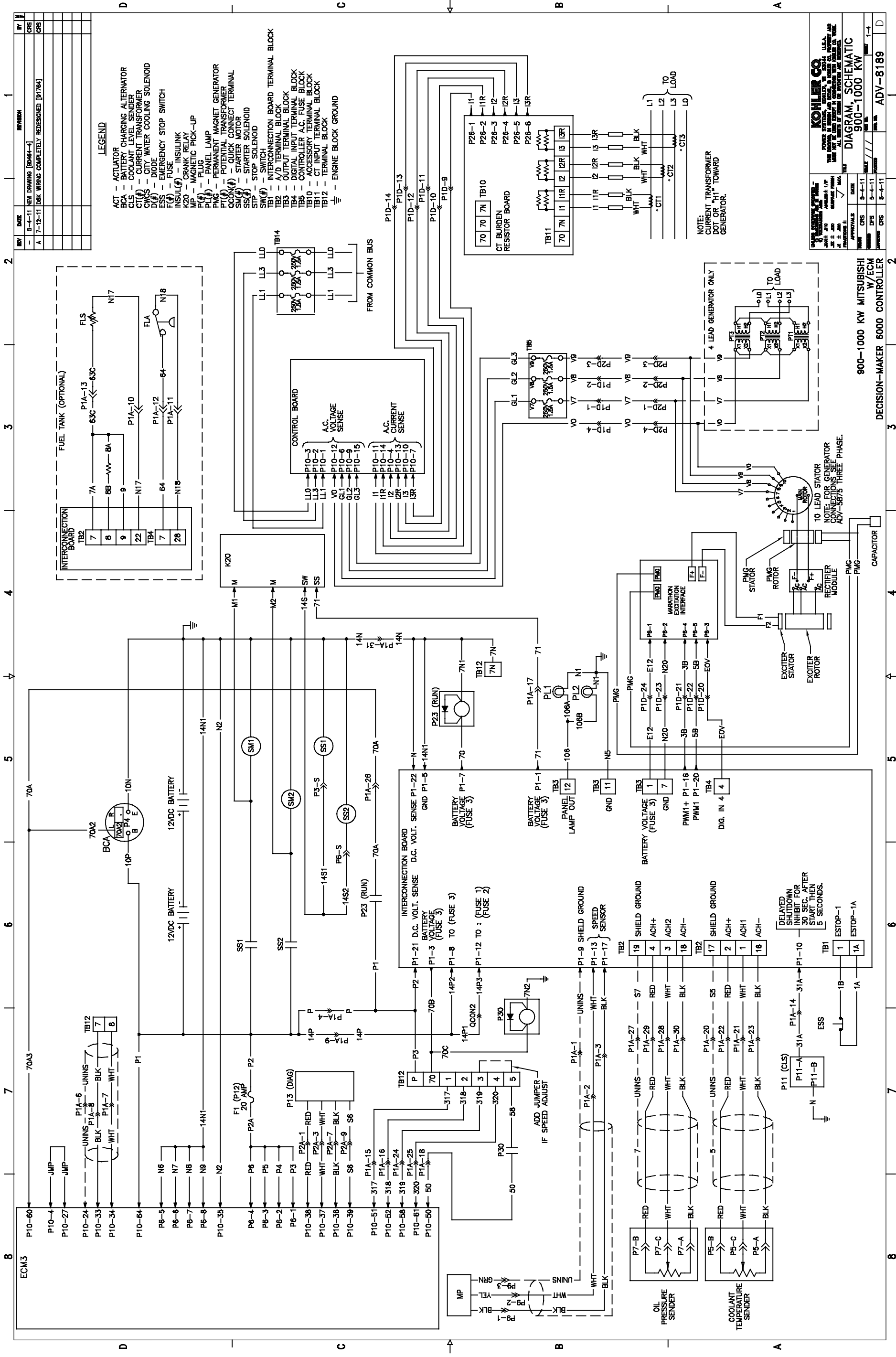
  

| APPROVALS                | DATE   |
|--------------------------|--------|
| DESIGNED BY: [Signature] | 5-4-11 |
| CHECKED BY: [Signature]  | 5-4-11 |
| APPROVED BY: [Signature] | 5-4-11 |

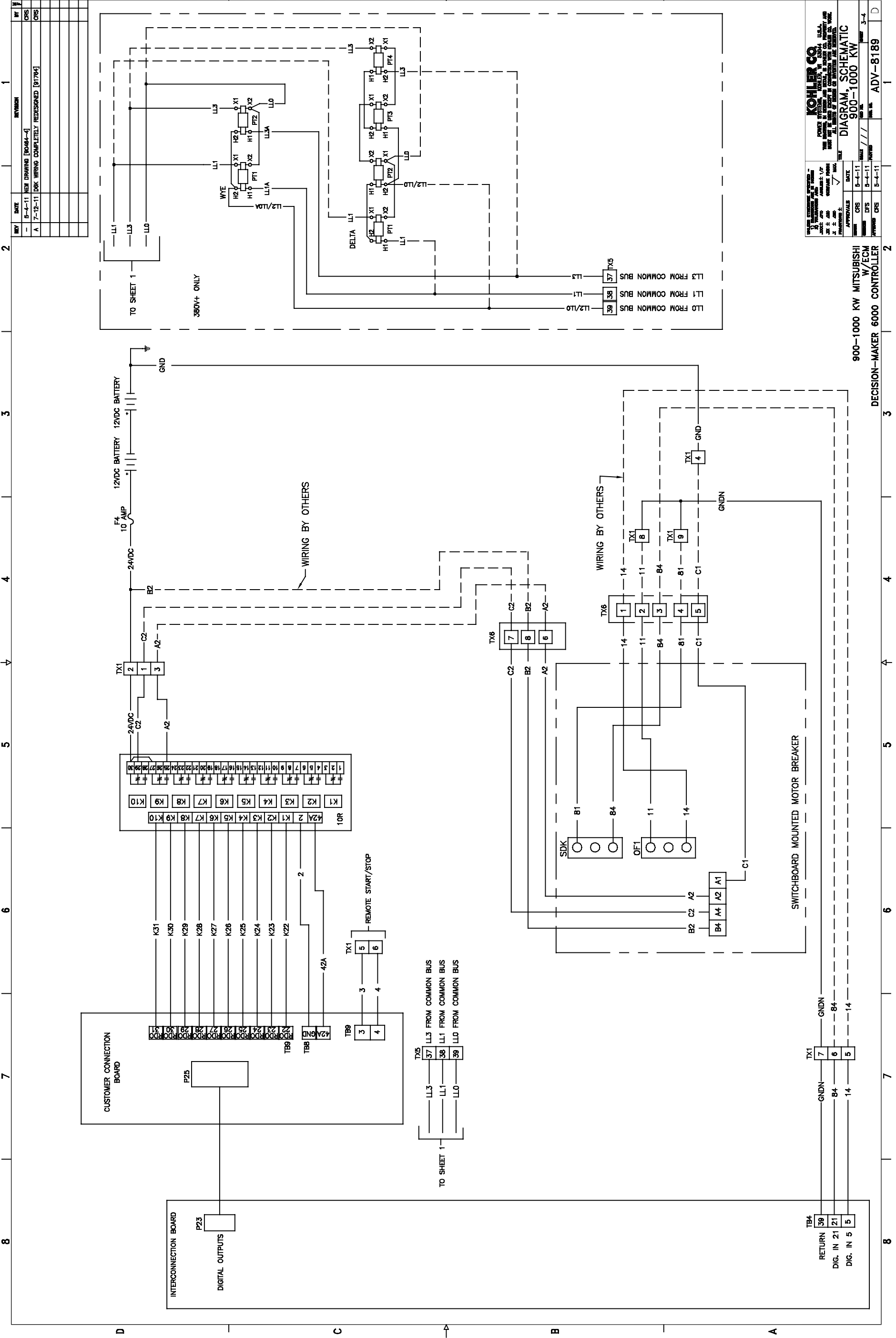
**KOHLER CO.**  
 900-1000 KW MITSUBISHI  
 W/ECM  
 DECISION-MAKER 550 CONTROLLER  
 ADV-8187











| REV | DATE    | REVISION                                 | BY  |
|-----|---------|--|-----|
| -   | 5-4-11  | NEW DRAWING [06484-4]                    | CRS |
| A   | 7-12-11 | DRG WIRING COMPLETELY REDESIGNED [91764] | CRS |
|     |         |  |     |
|     |         |  |     |
|     |         |  |     |
|     |         |  |     |
|     |         |  |     |
|     |         |  |     |
|     |         |  |     |
|     |         |  |     |

| APPROVALS |     | DATE   | BY |
|-----------|-----|--------|----|
| DESIGNED  | CRS | 5-4-11 |    |
| CHECKED   | DPS | 5-4-11 |    |
| APPROVED  | CRS | 5-4-11 |    |
| REVIEWED  | DPS | 5-4-11 |    |

900-1000 KW MITSUBISHI W/ECM W/ECM DECISION-MAKER 6000 CONTROLLER ADV-8189

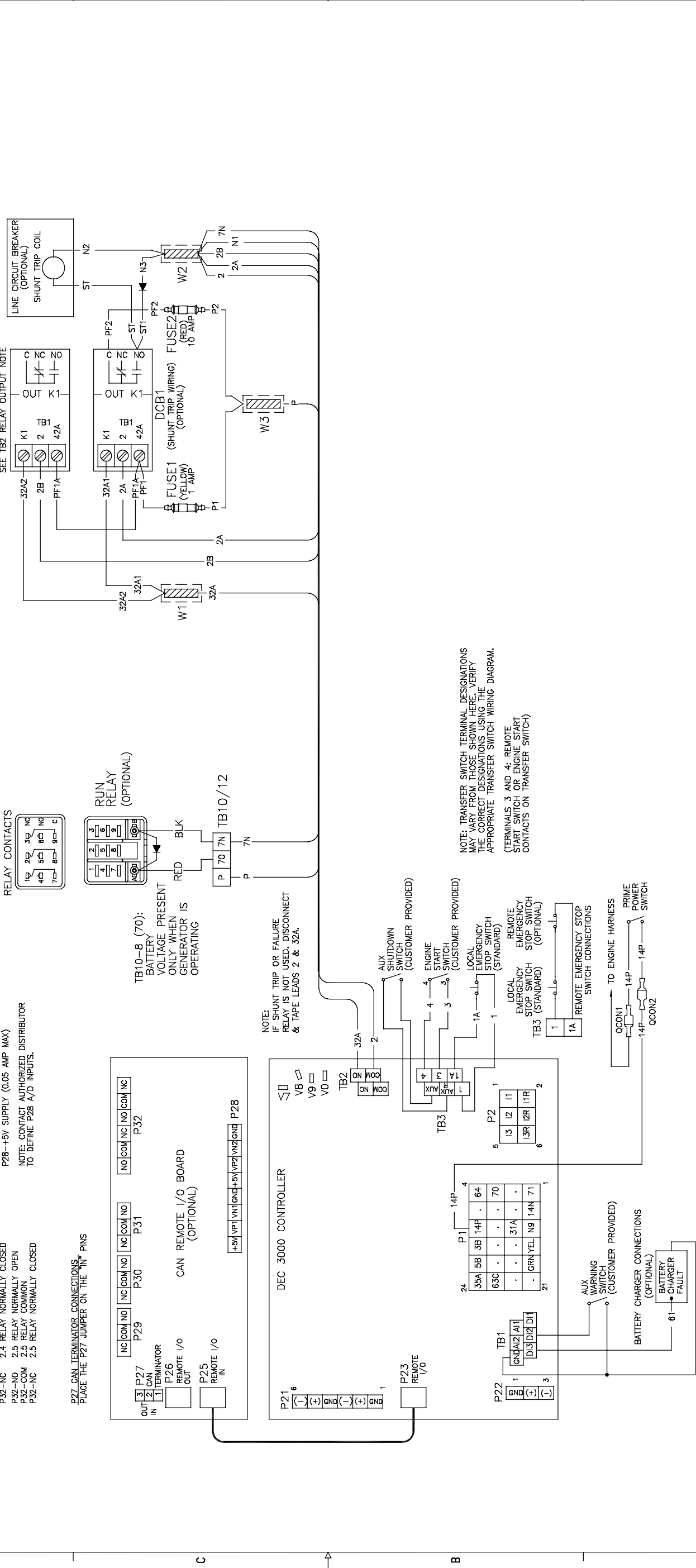
DIAGRAM, SCHEMATIC 900-1000 KW

KOHLER CO. U.S.A.  
 POWER SYSTEMS DIVISION  
 2000 WEST 10TH AVENUE  
 DENVER, CO 80202  
 TEL: 303.733.1000  
 FAX: 303.733.1001  
 WWW.KOHLER.COM



| REV | DATE    | REVISION              | BY  |
|-----|---------|-----------------------|-----|
| -   | 9-16-10 | NEW DRAWING [89518-4] | CRS |
|     |         |                       |     |
|     |         |                       |     |
|     |         |                       |     |
|     |         |                       |     |

**LEGEND**  
P(#)- PLUG  
QCON(#)- QUICK CONNECT  
TB(#)- TERMINAL BLOCK  
W(#)- SONIC WELD



**P22 CAN TERMINATOR CONNECTIONS.**  
PLACE THE P27 JUMPER ON THE "IN" PINS

**P23 REMOTE I/O**

**P21-1 GND**  
P21-2 +  
P21-3 -  
P21-4 GND  
P21-5 +  
P21-6 -

**TB1 ANALOG/DIGITAL INPUT FACTORY SETTINGS**  
TB1-D1 DCH1 EXCITATION OVER VOLTAGE (4M, 5M, 7M)  
TB1-D2 DCH2 AUX WARNING  
TB1-D3 DCH3 BATTERY CHARGER FAULT WARNING  
TB1-A1 ACH1 NO FUNCTION  
TB1-A2 ACH2 NO FUNCTION  
TB1-GND A/D/GND ANALOG/DIGITAL RETURN

**TB2 RELAY OUTPUT**  
TB2-COM (RELAY COMMON) COMMON FAULT  
TB2-COM (RELAY COMMON) COMMON FAULT  
TB2-NO (RELAY NORMALLY OPEN) COMMON FAULT  
TB2-NC (RELAY NORMALLY CLOSED) COMMON FAULT

**TB3 LOCAL EMERGENCY STOP SWITCH (STANDARD)**  
1 LOCAL EMERGENCY STOP SWITCH (STANDARD)  
1A REMOTE EMERGENCY STOP SWITCH (OPTIONAL)

**TO ENGINE HARNESS**  
QCON1 14P PRIME POWER SWITCH  
QCON2 14P BATTERY CHARGER FAULT

**NOTE: TRANSFER SWITCH TERMINAL DESIGNATIONS MAY VARY FROM THOSE SHOWN HERE. VERIFY THE CORRECT DESIGNATIONS USING THE APPROPRIATE TRANSFER SWITCH WIRING DIAGRAM. (TERMINALS 3 AND 4: REMOTE START SWITCH OR ENGINE START CONTACTS ON TRANSFER SWITCH)**

**NOTE: IF SHUNT TRIP OR FAILURE RELAY IS NOT USED, DISCONNECT & TAPE LEADS 2 & 32A.**

**NOTE: TB2 RELAY OUTPUT MAY BE REDEFINED - FACTORY DEFAULT LISTED. CONTACT AUTHORIZED DISTRIBUTOR FOR DETAILS. CUSTOMER TO CONNECT TO TB2 UNLESS SHUNT TRIP IS USED. IF SHUNT TRIP IS USED, CUSTOMER TO CONNECT TO DCB2 FOR COMMON FAULT.**

**NOTE: TB1 A/D INPUTS MAY BE REDEFINED - FACTORY DEFAULTS LISTED. CONTACT AUTHORIZED DISTRIBUTOR FOR DETAILS.**

**INSTALLATION NOTE:**  
FOR FIELD INSTALLATION A MAXIMUM OF TWO WIRE TERMINALS PER TERMINAL STRIP SCREW IS RECOMMENDED UNLESS OTHERWISE NOTED ON THE WIRING DIAGRAM. DO NOT EXTEND ABOVE THE TERMINAL STRIP BARRIER.

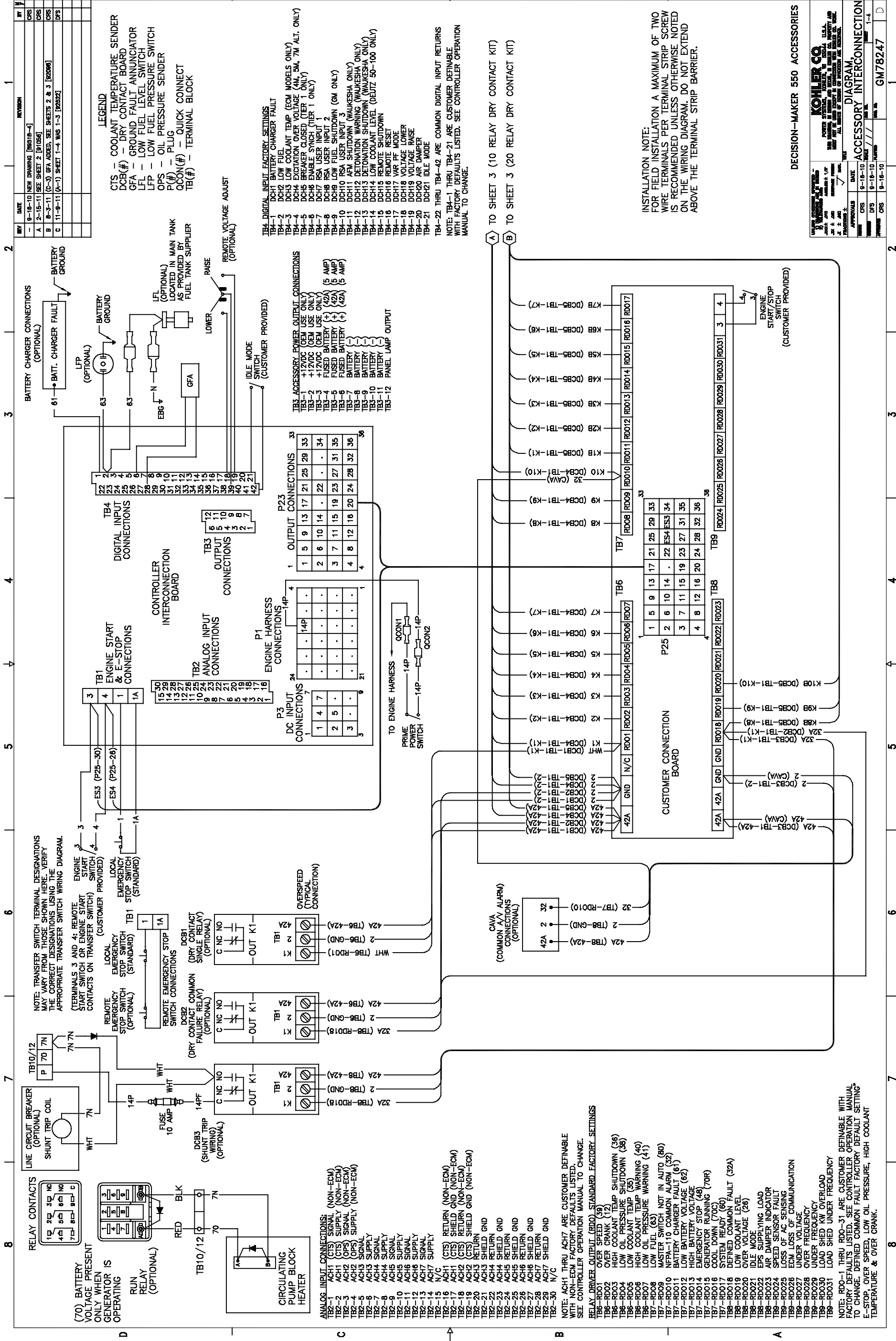
**APPROVALS**  
DATE 9-16-10  
DESIGNED BY CRS  
CHECKED BY JTO  
DRAWN BY JTO  
SCALE 1:1  
DATE 9-16-10  
APPROVED BY CRS  
DRAWN BY JTO

**COHLEK CO.**  
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**DIAGRAM, DEC 3000 ACCY INTERCONNECTION**

**DEC 3000 ACCESSORIES**

**GM78246**

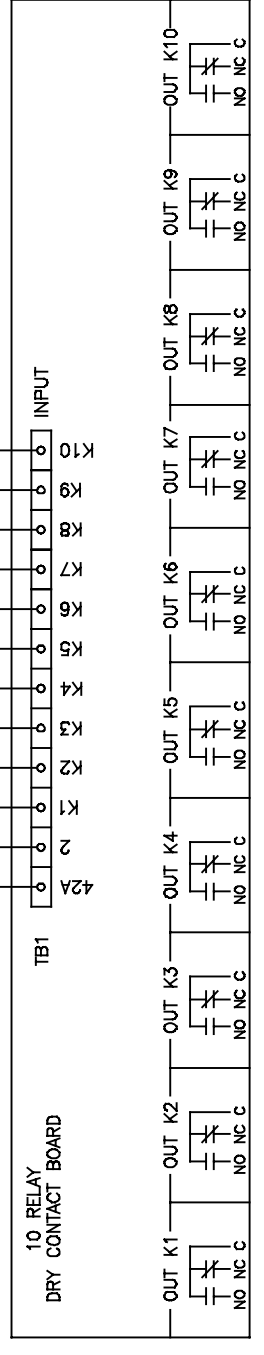




| REV | DATE    | REVISION   | BY  |
|-----|---------|--|-----|
| -   | 9-16-10 | NEW DRAWING [80018-4]  | CRS |
| A   | 2-19-11 | (B-4) 20 RELAY CONTACT WIRING ADDED [11056]                                  | CRS |
| B   | 8-3-11  | (SHEET 1 AND SHEET 2 CONTACT FUNCTION NOTES ADDED, SEE SHEETS 1 & 2 [80096]) | CRS |
| C   | 11-9-11 | (A-1) SHEET 3-4 WAS 3-3 [92522]  | CRS |

TO SHEET 1 (DEC 550)  
TO SHEET 2 (DEC 6000)

DCB4  
(10 RELAY DRY CONTACT KIT)

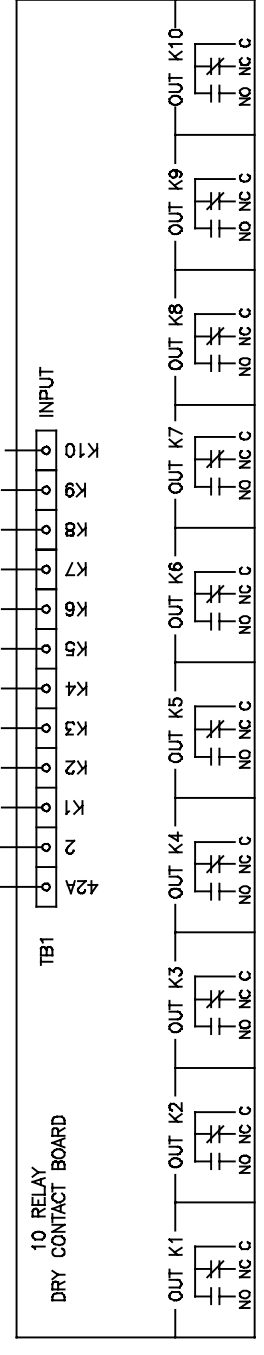


SEE SHEET 1 FOR DEFAULT CONTACT FUNCTIONS FOR DEC550  
SEE SHEET 2 FOR DEFAULT CONTACT FUNCTIONS FOR DEC6000

INSTALLATION NOTE:  
FOR FIELD INSTALLATION A MAXIMUM OF TWO WIRE TERMINALS PER TERMINAL STRIP SCREW IS RECOMMENDED UNLESS OTHERWISE NOTED ON THE WIRING DIAGRAM. DO NOT EXTEND ABOVE THE TERMINAL STRIP BARRIER.

TO SHEET 1 (DEC 550)  
TO SHEET 2 (DEC 6000)

DCB5  
(20 RELAY DRY CONTACT KIT)  
(DCB4 & DCB5 REQUIRED)



SEE SHEET 1 FOR DEFAULT CONTACT FUNCTIONS FOR DEC550  
SEE SHEET 2 FOR DEFAULT CONTACT FUNCTIONS FOR DEC6000

DECISION-MAKER 550 & 6000 ACCESSORIES

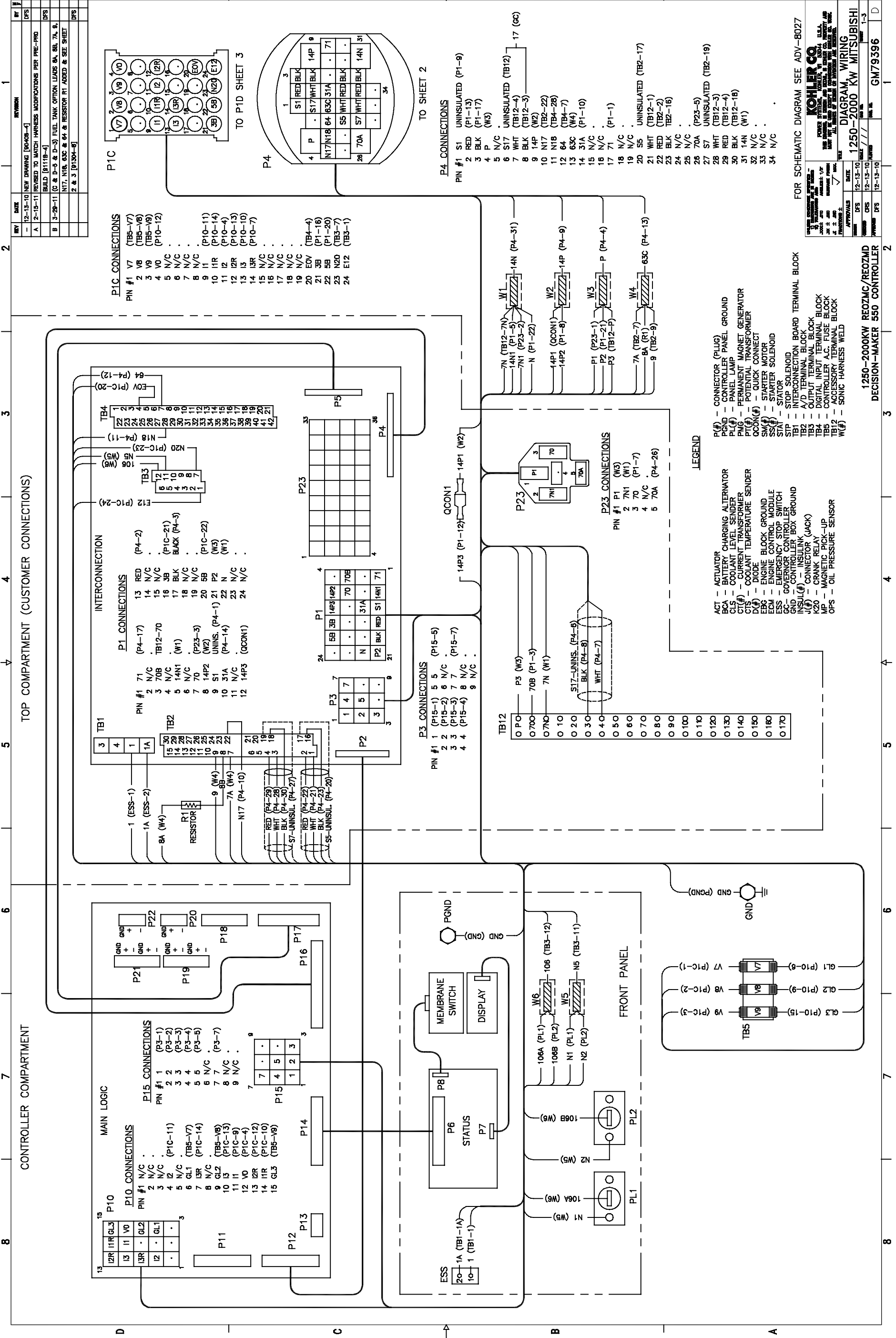
| APPROVALS |     | DATE    |
|-----------|-----|---------|
| DESIGN    | CRS | 9-16-10 |
| CHECKED   | DPS | 9-16-10 |
| APPROVED  | CRS | 9-16-10 |

| DIAGRAM ACCESSORY INTERCONNECTION |         |
|-----------------------------------|---------|
| DATE                              | 9-16-10 |
| BY                                | CRS     |
| NO. IN                            | 3-4     |
| REV. NO.                          | GM78247 |







**REVISION**

| REV | DATE     | DESCRIPTION  | BY | CHK |
|-----|----------|--|----|-----|
| -   | 12-13-10 | NEW DRAWING [RACOB-4]  |    |     |
| A   | 2-15-11  | REVISED TO MATCH HARNESS MODIFICATIONS PER PRE-PROD                |    | DPS |
| B   | 3-29-11  | BUILD [R111B-4]  |    | DPS |
|     |          | N17, N18, 63C & 64 & RESISTOR R1 ADDED & SEE SHEET 2 & 3 [R1304-8] |    | DPS |

**P1C CONNECTIONS**

| PIN # | W   | DESCRIPTION |
|-------|-----|-------------|
| 1     | V7  | (TB5-V7)    |
| 2     | V8  | (TB5-V8)    |
| 3     | V9  | (TB5-V9)    |
| 4     | N/C | (P10-12)    |
| 5     | N/C |             |
| 6     | N/C |             |
| 7     | N/C |             |
| 8     | N/C |             |
| 9     | 11R | (P10-11)    |
| 10    | 12R | (P10-14)    |
| 11    | 13R | (P10-4)     |
| 12    | 14R | (P10-13)    |
| 13    | 15R | (P10-10)    |
| 14    | 16R | (P10-7)     |
| 15    | N/C |             |
| 16    | N/C |             |
| 17    | N/C |             |
| 18    | N/C |             |
| 19    | N/C |             |
| 20    | EV  | (TB4-4)     |
| 21    | 3B  | (P1-16)     |
| 22    | 5B  | (P1-20)     |
| 23    | N20 | (TB3-7)     |
| 24    | E12 | (TB3-1)     |

**INTERCONNECTION**

**P1 CONNECTIONS**

| PIN # | W    | DESCRIPTION   |
|-------|------|---------------|
| 1     | 71   | (P4-17)       |
| 2     | N/C  |               |
| 3     | 70B  | (P15-2)       |
| 4     | N/C  |               |
| 5     | 14N1 | (W1)          |
| 6     | N/C  |               |
| 7     | 70   | (P23-3)       |
| 8     | 14P2 | (W2)          |
| 9     | S1   | UNINS. (P4-1) |
| 10    | 31A  | (P4-14)       |
| 11    | N/C  |               |
| 12    | 14P3 | (QCON1)       |

**MAIN LOGIC**

**P10 CONNECTIONS**

| PIN # | W   | DESCRIPTION |
|-------|-----|-------------|
| 1     | N/C |             |
| 2     | N/C |             |
| 3     | N/C |             |
| 4     | 12  | (P10-11)    |
| 5     | N/C |             |
| 6     | GL1 | (TB5-V7)    |
| 7     | 13R | (P10-14)    |
| 8     | N/C |             |
| 9     | GL2 | (TB5-V8)    |
| 10    | 13  | (P10-13)    |
| 11    | 11  | (P10-4)     |
| 12    | 12R | (P10-12)    |
| 13    | 11R | (P10-10)    |
| 14    | 11R | (P10-10)    |
| 15    | GL3 | (TB5-V9)    |

**P4 CONNECTIONS**

| PIN # | W   | DESCRIPTION          |
|-------|-----|----------------------|
| 1     | S1  | UNINSULATED (P1-9)   |
| 2     | RED | (P1-13)              |
| 3     | BLK | (P1-17)              |
| 4     | P   | (W3)                 |
| 5     | N/C |                      |
| 6     | S17 | UNINSULATED (TB12)   |
| 7     | WHT | (TB12-4)             |
| 8     | BLK | (TB12-3)             |
| 9     | 14P | (W2)                 |
| 10    | N17 | (TB2-22)             |
| 11    | N18 | (TB4-28)             |
| 12    | 64  | (TB4-7)              |
| 13    | 63C | (W4)                 |
| 14    | 31A | (P1-10)              |
| 15    | N/C |                      |
| 16    | 71  | (P1-1)               |
| 17    | N/C |                      |
| 18    | N/C |                      |
| 19    | N/C |                      |
| 20    | S5  | UNINSULATED (TB2-17) |
| 21    | WHT | (TB12-1)             |
| 22    | RED | (TB2-2)              |
| 23    | BLK | (TB2-16)             |
| 24    | N/C |                      |
| 25    | N/C |                      |
| 26    | 70A | UNINSULATED (TB2-19) |
| 27    | S7  | (TB12-3)             |
| 28    | WHT | (TB12-4)             |
| 29    | RED | (TB12-4)             |
| 30    | BLK | (TB12-18)            |
| 31    | 14N | (W1)                 |
| 32    | N/C |                      |
| 33    | N/C |                      |
| 34    | N/C |                      |

**P3 CONNECTIONS**

| PIN # | W       | DESCRIPTION |
|-------|---------|-------------|
| 1     | (P15-1) | 5 5 (P15-5) |
| 2     | (P15-2) | 6 N/C       |
| 3     | (P15-3) | 7 7 (P15-7) |
| 4     | (P15-4) | 8 N/C       |
| 5     | (P15-5) | 9 N/C       |

**P23 CONNECTIONS**

| PIN # | W   | DESCRIPTION |
|-------|-----|-------------|
| 1     | P1  | (W3)        |
| 2     | 7N1 | (W1)        |
| 3     | 70  | (P1-7)      |
| 4     | N/C |             |
| 5     | 70A | (P4-26)     |

**LEGEND**

- ACT - ACTUATOR
- BCA - BATTERY CHARGING ALTERNATOR
- CLS - COOLANT LEVEL SENDER
- CTI - CURRENT TRANSFORMER
- CTIS - COOLANT TEMPERATURE SENDER
- D - DIODE
- EBG - ENGINE BLOCK GROUND
- ECM - ENGINE CONTROL MODULE
- ESS - EMERGENCY STOP SWITCH
- GN - CONTROLLER GROUND
- INSUL - INSULATION
- J - CONNECTOR (JACK)
- K20 - CRANK RELAY
- MP - MAGNETIC PICK-UP
- OPS - OIL PRESSURE SENSOR
- P(#)- CONNECTOR (PLUG)
- PGND - CONTROLLER PANEL GROUND
- PL(#)- PANEL LAMP
- PMG - PERMANENT MAGNET GENERATOR
- PTI - POTENTIAL TRANSFORMER
- QCON(#)- QUICK CONNECT
- SM(#)- STARTER MOTOR
- SS(#)- STOP SOLENOID
- STAT - STATOR
- STP - STOP SOLENOID
- INT - INTERCONNECTION BOARD TERMINAL BLOCK
- TB1 - A/D TERMINAL BLOCK
- TB2 - OUTPUT TERMINAL BLOCK
- TB3 - DIGITAL INPUT TERMINAL BLOCK
- TB4 - COOLANT TEMPERATURE SENDER TERMINAL BLOCK
- TB5 - CONNECTOR (JACK)
- W(#)- WIRE (SONIC HARNESS WELD)

FOR SCHEMATIC DIAGRAM SEE ADV-8027

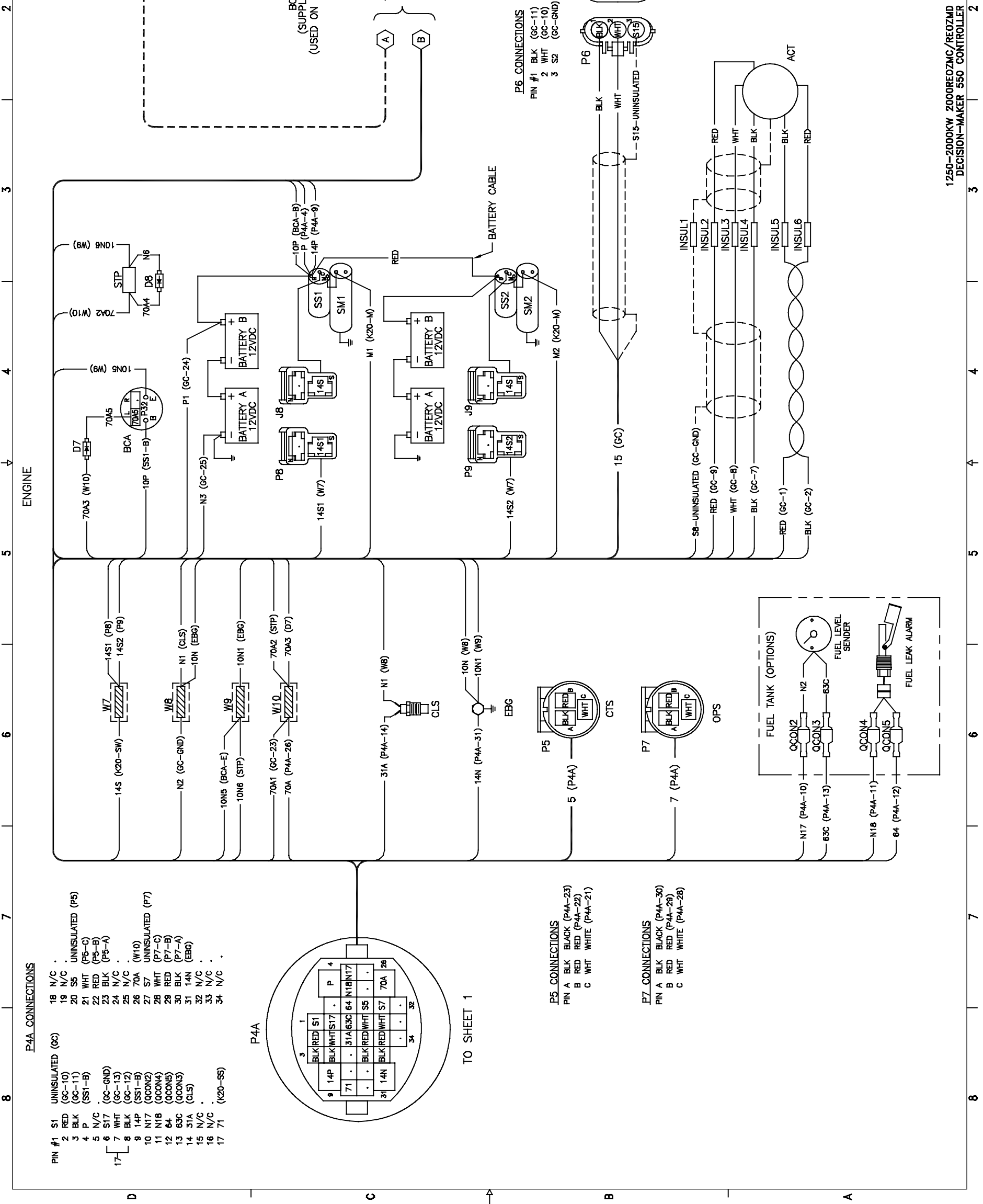
**APPROVALS**

| DATE     | BY | CHK |
|----------|----|-----|
| 12-13-10 |    |     |
| 12-13-10 |    |     |
| 12-13-10 |    |     |

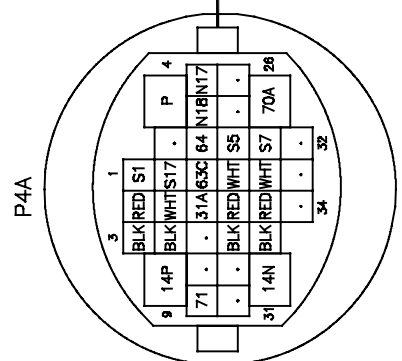
**1250-2000 KW MITSUBISHI**

GM79396

| REV | DATE     | REVISION   | BY  |
|-----|----------|--|-----|
| -   | 12-13-10 | NEW DRAWING [90408-4]  | DFS |
| A   | 2-15-11  | REVISED TO MATCH HARNESS MODIFICATIONS PER PRE-PRO BUILD [91118-4]   | DFS |
| B   | 3-26-11  | [A-5, 8 & D-8] FUEL TANK OPTIONS & CORRESPONDING FT. TO FT. CONNECTIONS ADDED & SEE SHEETS 1 & 3 [91304-8] DFS | DFS |



- P44 CONNECTIONS**
- |           |                  |                                |
|-----------|------------------|--------------------------------|
| PIN #1 S1 | UNINSULATED (GC) | 18 N/C                         |
| 2 RED     | (GC-10)          | 19 N/C                         |
| 3 BLK     | (GC-11)          | 20 SS                          |
| 4 P       | (SS1-B)          | 21 WHT (P5-C) UNINSULATED (P5) |
| 5 N/C     | (SS1-B)          | 22 RED (P5-B)                  |
| 6 S17     | (GC-GND)         | 23 BLK (P5-A)                  |
| 7 WHT     | (GC-13)          | 24 N/C                         |
| 8 BLK     | (GC-12)          | 25 N/C                         |
| 9 14P     | (SS1-B)          | 26 70A (W10)                   |
| 10 N17    | (OCON2)          | 27 S7 UNINSULATED (P7)         |
| 11 N18    | (OCON4)          | 28 WHT (P7-C)                  |
| 12 64     | (OCON5)          | 29 RED (P7-B)                  |
| 13 65C    | (OCON3)          | 30 BLK (P7-A)                  |
| 14 31A    | (CLS)            | 31 14N (EBG)                   |
| 15 N/C    |                  | 32 N/C                         |
| 16 N/C    |                  | 33 N/C                         |
| 17 71     | (K20-SS)         | 34 N/C                         |



TO SHEET 1

- P5 CONNECTIONS**
- |       |     |          |
|-------|-----|----------|
| PIN A | BLK | (P4A-23) |
| B     | RED | (P4A-22) |
| C     | WHT | (P4A-21) |

- P7 CONNECTIONS**
- |       |     |          |
|-------|-----|----------|
| PIN A | BLK | (P4A-30) |
| B     | RED | (P4A-29) |
| C     | WHT | (P4A-28) |

- P6 CONNECTIONS**
- |        |     |          |
|--------|-----|----------|
| PIN #1 | BLK | (GC-11)  |
| 2      | WHT | (GC-10)  |
| 3      | S2  | (GC-GND) |

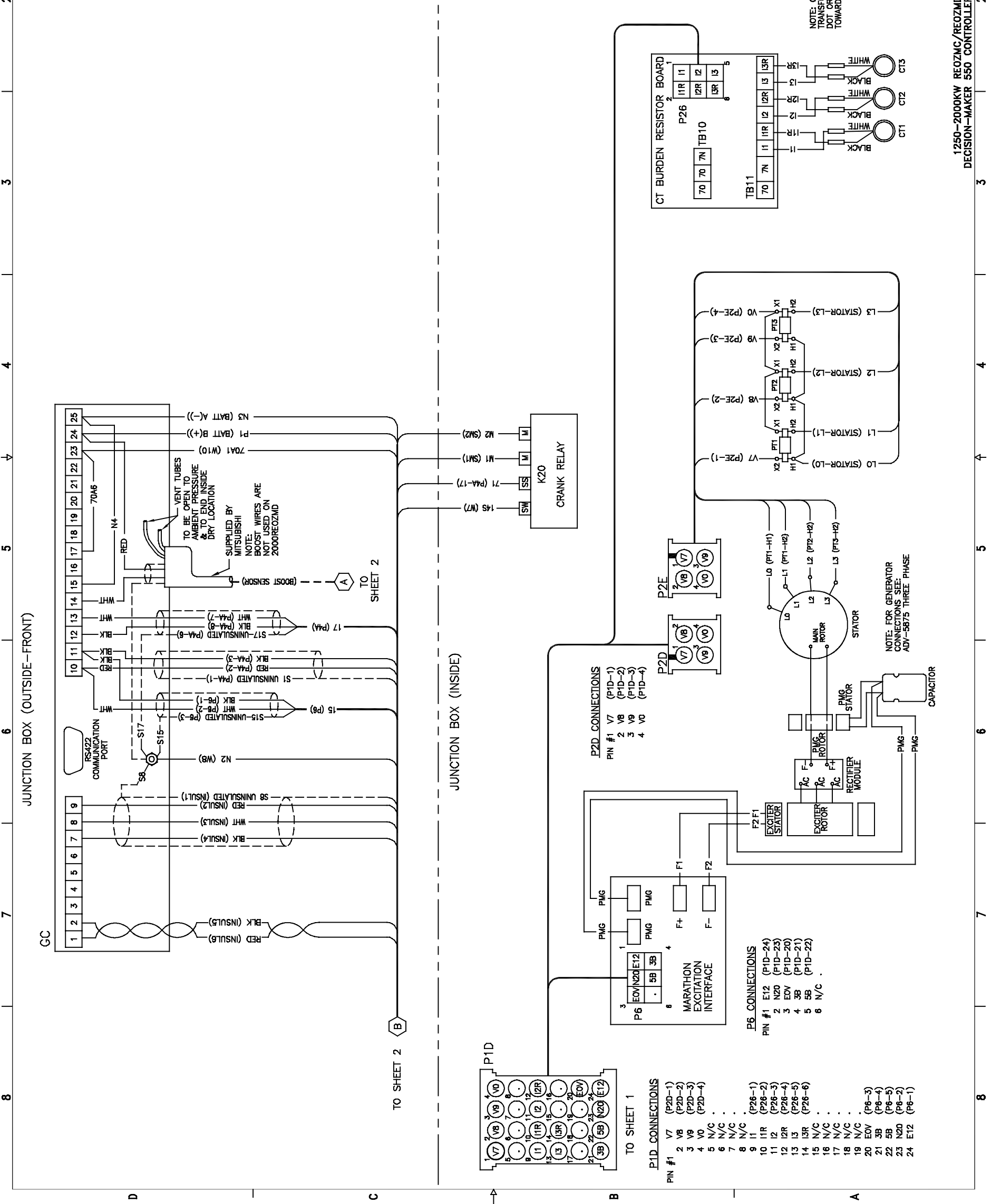
| REV | DATE     | REVISION   | BY  |
|-----|----------|--|-----|
| -   | 12-13-10 | NEW DRAWING [90408-4]  | DFS |
| A   | 2-15-11  | REVISED TO MATCH HARNESS MODIFICATIONS PER PRE-PRO BUILD [91118-4]   | DFS |
| B   | 3-26-11  | [A-5, 8 & D-8] FUEL TANK OPTIONS & CORRESPONDING FT. TO FT. CONNECTIONS ADDED & SEE SHEETS 1 & 3 [91304-8] DFS | DFS |

| APPROVALS |     | DATE     | BY  |
|-----------|-----|----------|-----|
| DESIGNED  | DFS | 12-13-10 | DFS |
| CHECKED   | DFS | 12-13-10 | DFS |
| APPROVED  | DFS | 12-13-10 | DFS |

1250-2000KW 2000REDZMC/REDZMD  
DECISION-MAKER 550 CONTROLLER

**KOHLER CO.**  
U.S.A.  
1250-2000 KW MITSUBISHI  
DIAGRAM WIRING  
GM79396

| REV | DATE     | REVISION  | BY  |
|-----|----------|---|-----|
| -   | 12-13-10 | NEW DRAWING [8040B-4]   | DPS |
| A   | 2-15-11  | REVISED TO MATCH HARNESS MODIFICATIONS PER PRE-PRO BUILD [91118-4]                            | DPS |
| B   | 3-28-11  | 4 LEAD STATOR WAS 12 LEAD STATOR. PT. TO PT. CONNECTIONS REWAS AND SEE SHEETS 1 & 2 [91304-8] | DPS |



JUNCTION BOX (OUTSIDE-FRONT)

JUNCTION BOX (INSIDE)

CT BURDEN RESISTOR BOARD

P6 CONNECTIONS

- PIN #1 E12 (P1D-24)
- 2 N20 (P1D-23)
- 3 EOV (P1D-20)
- 4 3B (P1D-21)
- 5 5B (P1D-22)
- 6 N/C

P2D CONNECTIONS

- PIN #1 V7 (P1D-1)
- 2 V8 (P1D-2)
- 3 V9 (P1D-3)
- 4 V0 (P1D-4)

P2E CONNECTIONS

- PIN #1 V7 (P2E-1)
- 2 V8 (P2E-2)
- 3 V9 (P2E-3)
- 4 V0 (P2E-4)

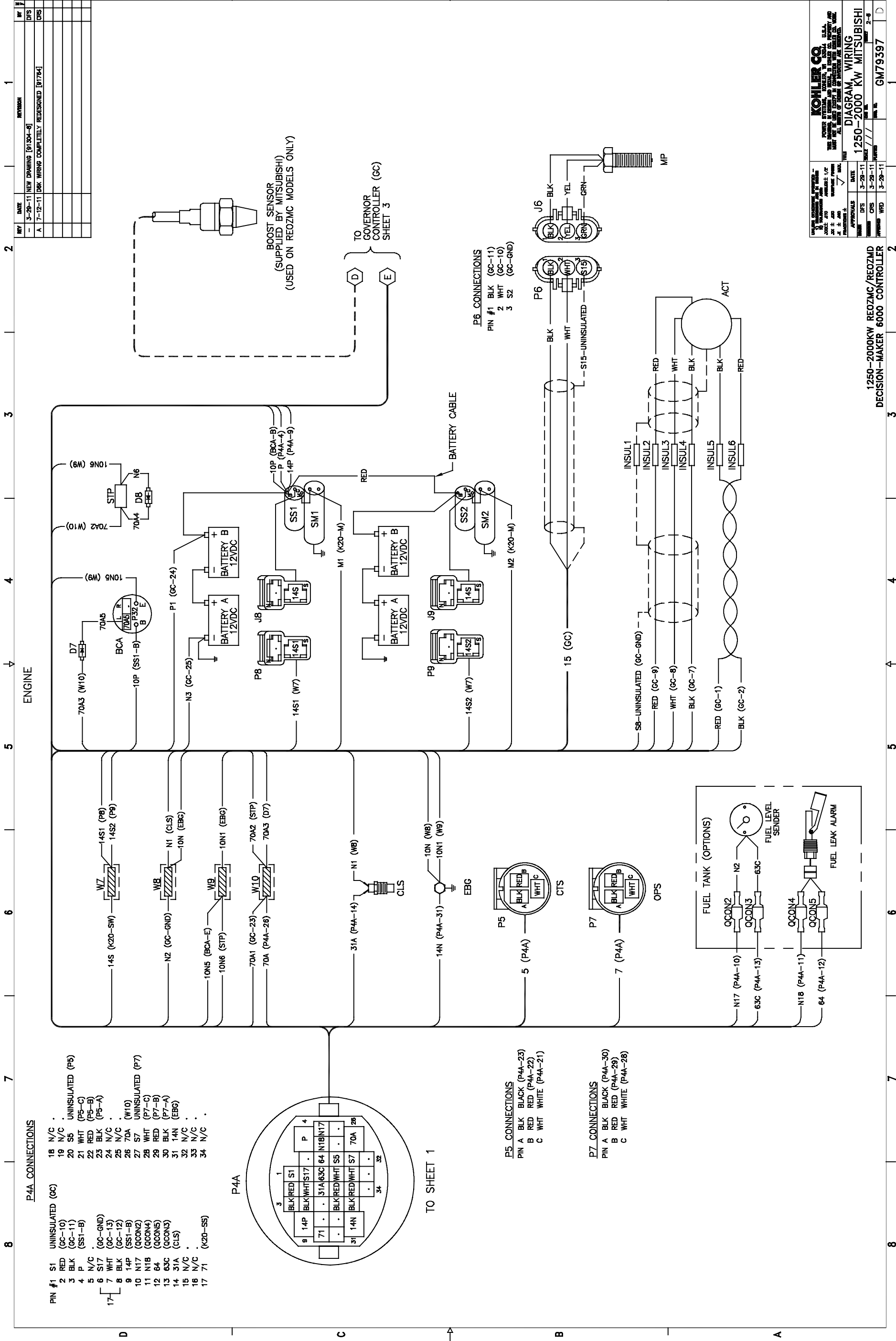
NOTE: CURRENT TRANSFORMER DOT OR "H1" TOWARD GENERATOR.

1250-2000KW REOZMC/REOZMD  
DECISION-MAKER 550 CONTROLLER

| APPROVALS | DATE     |
|-----------|----------|
| DPS       | 12-13-10 |
| CRS       | 12-13-10 |
| DPS       | 12-13-10 |

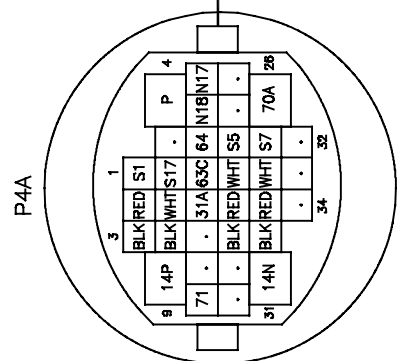
1250-2000 KW MITSUBISHI  
 DIAGRAM, WIRING  
 GM79396





**P4A CONNECTIONS**

- |        |              |                  |            |                  |
|--------|--------------|------------------|------------|------------------|
| PIN #1 | S1           | UNINSULATED (GC) | 18         | N/C              |
| 2      | RED (GC-10)  | 19               | N/C        | UNINSULATED (P5) |
| 3      | BLK (GC-11)  | 20               | S5         | UNINSULATED (P5) |
| 4      | P (SS1-B)    | 21               | WHT (P5-C) |                  |
| 5      | N/C          | 22               | RED (P5-B) |                  |
| 6      | S17 (GC-GND) | 23               | BLK (P5-A) |                  |
| 7      | WHT (GC-13)  | 24               | N/C        |                  |
| 8      | BLK (GC-12)  | 25               | N/C        |                  |
| 9      | 14P (SS1-B)  | 26               | 70A (W10)  |                  |
| 10     | N17 (QCON2)  | 27               | S7         | UNINSULATED (P7) |
| 11     | N18 (QCON4)  | 28               | WHT (P7-C) |                  |
| 12     | 64 (QCON5)   | 29               | RED (P7-B) |                  |
| 13     | 63C (QCON3)  | 30               | BLK (P7-A) |                  |
| 14     | 31A (CLS)    | 31               | 14N (EBG)  |                  |
| 15     | N/C          | 32               | N/C        |                  |
| 16     | N/C          | 33               | N/C        |                  |
| 17     | 71 (K20-SS)  | 34               | N/C        |                  |



TO SHEET 1

**P5 CONNECTIONS**

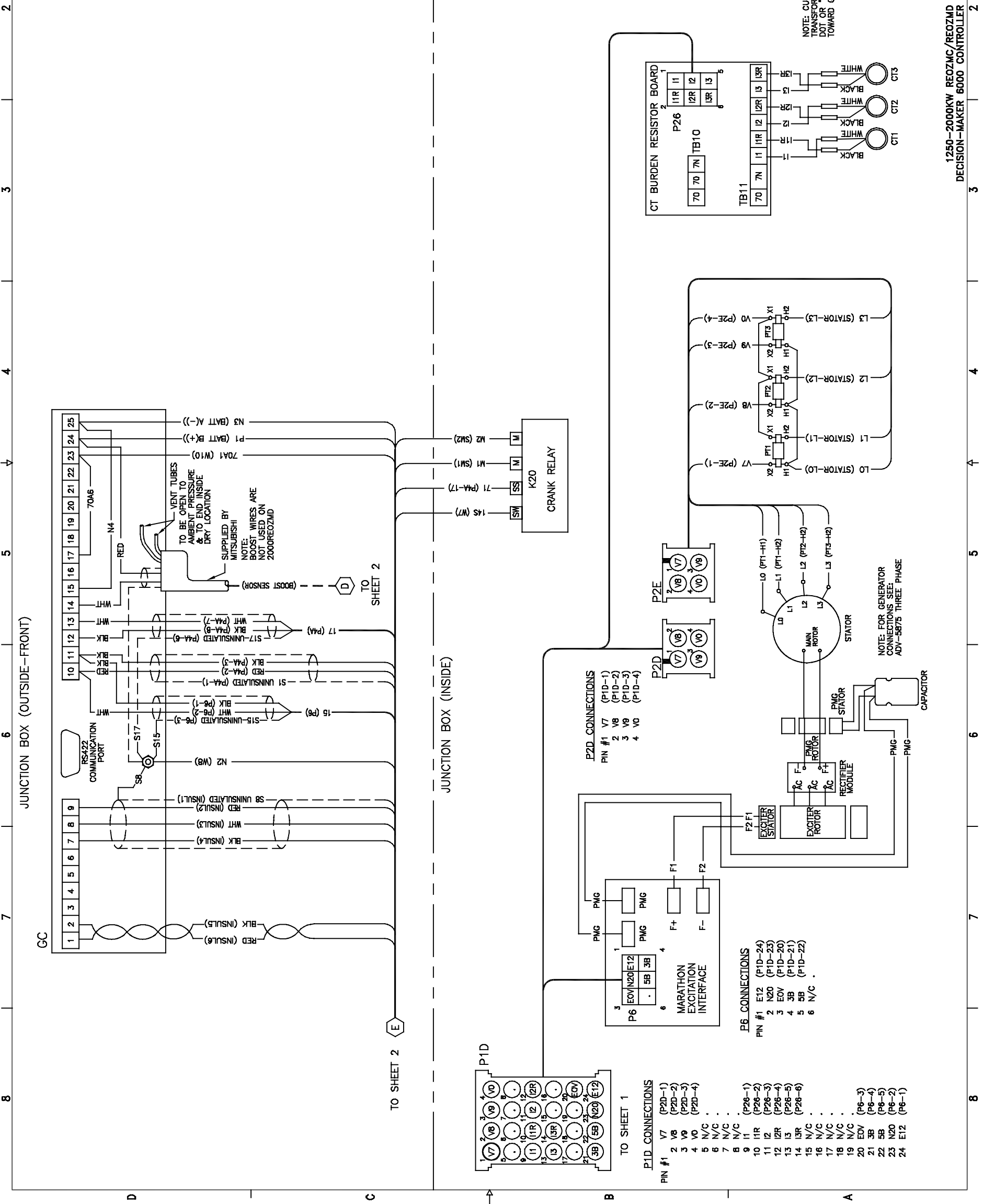
- PIN A BLK BLACK (P4A-23)  
 B RED RED (P4A-22)  
 C WHT WHITE (P4A-21)

**P7 CONNECTIONS**

- PIN A BLK BLACK (P4A-30)  
 B RED RED (P4A-29)  
 C WHT WHITE (P4A-28)

|  |  |  |
|--|--|--|
| <b>KOHLER CO.</b><br>1250-2000KW REDZMC/REOZMD<br>DECISION-MAKER 6000 CONTROLLER |  | DATE: 3-29-11<br>DESIGNED BY: JRS<br>CHECKED BY: JRS<br>APPROVED BY: JRS |
| 1250-2000 KW MITSUBISHI  |  | SHEET: 2-8<br>OF: 2-8  |
| 1250-2000 KW MITSUBISHI  |  | PART NO: GM79397   |

| REV | DATE    | REVISION                                 |
|-----|---------|--|
| -   | 3-28-11 | NEW DRAWING [81304-B]                    |
| A   | 7-12-11 | DKK WIRING COMPLETELY REDESIGNED [81764] |
|     |         |  |
|     |         |  |
|     |         |  |
|     |         |  |
|     |         |  |
|     |         |  |
|     |         |  |
|     |         |  |



NOTE: CURRENT TRANSFORMER DOT OR "H1" TOWARD GENERATOR.

| APPROVALS        | DATE    |
|------------------|---------|
| DESIGNED BY: JRS | 3-28-11 |
| CHECKED BY: CRS  | 3-28-11 |
| APPROVED BY: WJD | 3-28-11 |

1250-2000KW REOZMC/REOZMD  
DECISION-MAKER 6000 CONTROLLER

DIAGRAM, WIRING  
1250-2000 KW MITSUBISHI

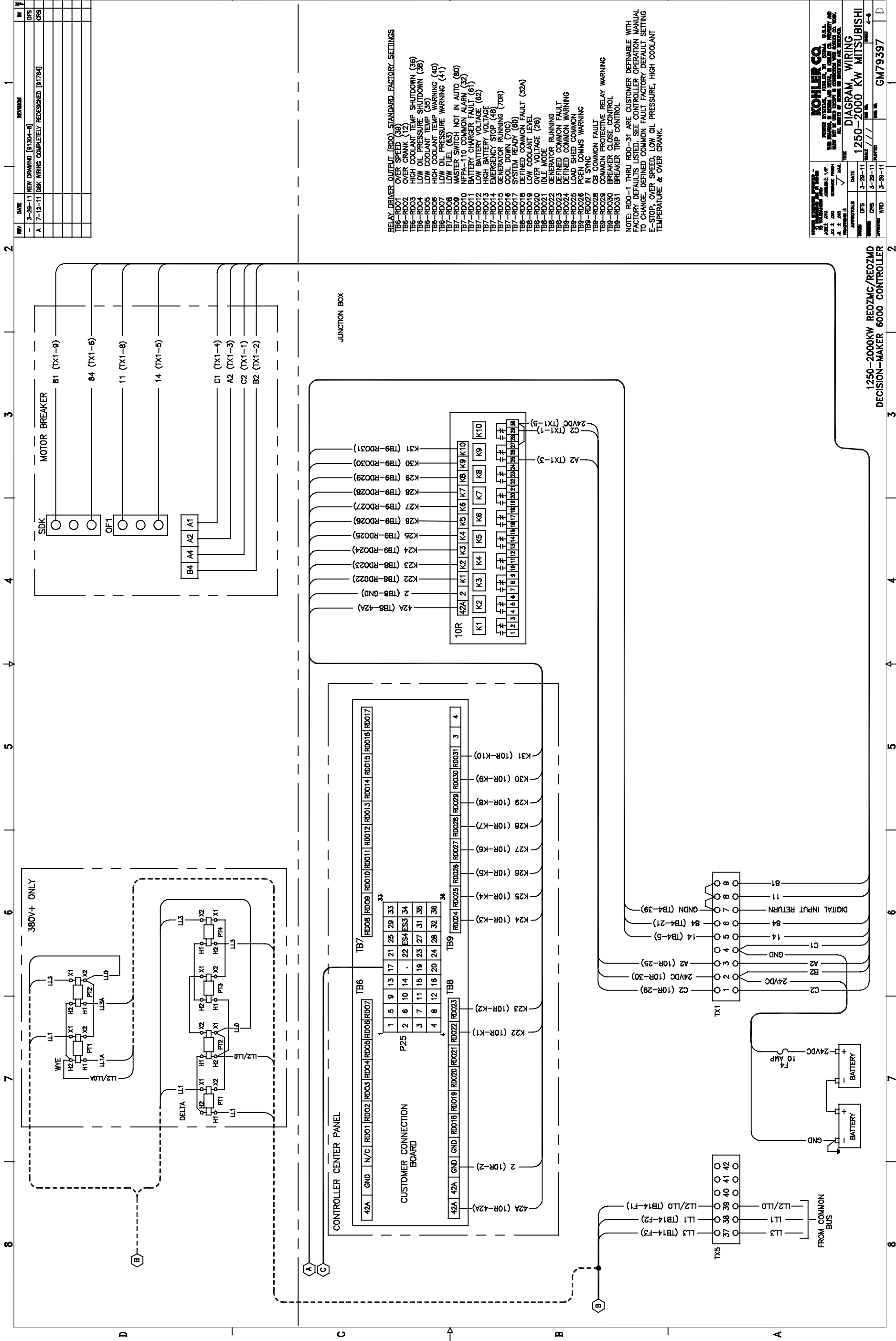
GM79397

NOTE: FOR GENERATOR CONNECTIONS SEE ADV-5875 THREE PHASE

TO SHEET 1

TO SHEET 2

TO SHEET 2



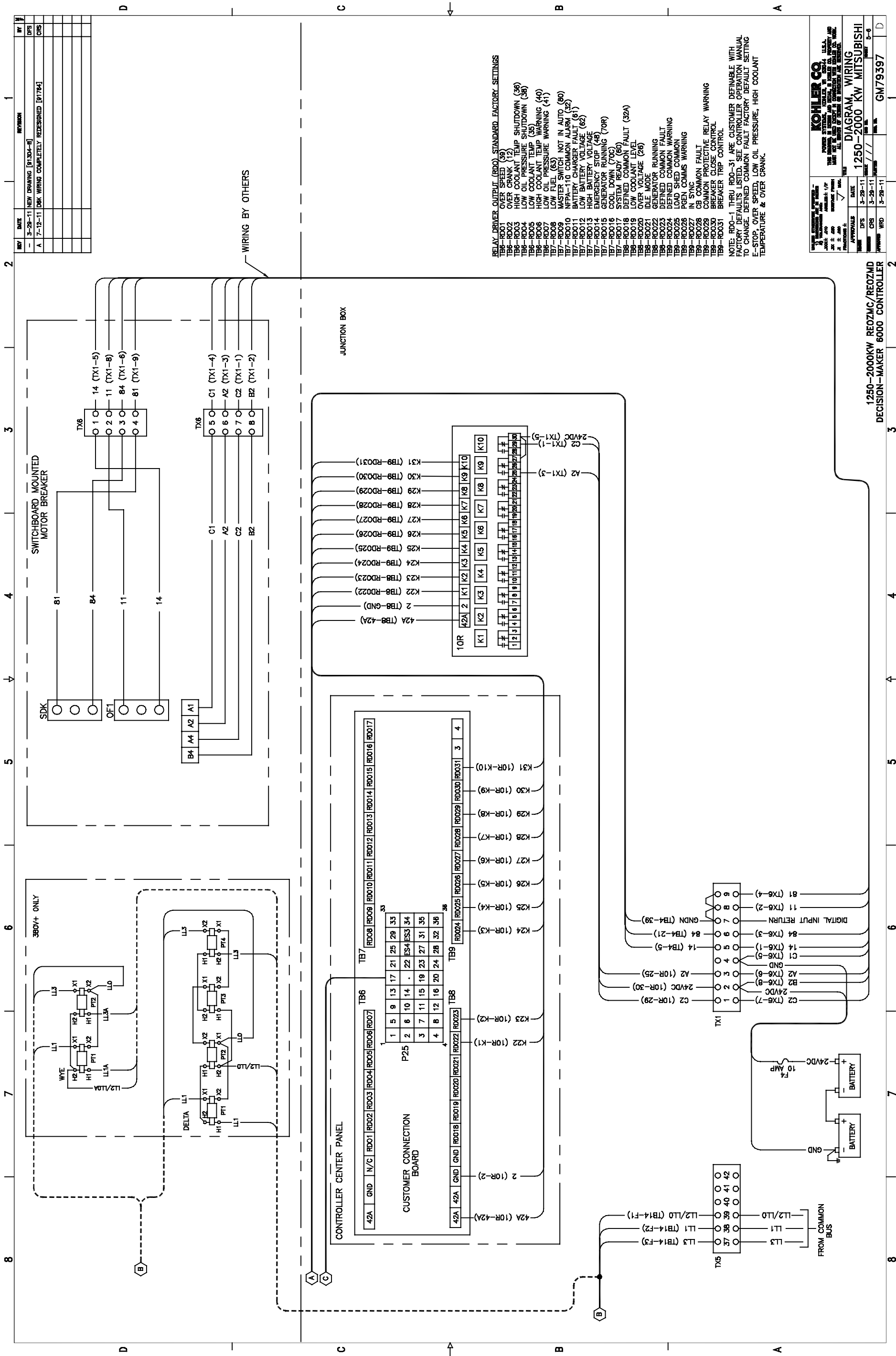
|     |         |  |     |
|-----|---------|--|-----|
| REV | DATE    | REVISION                                 | BY  |
| -   | 3-29-11 | NEW DRAWING [01304-8]                    | DJS |
| A   | 7-12-11 | DBK WIRING COMPLETELY REDESIGNED [01764] | DJS |

|           |         |
|-----------|---------|
| APPROVALS | DATE    |
| DESIGNER  | 3-29-11 |
| CHECKER   | 3-29-11 |
| APPROVER  | 3-29-11 |
| WDR       | 3-29-11 |

**KOHLER CO. U.S.A.**  
 1250-2000 KW MITSUBISHI  
 DIAGRAM, WIRING  
 GM79397





- RELAY DRIVER OUTPUT (RDO) STANDARD FACTORY SETTINGS
- TB6-RDO01 OVER SPEED (12)
  - TB6-RDO02 OVER CRANK (12)
  - TB6-RDO03 HIGH COOLANT TEMP SHUTDOWN (36)
  - TB6-RDO04 LOW OIL PRESSURE SHUTDOWN (36)
  - TB6-RDO05 LOW COOLANT TEMP (35)
  - TB6-RDO06 HIGH COOLANT TEMP WARNING (40)
  - TB6-RDO07 LOW OIL PRESSURE WARNING (41)
  - TB7-RDO08 LOW FUEL (63)
  - TB7-RDO09 MASTER SWITCH NOT IN AUTO (60)
  - TB7-RDO10 NFPA-110 COMMON ALARM (32)
  - TB7-RDO11 CAPTIVE CHARGER (61)
  - TB7-RDO12 LOW BATTERY VOLTAGE (62)
  - TB7-RDO13 HIGH BATTERY VOLTAGE (62)
  - TB7-RDO14 EMERGENCY STOP (48)
  - TB7-RDO15 GENERATOR RUNNING (70R)
  - TB7-RDO16 COOL DOWN (70C)
  - TB7-RDO17 SYSTEM READY (60)
  - TB7-RDO18 DEFINED COMMON FAULT (32A)
  - TB8-RDO19 LOW COOLANT LEVEL
  - TB8-RDO20 OVER VOLTAGE (26)
  - TB8-RDO21 IDLE MODE RUNNING
  - TB8-RDO22 GENERATOR COMMON FAULT
  - TB8-RDO23 DEFINED COMMON WARNING
  - TB8-RDO24 LOAD SHED COMMON
  - TB8-RDO25 LOAD SHED COMMON
  - TB8-RDO26 PGEN COMMS WARNING
  - TB8-RDO27 IN SYNC
  - TB8-RDO28 CB COMMON FAULT
  - TB8-RDO29 COMMON PROTECTIVE RELAY WARNING
  - TB8-RDO30 BREAKER CLOSE CONTROL
  - TB8-RDO31 BREAKER TRIP CONTROL
- NOTE: RDO-1 THRU RDO-31 ARE CUSTOMER DEFINABLE WITH FACTORY DEFAULTS LISTED. SEE CONTROLLER OPERATION MANUAL TO CHANGE. DEFINED COMMON FAULT FACTORY DEFAULT SETTING E-STOP, OVER SPEED, LOW OIL PRESSURE, HIGH COOLANT TEMPERATURE & OVER CRANK.

|         |  |         |     |
|---------|--|---------|-----|
| DATE    |  | BY      | REV |
| 3-28-11 | NEW DRAWING [01304-B]                    | REVISON | 1   |
| 7-12-11 | DKK WIRING COMPLETELY REDESIGNED [01704] |         | 2   |
|         |  |         | 3   |
|         |  |         | 4   |
|         |  |         | 5   |
|         |  |         | 6   |
|         |  |         | 7   |
|         |  |         | 8   |

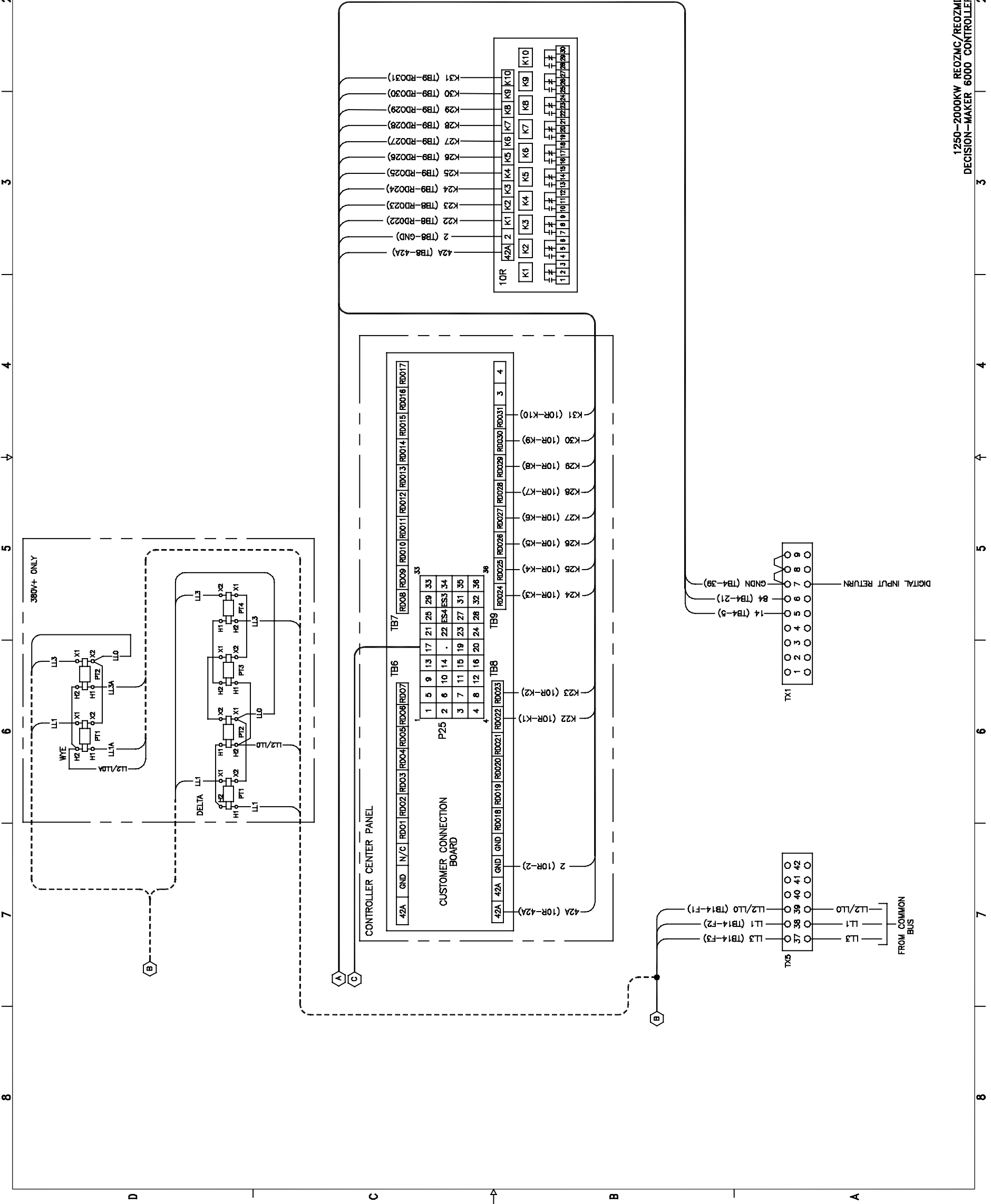
  

|         |      |         |     |
|---------|------|---------|-----|
| DATE    |      | BY      | REV |
| 3-28-11 | DATE | 3-28-11 | REV |
| CRS     | DATE | 3-28-11 | REV |
| WRD     | DATE | 3-28-11 | REV |

1250-2000KW REDZMC/REOZMD  
DECISION-MAKER 6000 CONTROLLER

GM79397

| REV | DATE    | REVISION                                 |
|-----|---------|--|
| -   | 3-29-11 | NEW DRAWING [01304-B]                    |
| A   | 7-12-11 | DRK WIRING COMPLETELY REDESIGNED [01704] |
|     |         |  |
|     |         |  |
|     |         |  |
|     |         |  |
|     |         |  |
|     |         |  |
|     |         |  |



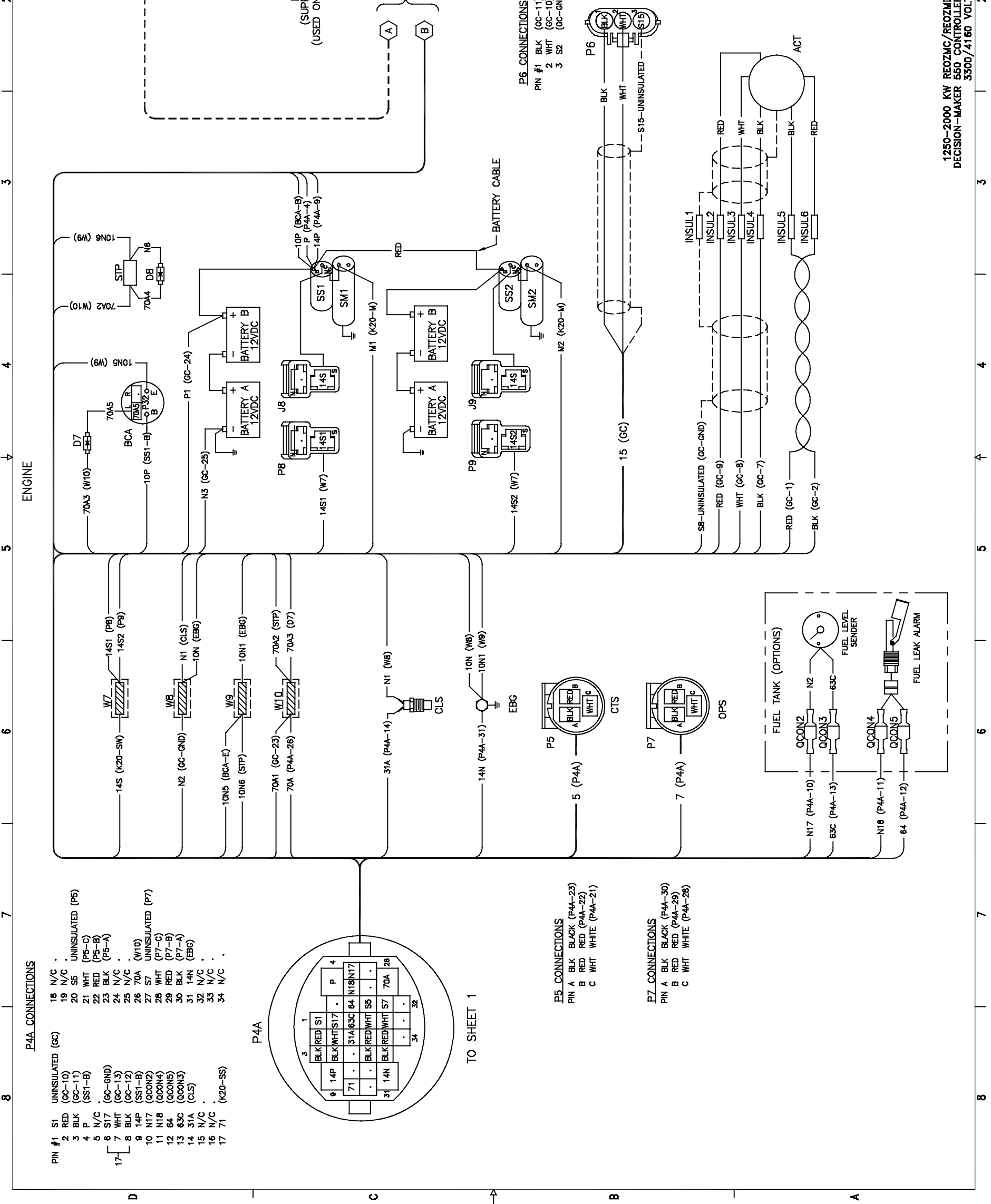
| APPROVALS |     | DATE    | BY |
|-----------|-----|---------|----|
| DESIGNED  | DRS | 3-29-11 |    |
| CHECKED   | CRS | 3-29-11 |    |
| APPROVED  | WRD | 3-29-11 |    |

| KOHLER CO. U.S.A.         |                                |
|---------------------------|--------------------------------|
| 1250-2000KW REDZMC/REOZMD | DECISION-MAKER 6000 CONTROLLER |
| DIAGRAM WIRING            | 1250-2000 KW MITSUBISHI        |
| PROJECT NO.               | GM79397                        |
| REVISION                  | 6-6                            |

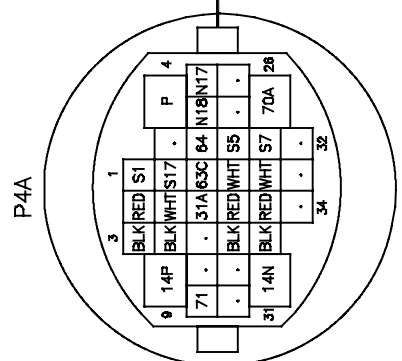


| REV | DATE    | REVISION              | BY  |
|-----|---------|-----------------------|-----|
| -   | 3-29-11 | NEW DRAWING [P1304-B] | DPS |
|     |         |                       |     |
|     |         |                       |     |
|     |         |                       |     |
|     |         |                       |     |



**P4A CONNECTIONS**

- PIN #1 S1 UNINSULATED (GC)
- 2 RED (GC-10)
- 3 BLK (GC-11)
- 4 P (SS1-B)
- 5 N/C (GC-GND)
- 6 S17 (GC-13)
- 7 WHT (GC-12)
- 8 BLK (SS1-B)
- 9 14P (QCON2)
- 10 N17 (QCON4)
- 11 N18 (QCON5)
- 12 64 (QCON5)
- 13 65C (QCON5)
- 14 31A (CLS)
- 15 N/C
- 16 N/C
- 17 71 (K20-SS)
- 18 N/C
- 19 N/C
- 20 S5 UNINSULATED (P5)
- 21 WHT (P5-C)
- 22 RED (P5-B)
- 23 BLK (P5-A)
- 24 N/C
- 25 N/C
- 26 70A (W10)
- 27 57 UNINSULATED (P7)
- 28 WHT (P7-C)
- 29 RED (P7-B)
- 30 BLK (P7-A)
- 31 14N (EB6)
- 32 N/C
- 33 N/C
- 34 N/C



TO SHEET 1

**P5 CONNECTIONS**

- PIN A BLK BLACK (P4A-23)
- B RED RED (P4A-22)
- C WHT WHITE (P4A-21)

**PZ CONNECTIONS**

- PIN A BLK BLACK (P4A-30)
- B RED RED (P4A-29)
- C WHT WHITE (P4A-28)

**P6 CONNECTIONS**

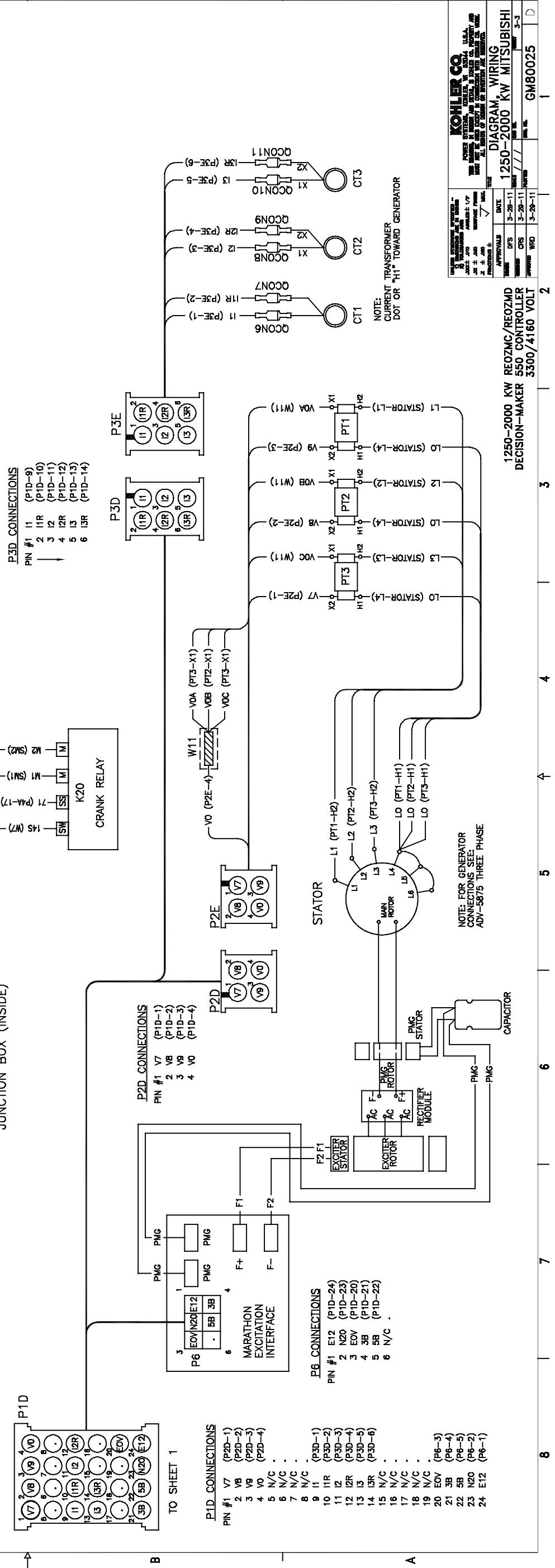
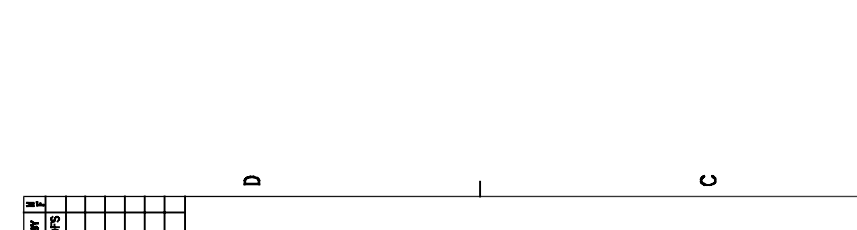
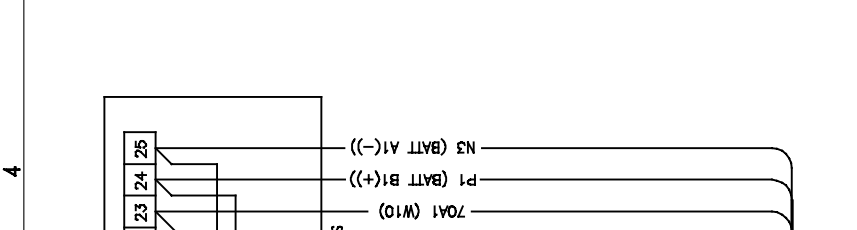
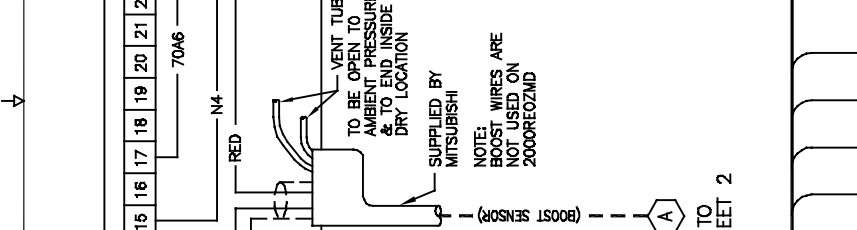
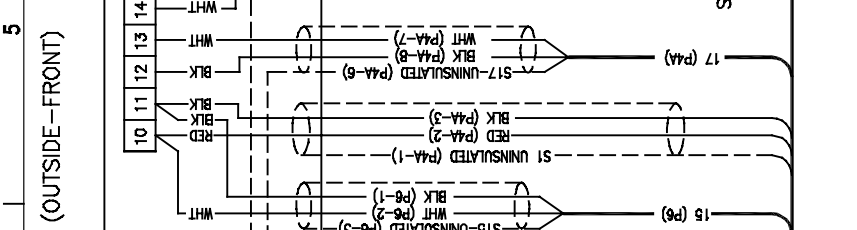
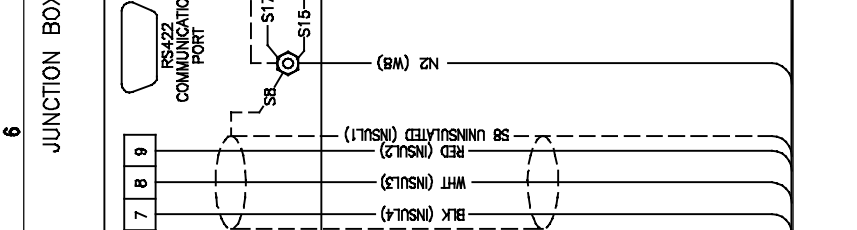
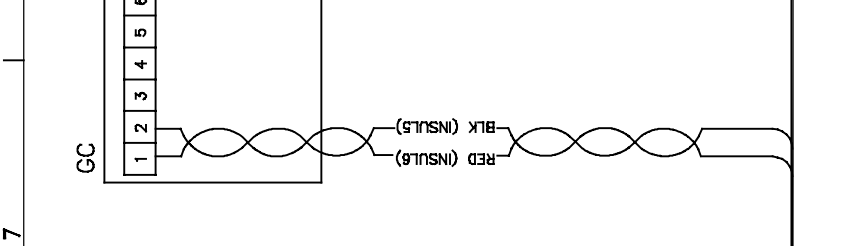
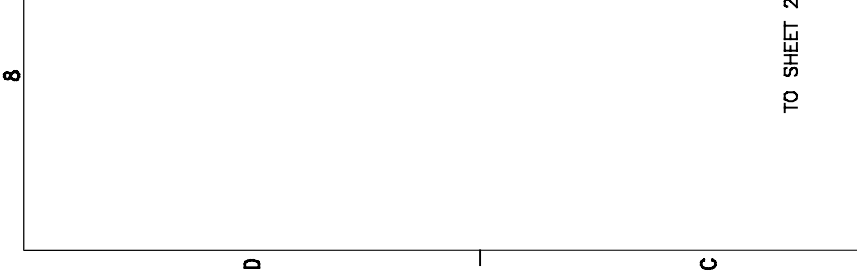
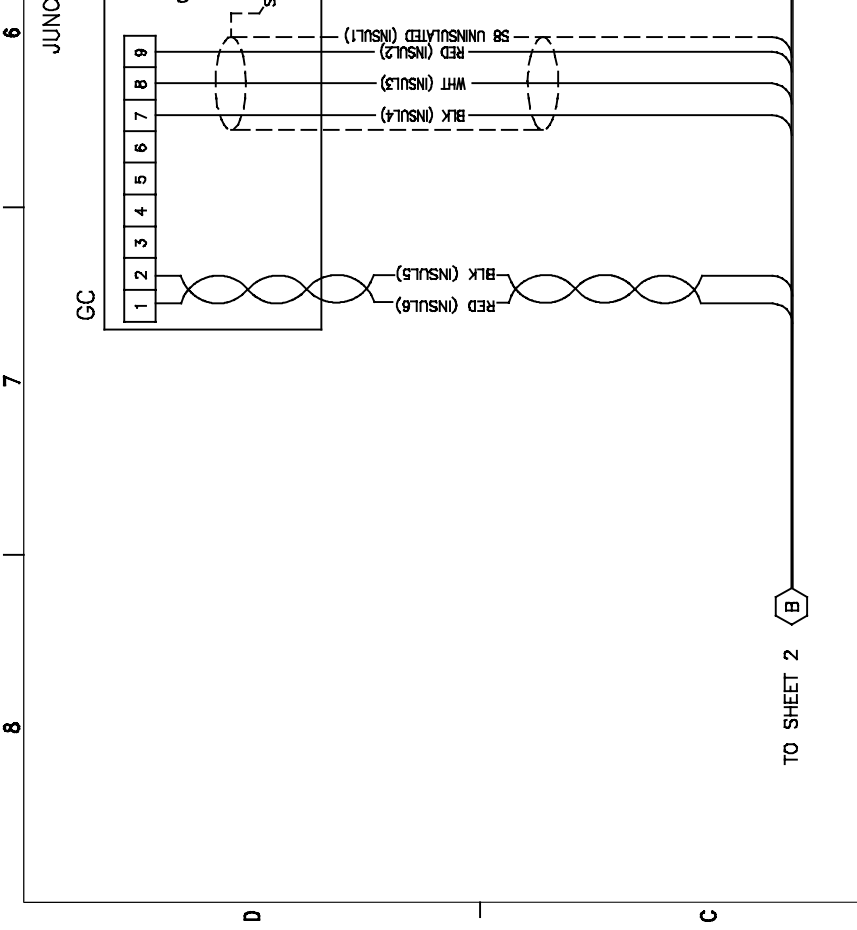
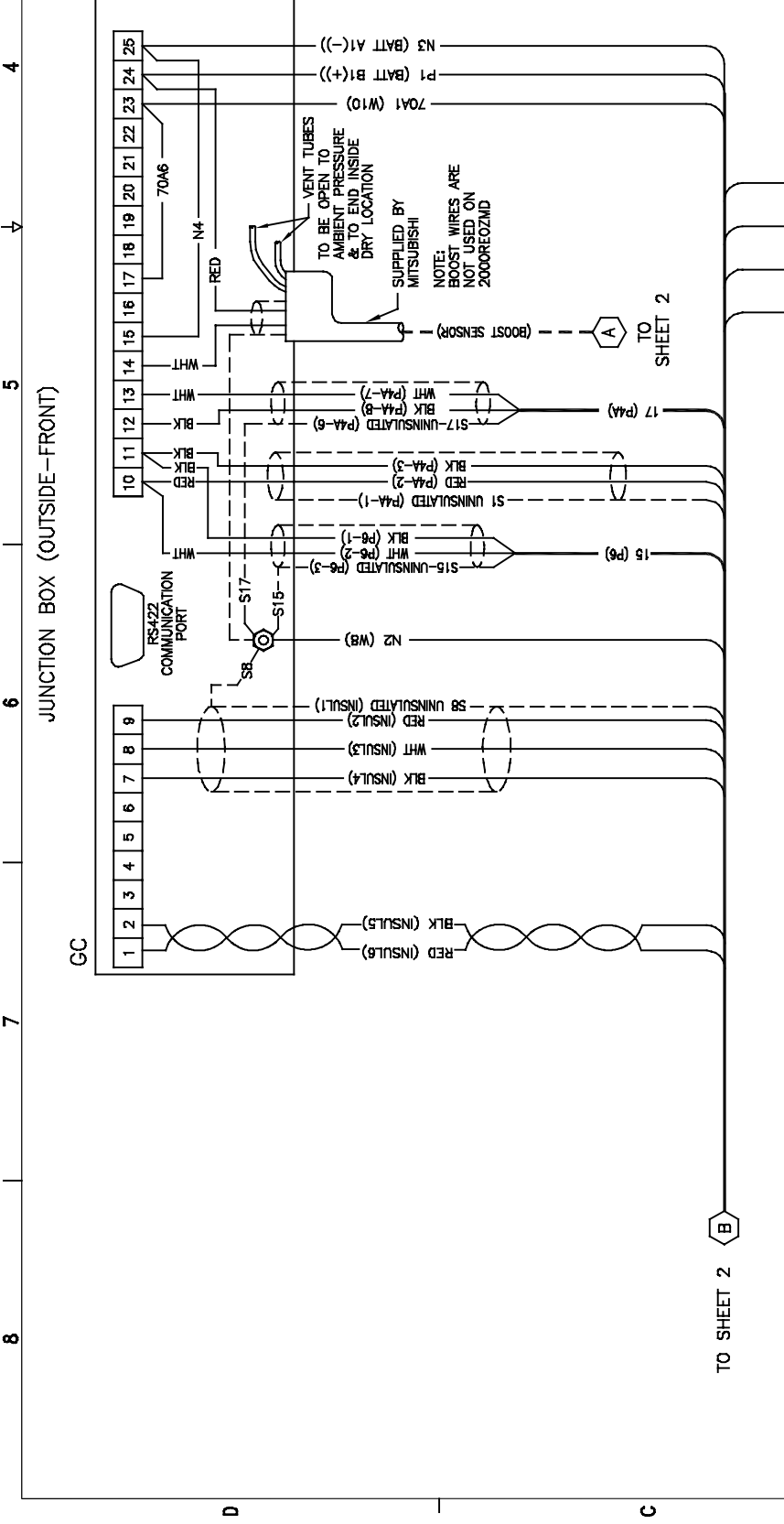
- PIN #1 BLK (GC-11)
- 2 WHT (GC-10)
- 3 S2 (GC-GND)

| APPROVALS |     | DATE    | BY |
|-----------|-----|---------|----|
| DESIGNED  | DPS | 3-29-11 |    |
| CHECKED   |     |         |    |
| APPROVED  |     |         |    |

**KOHLER CO. U.S.A.**  
 1250-2000 KW REDZMC/REDZMD 550 CONTROLLER  
 DECISION-MAKER 3500/4160 VOLT

DIAGRAM, WIRING  
 1250-2000 KW MITSUBISHI  
 SHEET 2-3  
 PART NO. GM80025

| REV | DATE    | DESCRIPTION           | BY | CHK |
|-----|---------|-----------------------|----|-----|
| -   | 3-29-11 | NEW DRAWING [01304-8] |    | DPS |
|     |         |                       |    |     |
|     |         |                       |    |     |
|     |         |                       |    |     |
|     |         |                       |    |     |
|     |         |                       |    |     |



| APPROVALS | DATE    | BY | CHK |
|-----------|---------|----|-----|
| DESIGNED  | 3-29-11 |    |     |
| DRAWN     | 3-29-11 |    |     |
| CHECKED   | 3-29-11 |    |     |
| APPROVED  | 3-29-11 |    |     |

| FILE NO.                   | REV. | DATE | BY | CHK |
|----------------------------|------|------|----|-----|
| 1250-2000 KW REO7MC/REO7MD |      |      |    |     |
| 550 CONTROLLER             |      |      |    |     |
| DECISION-MAKER             |      |      |    |     |
| 3300/4160 VOLT             |      |      |    |     |

| REV. | DATE    | DESCRIPTION           | BY | CHK |
|------|---------|-----------------------|----|-----|
| 1    | 3-29-11 | NEW DRAWING [01304-8] |    | DPS |

| REV. | DATE    | DESCRIPTION           | BY | CHK |
|------|---------|-----------------------|----|-----|
| 1    | 3-29-11 | NEW DRAWING [01304-8] |    | DPS |

| REV. | DATE    | DESCRIPTION           | BY | CHK |
|------|---------|-----------------------|----|-----|
| 1    | 3-29-11 | NEW DRAWING [01304-8] |    | DPS |

| REV. | DATE    | DESCRIPTION           | BY | CHK |
|------|---------|-----------------------|----|-----|
| 1    | 3-29-11 | NEW DRAWING [01304-8] |    | DPS |

| REV. | DATE    | DESCRIPTION           | BY | CHK |
|------|---------|-----------------------|----|-----|
| 1    | 3-29-11 | NEW DRAWING [01304-8] |    | DPS |

| REV. | DATE    | DESCRIPTION           | BY | CHK |
|------|---------|-----------------------|----|-----|
| 1    | 3-29-11 | NEW DRAWING [01304-8] |    | DPS |

| REV. | DATE    | DESCRIPTION           | BY | CHK |
|------|---------|-----------------------|----|-----|
| 1    | 3-29-11 | NEW DRAWING [01304-8] |    | DPS |

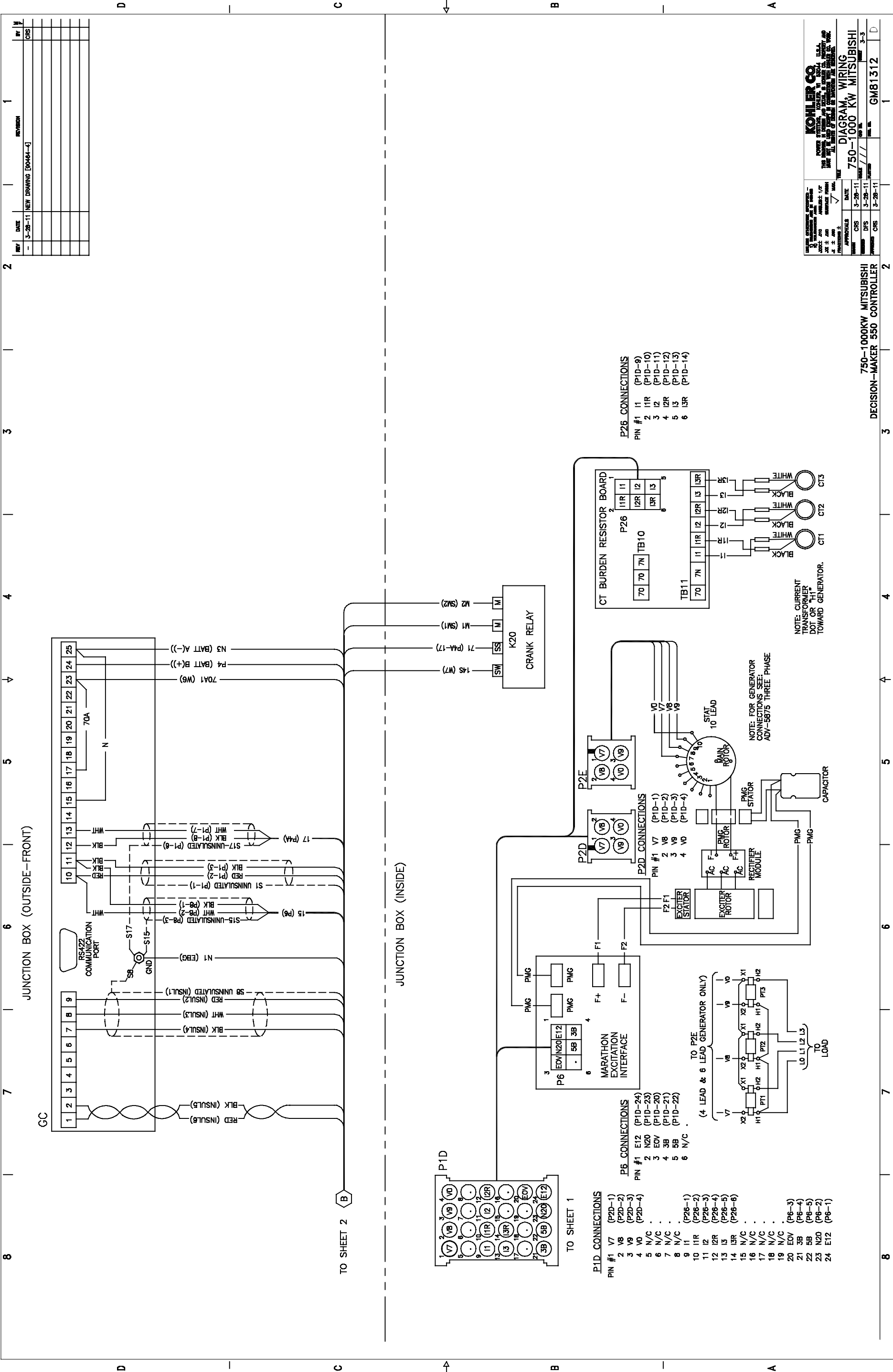
| REV. | DATE    | DESCRIPTION           | BY | CHK |
|------|---------|-----------------------|----|-----|
| 1    | 3-29-11 | NEW DRAWING [01304-8] |    | DPS |

| REV. | DATE    | DESCRIPTION           | BY | CHK |
|------|---------|-----------------------|----|-----|
| 1    | 3-29-11 | NEW DRAWING [01304-8] |    | DPS |

| REV. | DATE    | DESCRIPTION           | BY | CHK |
|------|---------|-----------------------|----|-----|
| 1    | 3-29-11 | NEW DRAWING [01304-8] |    | DPS |







| REV | DATE    | DESCRIPTION           | BY | CHK |
|-----|---------|-----------------------|----|-----|
| -   | 3-28-11 | NEW DRAWING [04044-4] |    | CRS |
|     |         |                       |    |     |
|     |         |                       |    |     |
|     |         |                       |    |     |
|     |         |                       |    |     |

| APPROVALS |     | DATE    |  | DRAWN BY |  | CHECKED BY |  |
|-----------|-----|---------|--|----------|--|------------|--|
| DESIGNER  | CRS | 3-28-11 |  | DATE     |  | DATE       |  |
| APPROVER  | DFS | 3-28-11 |  | DATE     |  | DATE       |  |
| APPROVER  | CRS | 3-28-11 |  | DATE     |  | DATE       |  |

**KOHLER CO.**  
POWER SYSTEMS DIVISION  
1000 W. WASHINGTON ST., MILWAUKEE, WI 53212 U.S.A.  
THIS DRAWING IS THE PROPERTY OF KOHLER CO. IT IS TO BE KEPT IN CONFIDENTIALITY AND NOT REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM.

**DIAGRAM WIRING**  
**750-1000 KW MITSUBISHI**

750-1000KW MITSUBISHI  
DECISION-MAKER 550 CONTROLLER  
GM81312

- P26 CONNECTIONS**
- |        |     |          |
|--------|-----|----------|
| PIN #1 | 11  | (P1D-8)  |
| 2      | 11R | (P1D-10) |
| 3      | 12  | (P1D-11) |
| 4      | 12R | (P1D-12) |
| 5      | 13  | (P1D-13) |
| 6      | 13R | (P1D-14) |

- P2D CONNECTIONS**
- |        |    |         |
|--------|----|---------|
| PIN #1 | V7 | (P1D-1) |
| 2      | V8 | (P1D-2) |
| 3      | V8 | (P1D-3) |
| 4      | V8 | (P1D-4) |

- P6 CONNECTIONS**
- |        |     |          |
|--------|-----|----------|
| PIN #1 | E12 | (P1D-24) |
| 2      | N20 | (P1D-23) |
| 3      | EOV | (P1D-20) |
| 4      | 3B  | (P1D-21) |
| 5      | 5B  | (P1D-22) |
| 6      | N/C |          |

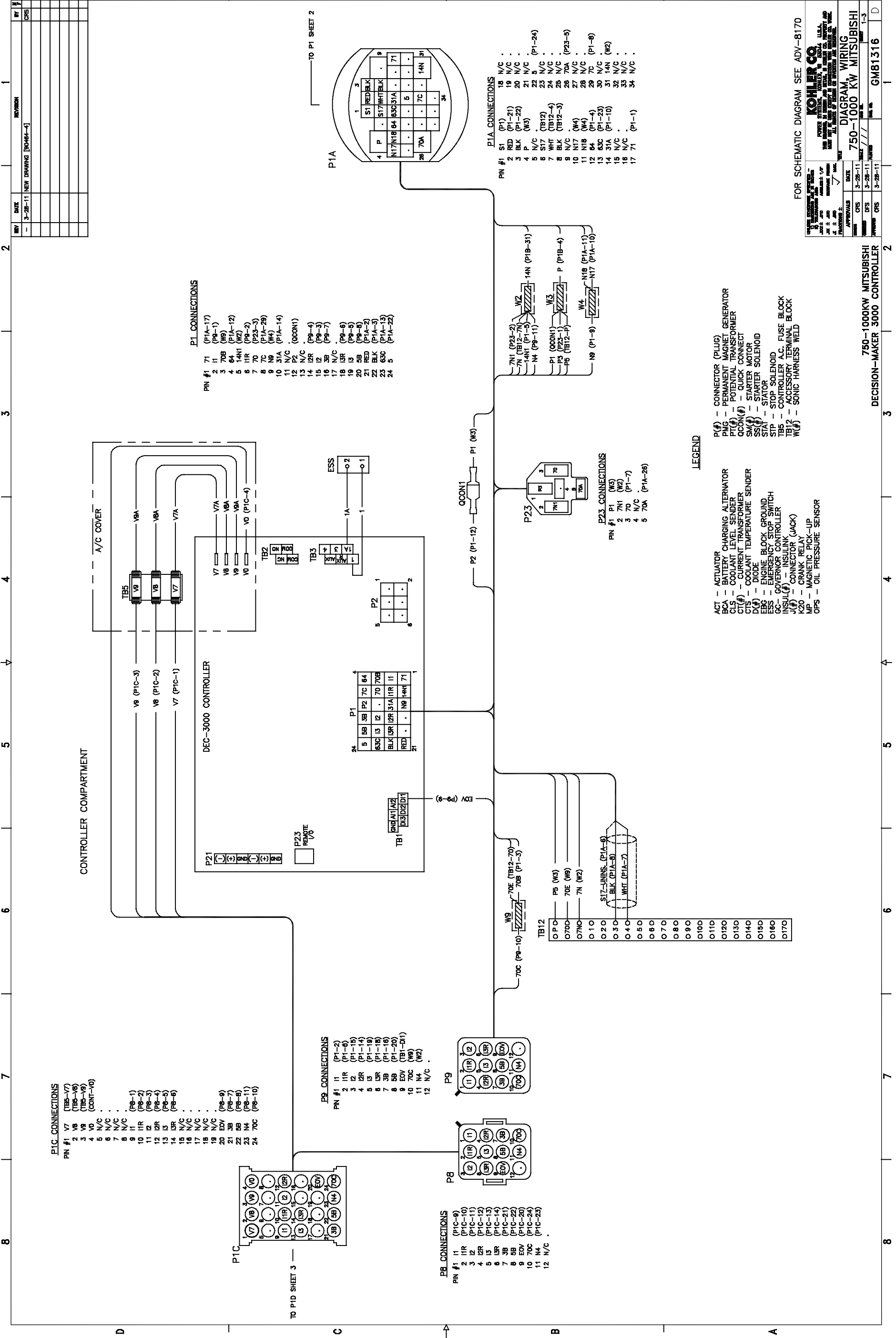
- P1D CONNECTIONS**
- |        |     |         |
|--------|-----|---------|
| PIN #1 | V7  | (P2D-1) |
| 2      | V8  | (P2D-2) |
| 3      | V9  | (P2D-3) |
| 4      | V8  | (P2D-4) |
| 5      | N/C |         |
| 6      | N/C |         |
| 7      | N/C |         |
| 8      | N/C |         |
| 9      | 11  | (P26-1) |
| 10     | 11R | (P26-2) |
| 11     | 12  | (P26-3) |
| 12     | 12R | (P26-4) |
| 13     | 13  | (P26-5) |
| 14     | 13R | (P26-6) |
| 15     | N/C |         |
| 16     | N/C |         |
| 17     | N/C |         |
| 18     | N/C |         |
| 19     | N/C |         |
| 20     | EOV | (P6-3)  |
| 21     | 3B  | (P6-4)  |
| 22     | 5B  | (P6-5)  |
| 23     | N20 | (P6-2)  |
| 24     | E12 | (P6-1)  |

NOTE: CURRENT TRANSFORMER DOT OR HI TOWARD GENERATOR.

NOTE: FOR GENERATOR CONNECTIONS SEE: ADV-5875 THREE PHASE

(4 LEAD & 6 LEAD GENERATOR ONLY)





- P1C CONNECTIONS**
- PN #1 V7 (TB5-V7)
  - 2 V8 (TB5-V8)
  - 3 V9 (TB5-V9)
  - 4 V0 (CONT-V0)
  - 5 N/C
  - 6 N/C
  - 7 N/C
  - 8 N/C
  - 9 I1 (PB-1)
  - 10 I2 (PB-2)
  - 11 I3 (PB-3)
  - 12 I4 (PB-4)
  - 13 I5 (PB-5)
  - 14 I6 (PB-6)
  - 15 N/C
  - 16 N/C
  - 17 N/C
  - 18 N/C
  - 19 EDV (PB-9)
  - 20 EDV (PB-7)
  - 21 3B (PB-8)
  - 22 5B (PB-11)
  - 23 N4 (PB-10)
  - 24 70C

- P8 CONNECTIONS**
- PN #1 I1 (P1-2)
  - 2 I2 (P1-8)
  - 3 I3 (P1-15)
  - 4 I4 (P1-14)
  - 5 I5 (P1-10)
  - 6 I6 (P1-18)
  - 7 3B (P1-16)
  - 8 5B (P1-20)
  - 9 EDV (TB1-D1)
  - 10 70C (WB)
  - 11 N4 (W2)
  - 12 N/C

- P9 CONNECTIONS**
- PN #1 I1 (P1C-9)
  - 2 I2 (P1C-10)
  - 3 I3 (P1C-11)
  - 4 I4 (P1C-12)
  - 5 I5 (P1C-13)
  - 6 I6 (P1C-14)
  - 7 3B (P1C-21)
  - 8 5B (P1C-22)
  - 9 EDV (P1C-24)
  - 10 70C (P1C-20)
  - 11 N4 (P1C-23)
  - 12 N/C

- P1 CONNECTIONS**
- PN #1 71 (P1A-17)
  - 2 I1 (P8-1)
  - 3 70B (W9)
  - 4 64 (P1A-12)
  - 5 14N1 (W2)
  - 6 I1R (P8-2)
  - 7 70 (P23-3)
  - 8 7C (P1A-29)
  - 9 N9 (W4)
  - 10 31A (P1A-14)
  - 11 N/C (QCON1)
  - 12 P2
  - 13 N/C (P8-4)
  - 14 I2R (P8-3)
  - 15 I2 (P8-7)
  - 16 3B (P8-6)
  - 17 N/C (P8-5)
  - 18 I3R (P8-8)
  - 19 I3 (P8-2)
  - 20 5B (P1A-2)
  - 21 RED (P1A-3)
  - 22 BLK (P1A-13)
  - 23 63C (P1A-22)
  - 24 5

- P1A CONNECTIONS**
- PN #1 S1 (P1)
  - 2 RED (P1-21)
  - 3 BLK (P1-22)
  - 4 P (W3)
  - 5 N/C
  - 6 S17 (TB12)
  - 7 WHT (TB12-4)
  - 8 BLK (TB12-3)
  - 9 N/C
  - 10 N17 (W4)
  - 11 N18 (W4)
  - 12 64 (P1-4)
  - 13 63C (P1-23)
  - 14 31A (P1-10)
  - 15 N/C
  - 16 N/C
  - 17 71 (P1-1)
  - 18 N/C
  - 19 N/C
  - 20 N/C
  - 21 N/C (P1-24)
  - 22 5 (P1-24)
  - 23 N/C
  - 24 N/C
  - 25 N/C
  - 26 70A (P23-5)
  - 27 N/C
  - 28 N/C
  - 29 7C (P1-8)
  - 30 N/C
  - 31 14N (W2)
  - 32 N/C
  - 33 N/C
  - 34 N/C

- P23 CONNECTIONS**
- PN #1 P1 (W3)
  - 2 7N1 (W2)
  - 3 70 (P1-7)
  - 4 N/C
  - 5 70A (P1A-26)

**LEGEND**

- ACT - ACTUATOR
- BCA - BATTERY CHARGING ALTERNATOR
- CLS - COOLANT LEVEL SENDER
- CTC - CURRENT TRANSFORMER
- CTIS - COOLANT TEMPERATURE SENDER
- D(#)- DIODE
- EBGS - ENGINE BLOCK GROUND
- EGS - ENGINE GROUND SWITCH
- GV - GOVERNOR CONTROLLER
- INSUL - INSULATION
- J(#)- CONNECTOR (JACK)
- K20 - CRANK RELAY
- MP - MAGNETIC PICK-UP
- OPS - OIL PRESSURE SENSOR
- P(#)- CONNECTOR (PLUG)
- PMG - PERMANENT MAGNET GENERATOR
- PTI(#)- POTENTIAL TRANSFORMER
- QCON(#)- QUICK CONNECT
- SM(#)- STARTER MOTOR
- SSS(#)- STARTER SOLENOID
- STAT - STATOR
- STP - STOP SOLENOID
- TBS - CONTROLLER A.C. FUSE BLOCK
- TB12 - ACCESSORY TERMINAL BLOCK
- W(#)- SONIC HARNESS WELD

FOR SCHEMATIC DIAGRAM SEE ADV-8170

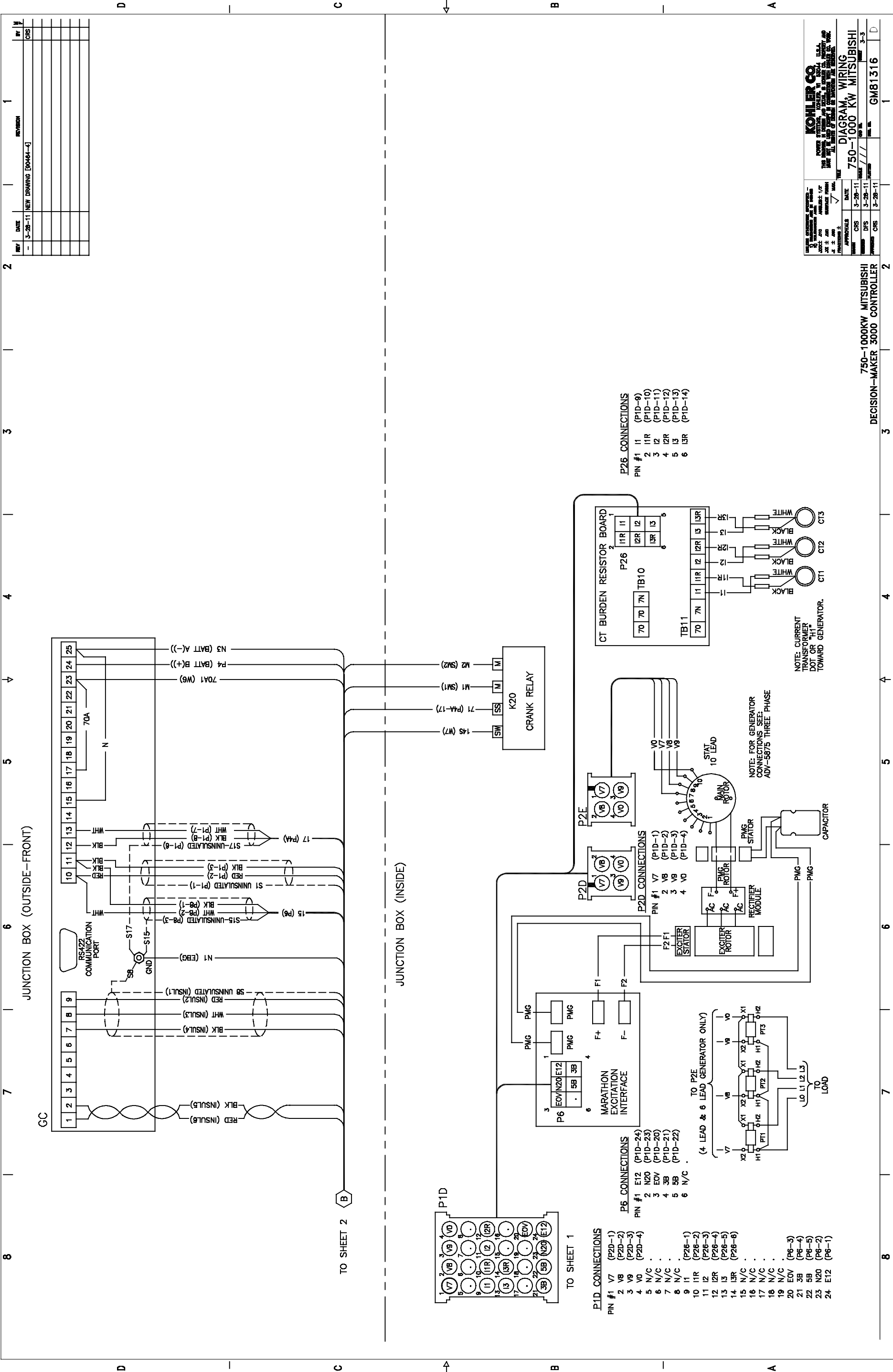
|  |   |
|--|---|
| <b>KOHLER CO.</b><br>POWER GENERATORS, DIESEL ENGINES, ALTERNATORS, TRANSFORMERS, CONTROLLERS, AND ACCESSORIES<br>1000 WEST 10TH AVENUE, DENVER, COLORADO 80202, U.S.A.<br>TEL: 303-733-1000 FAX: 303-733-1001 |   |
| <b>DIAGRAM, WIRING</b><br><b>750-1000 KW MITSUBISHI</b>  |   |
| APPROVALS<br>DESIGNED BY: [Signature]<br>CHECKED BY: [Signature]<br>DRAWN BY: [Signature]  | DATE: 3-28-11<br>SHEET: 1-3<br>TOTAL: 3 |
| APPROVALS<br>DESIGNED BY: [Signature]<br>CHECKED BY: [Signature]<br>DRAWN BY: [Signature]  | DATE: 3-28-11<br>SHEET: 1-3<br>TOTAL: 3 |

750-1000KW MITSUBISHI  
 DECISION-MAKER 3000 CONTROLLER

TO P1D SHEET 3

TO P1D SHEET 2





| REV | DATE    | DESCRIPTION           | BY  | CHK |
|-----|---------|-----------------------|-----|-----|
| 1   | 3-28-11 | NEW DRAWING [30464-4] | CRS |     |
|     |         |                       |     |     |
|     |         |                       |     |     |
|     |         |                       |     |     |
|     |         |                       |     |     |

| APPROVALS |     | DATE    |      | BY |  |
|-----------|-----|---------|------|----|--|
| DESIGN    | CRS | 3-28-11 | DATE |    |  |
| CHECKED   | DFS | 3-28-11 | DATE |    |  |
| APPROVED  | CRS | 3-28-11 | DATE |    |  |

|  |                  |
|--|------------------|
| <b>KOHLER CO.</b><br>POWER ELECTRONICS DIVISION<br>1000 W. 10TH AVENUE<br>MILWAUKEE, WI 53217-1000 U.S.A.<br>TEL: 414.764.1000 FAX: 414.764.1001<br>WWW.KOHLER.COM |                  |
| <b>DIAGRAM WIRING</b><br>750-1000 KW MITSUBISHI<br>DECISION-MAKER 3000 CONTROLLER  |                  |
| SHEET NO. 1<br>TOTAL SHEETS 3  | PART NO. GM81316 |

| P1D CONNECTIONS |             |
|-----------------|-------------|
| PIN #1          | V7 (P2D-1)  |
| 2               | V8 (P2D-2)  |
| 3               | V9 (P2D-3)  |
| 4               | V0 (P2D-4)  |
| 5               | N/C         |
| 6               | N/C         |
| 7               | N/C         |
| 8               | N/C         |
| 9               | I1 (P26-1)  |
| 10              | I2 (P26-2)  |
| 11              | I2 (P26-3)  |
| 12              | I2R (P26-4) |
| 13              | I3 (P26-5)  |
| 14              | I3R (P26-6) |
| 15              | N/C         |
| 16              | N/C         |
| 17              | N/C         |
| 18              | N/C         |
| 19              | N/C         |
| 20              | E0V (P6-3)  |
| 21              | 3B (P6-4)   |
| 22              | 5B (P6-5)   |
| 23              | N20 (P6-2)  |
| 24              | E12 (P6-1)  |

| P6 CONNECTIONS |              |
|----------------|--------------|
| PIN #1         | E12 (P1D-24) |
| 2              | N20 (P1D-23) |
| 3              | E0V (P1D-20) |
| 4              | 3B (P1D-21)  |
| 5              | 5B (P1D-22)  |
| 6              | N/C          |

| P2D CONNECTIONS |            |
|-----------------|------------|
| PIN #1          | V7 (P1D-1) |
| 2               | V8 (P1D-2) |
| 3               | V8 (P1D-3) |
| 4               | V0 (P1D-4) |

| P2E CONNECTIONS |    |
|-----------------|----|
| 1               | V7 |
| 2               | V8 |
| 3               | V0 |
| 4               | V0 |

| P26 CONNECTIONS |              |
|-----------------|--------------|
| PIN #1          | I1 (P1D-9)   |
| 2               | I1R (P1D-10) |
| 3               | I2 (P1D-11)  |
| 4               | I2R (P1D-12) |
| 5               | I3 (P1D-13)  |
| 6               | I3R (P1D-14) |

| P6-3 (E0V) CONNECTIONS |    |
|------------------------|----|
| 1                      | V7 |
| 2                      | V8 |
| 3                      | V0 |
| 4                      | V0 |

| P6-4 (3B) CONNECTIONS |    |
|-----------------------|----|
| 1                     | V7 |
| 2                     | V8 |
| 3                     | V0 |
| 4                     | V0 |

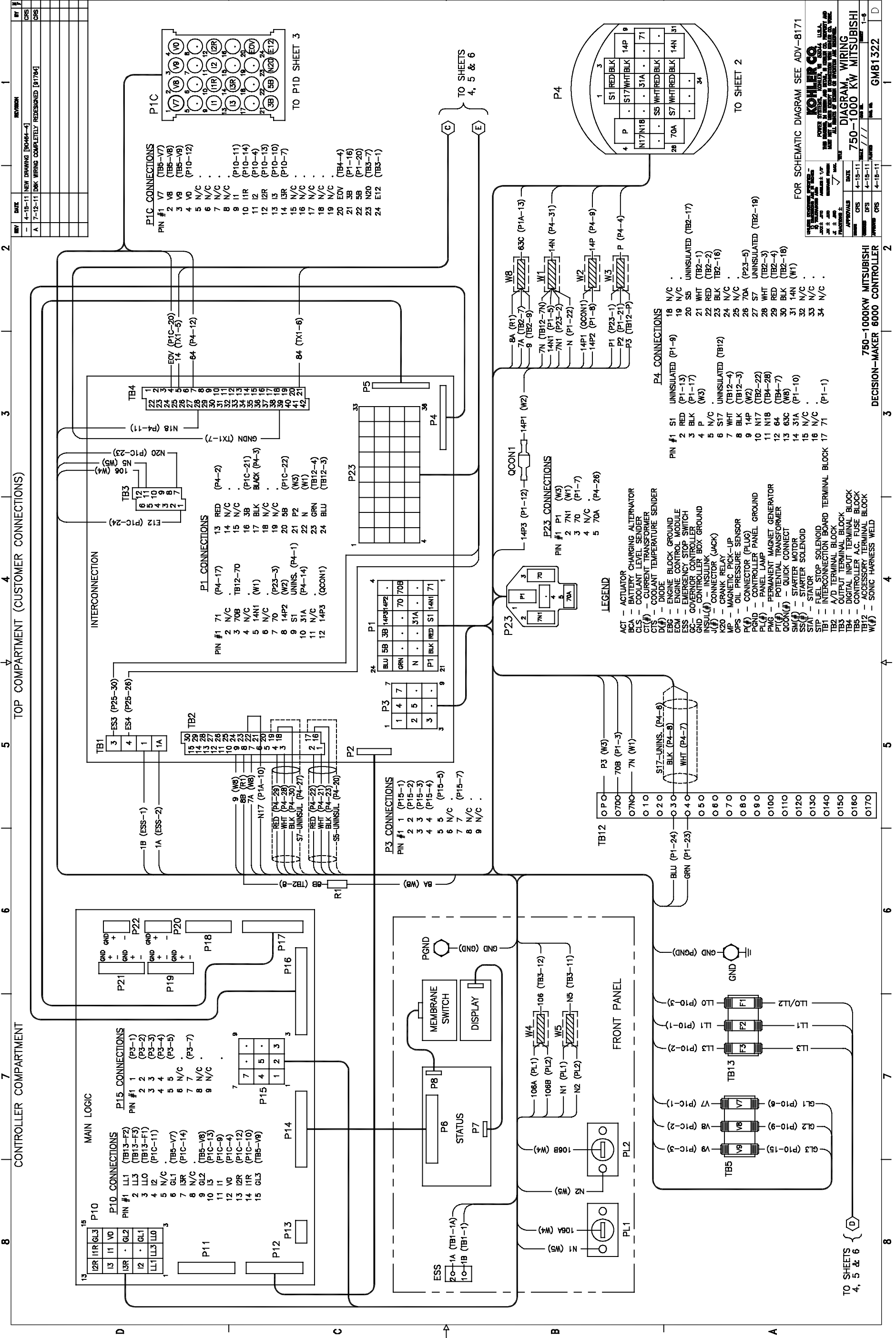
| P6-5 (5B) CONNECTIONS |    |
|-----------------------|----|
| 1                     | V7 |
| 2                     | V8 |
| 3                     | V0 |
| 4                     | V0 |

| P6-2 (N20) CONNECTIONS |    |
|------------------------|----|
| 1                      | V7 |
| 2                      | V8 |
| 3                      | V0 |
| 4                      | V0 |

| P6-1 (E12) CONNECTIONS |    |
|------------------------|----|
| 1                      | V7 |
| 2                      | V8 |
| 3                      | V0 |
| 4                      | V0 |



| REV | DATE    | REVISION                                 | BY  |
|-----|---------|--|-----|
| -   | 4-15-11 | NEW DRAWING [R0464-4]                    | CRS |
| A   | 7-12-11 | DRG WIRING COMPLETELY REDESIGNED [R1746] | CRS |

| APPROVALS | DATE    |
|-----------|---------|
| DESIGNER  | 4-15-11 |
| CHECKER   | 4-15-11 |
| APPROVER  | 4-15-11 |

| 750-1000KW MITSUBISHI DECISION-MAKER 6000 CONTROLLER |         |
|--|---------|
| WIRING DIAGRAM                                       | 1-8     |
| DATE   | 4-15-11 |
| BY   | CRS     |
| CHECKED BY   | CRS     |
| APPROVED BY  | CRS     |

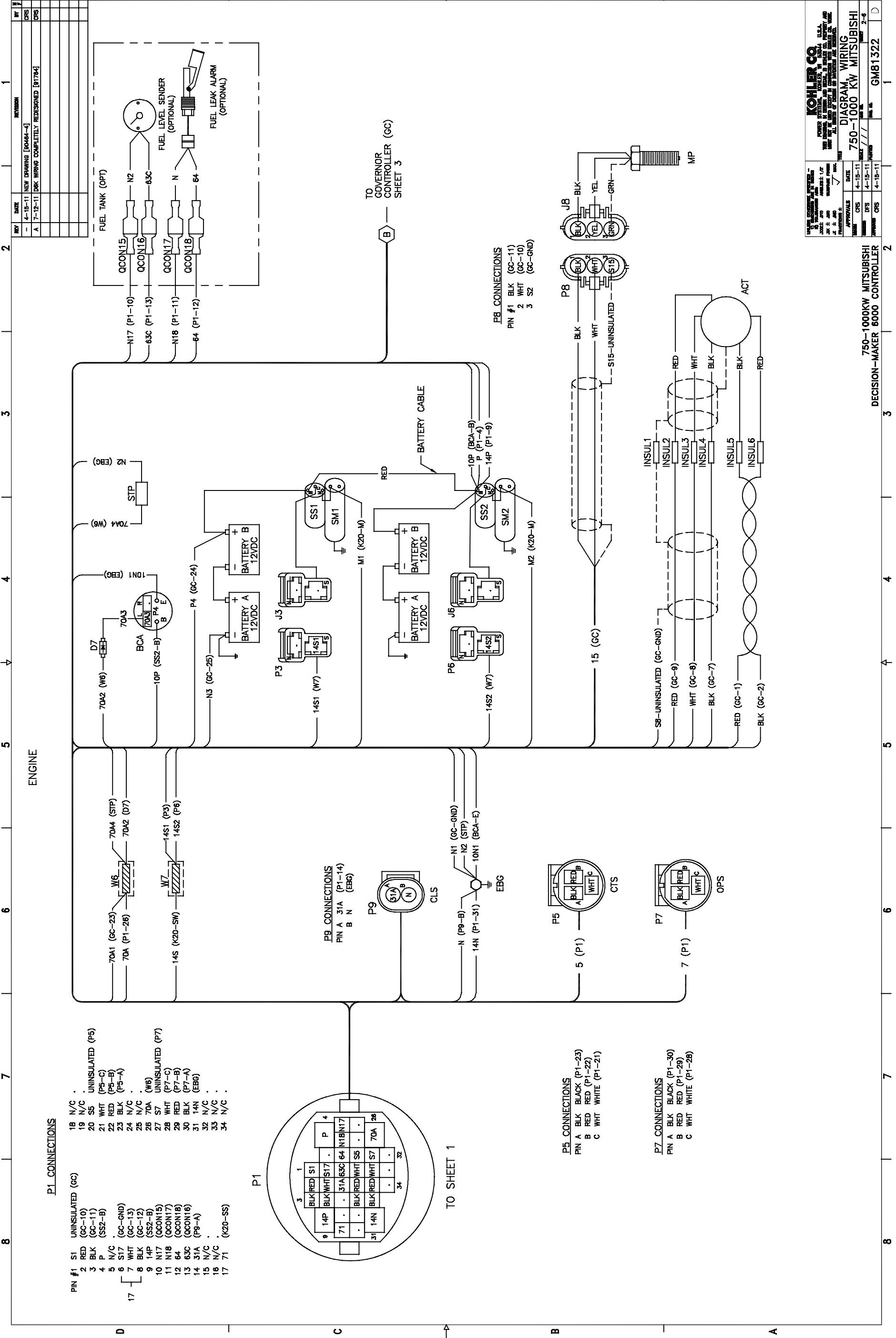
| 750-1000KW MITSUBISHI DECISION-MAKER 6000 CONTROLLER |         |
|--|---------|
| WIRING DIAGRAM                                       | 1-8     |
| DATE   | 4-15-11 |
| BY   | CRS     |
| CHECKED BY   | CRS     |
| APPROVED BY  | CRS     |

| 750-1000KW MITSUBISHI DECISION-MAKER 6000 CONTROLLER |         |
|--|---------|
| WIRING DIAGRAM                                       | 1-8     |
| DATE   | 4-15-11 |
| BY   | CRS     |
| CHECKED BY   | CRS     |
| APPROVED BY  | CRS     |

| 750-1000KW MITSUBISHI DECISION-MAKER 6000 CONTROLLER |         |
|--|---------|
| WIRING DIAGRAM                                       | 1-8     |
| DATE   | 4-15-11 |
| BY   | CRS     |
| CHECKED BY   | CRS     |
| APPROVED BY  | CRS     |

| 750-1000KW MITSUBISHI DECISION-MAKER 6000 CONTROLLER |         |
|--|---------|
| WIRING DIAGRAM                                       | 1-8     |
| DATE   | 4-15-11 |
| BY   | CRS     |
| CHECKED BY   | CRS     |
| APPROVED BY  | CRS     |

| 750-1000KW MITSUBISHI DECISION-MAKER 6000 CONTROLLER |         |
|--|---------|
| WIRING DIAGRAM                                       | 1-8     |
| DATE   | 4-15-11 |
| BY   | CRS     |
| CHECKED BY   | CRS     |
| APPROVED BY  | CRS     |

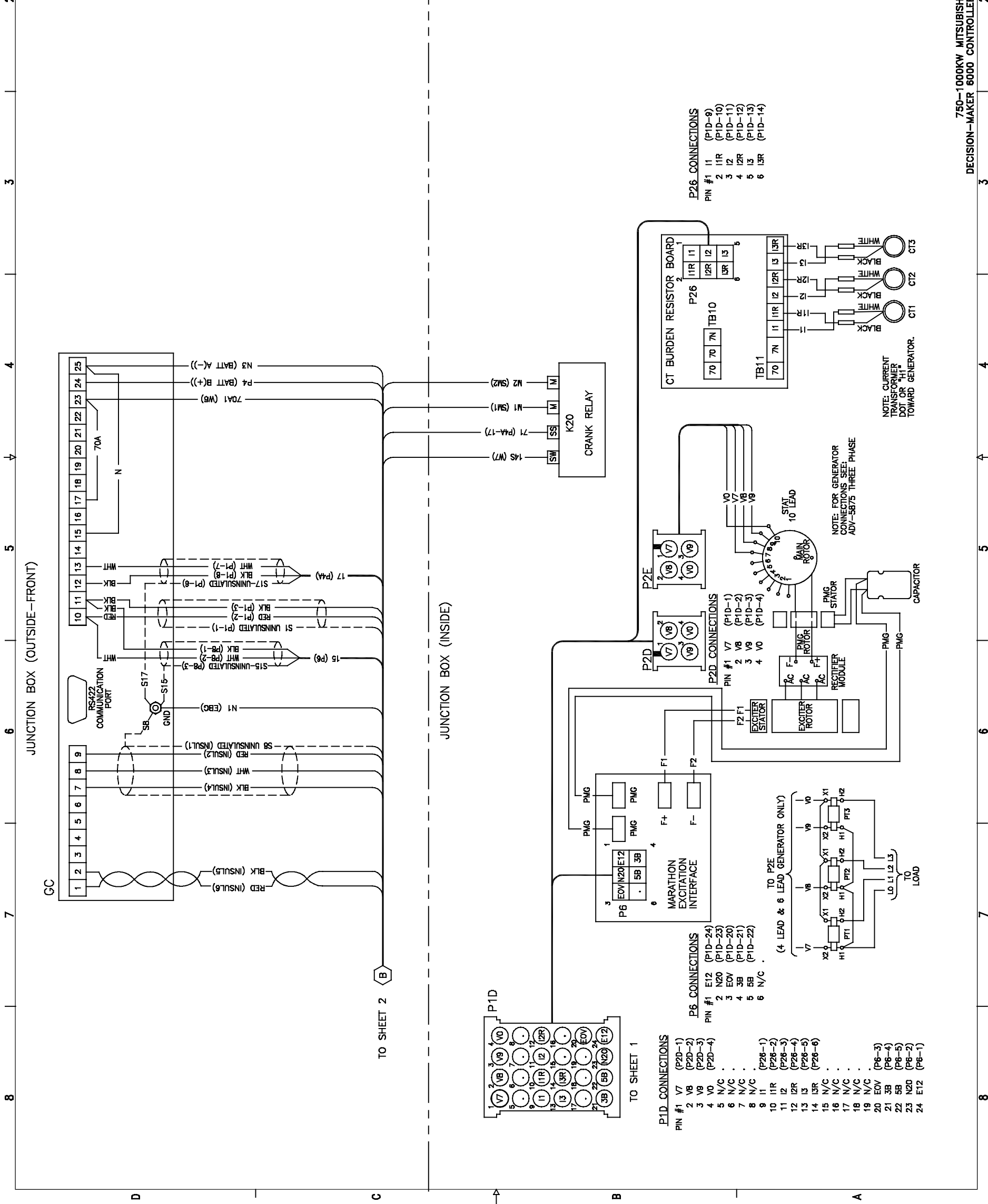


| REV | DATE    | DESCRIPTION                              | BY  |
|-----|---------|--|-----|
| -   | 4-15-11 | NEW DRAWING [80464-3]                    | CRS |
| A   | 7-12-11 | DRK WIRING COMPLETELY REDESIGNED [81764] | CRS |

| APPROVALS     |     | DATE    |
|---------------|-----|---------|
| DESIGN        | CRS | 4-15-11 |
| DRAWING       | CRS | 4-15-11 |
| MANUFACTURING | CRS | 4-15-11 |

|  |         |
|--|---------|
| <b>KOHLER CO. U.S.A.</b><br>10000 W. 10TH AVENUE, SUITE 100, DENVER, CO 80231<br>TEL: 303.440.1000 FAX: 303.440.1001<br>WWW.KOHLER.COM |         |
| <b>750-1000 KW MITSUBISHI</b><br>DIAGRAM, WIRING   |         |
| PART NO. 80464-3<br>REV. A   | GMB1322 |

| REV | DATE    | DESCRIPTION                              | BY  | CHK |
|-----|---------|--|-----|-----|
| -   | 4-15-11 | NEW DRAWING [B0464-4]                    | CRS | CRS |
| A   | 7-12-11 | DRG WIRING COMPLETELY REDESIGNED [91744] | CRS | CRS |
|     |         |  |     |     |
|     |         |  |     |     |
|     |         |  |     |     |



| APPROVALS        | DATE                       | REVISION                                 |
|------------------|----------------------------|--|
| DESIGNED BY: JRS | 4-15-11                    | 1  |
| CHECKED BY: JRS  | 4-15-11                    | 2  |
| APPROVED BY: JRS | 4-15-11                    | 3  |
| REVISIONS        | DATE <td>DESCRIPTION </td> | DESCRIPTION                              |
| 1                | 4-15-11                    | NEW DRAWING [B0464-4]                    |
| 2                | 7-12-11                    | DRG WIRING COMPLETELY REDESIGNED [91744] |

**KOHLER CO. U.S.A.**  
 POWER GENERATION DIVISION  
 2500 N. CENTRAL EXPRESSWAY, SUITE 100  
 MESA, AZ 85205-1000  
 TEL: 480-948-2000 FAX: 480-948-2001  
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**DIAGRAM, WIRING**  
**750-1000 KW MITSUBISHI**  
 DECISION-MAKER 6000 CONTROLLER

| NO. | DATE    | REVISION                                 |
|-----|---------|--|
| 1   | 4-15-11 | NEW DRAWING [B0464-4]                    |
| 2   | 7-12-11 | DRG WIRING COMPLETELY REDESIGNED [91744] |

**750-1000KW MITSUBISHI**  
**DECISION-MAKER 6000 CONTROLLER**  
 GMB1322

**P26 CONNECTIONS**  
 PIN #1 I1 (PID-9)  
 2 I1R (PID-10)  
 3 I2 (PID-11)  
 4 I2R (PID-12)  
 5 I3 (PID-13)  
 6 I3R (PID-14)

**P1D CONNECTIONS**  
 PIN #1 V7 (P2D-1)  
 2 V8 (P2D-2)  
 3 V8 (P2D-3)  
 4 V0 (P2D-4)  
 5 N/C  
 6 N/C  
 7 N/C  
 8 N/C  
 9 I1 (P26-1)  
 10 I1R (P26-2)  
 11 I2 (P26-3)  
 12 I2R (P26-4)  
 13 I3 (P26-5)  
 14 I3R (P26-6)  
 15 N/C  
 16 N/C  
 17 N/C  
 18 N/C  
 19 N/C  
 20 EOV (P6-3)  
 21 3B (P6-4)  
 22 5B (P6-5)  
 23 N20 (P6-2)  
 24 E12 (P6-1)

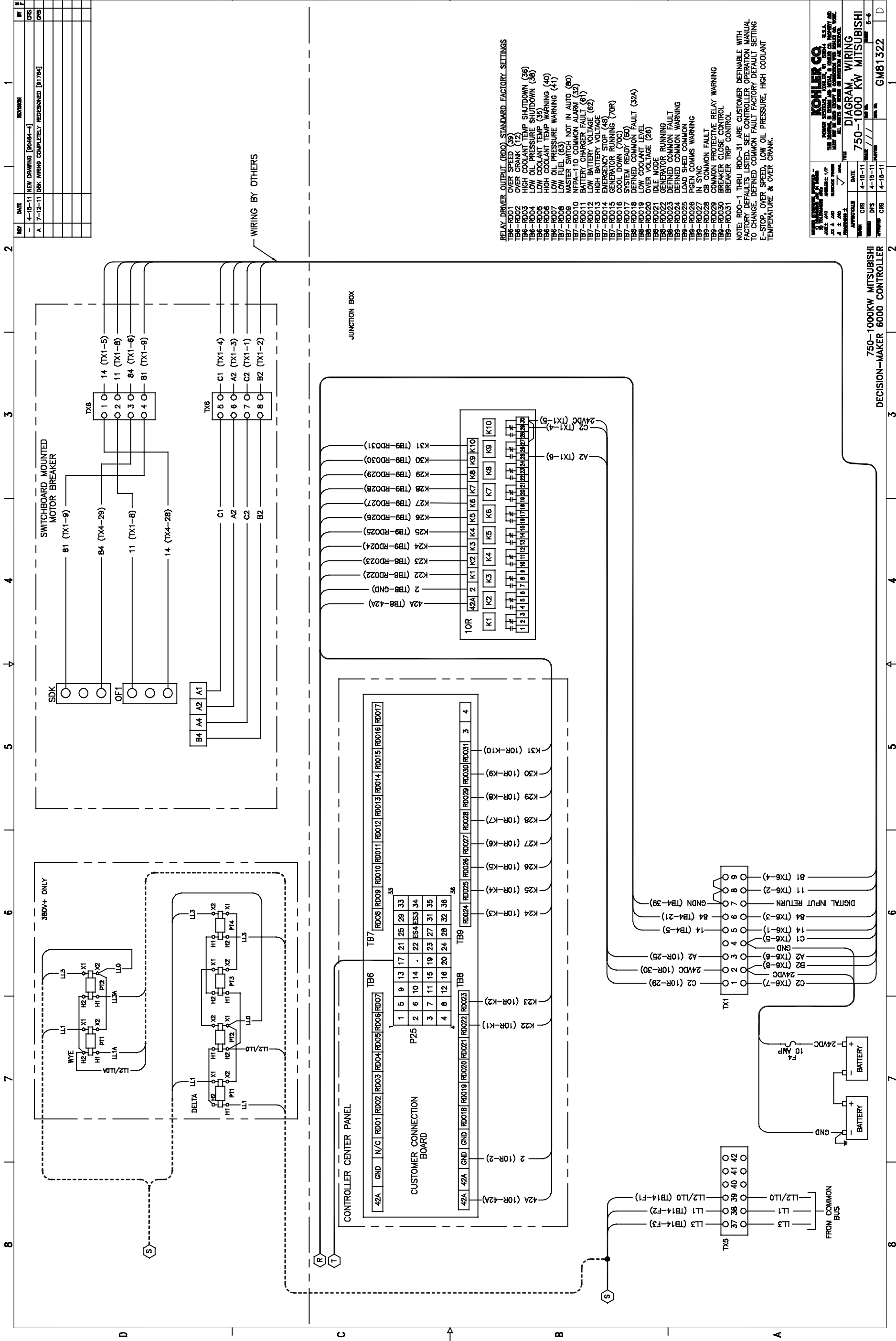
**P2D CONNECTIONS**  
 PIN #1 V7 (PID-1)  
 2 V8 (PID-2)  
 3 V8 (PID-3)  
 4 V0 (PID-4)

**P6 CONNECTIONS**  
 PIN #1 E12 (PID-24)  
 2 N20 (PID-23)  
 3 EOV (PID-20)  
 4 3B (PID-21)  
 5 5B (PID-22)  
 6 N/C

**TO SHEET 1**

**TO SHEET 2**





- RELAY DRIVER OUTPUT (RDO) STANDARD FACTORY SETTINGS
- TB8-RD01 OVER SPEED (32)
  - TB8-RD02 OVER CRANK (32)
  - TB8-RD03 HIGH COOLANT TEMP SHUTDOWN (36)
  - TB8-RD04 LOW OIL PRESSURE SHUTDOWN (36)
  - TB8-RD05 LOW COOLANT TEMP WARNING (40)
  - TB8-RD06 HIGH COOLANT TEMP WARNING (40)
  - TB8-RD07 LOW OIL PRESSURE WARNING (41)
  - TB7-RD08 LOW FUEL (63)
  - TB7-RD09 MASTER SWITCH NOT IN AUTO (80)
  - TB7-RD10 NPPA-1 TO COMMON ALARM (32)
  - TB7-RD11 LOW BATTERY VOLTAGE (61)
  - TB7-RD12 HIGH BATTERY VOLTAGE (62)
  - TB7-RD13 EMERGENCY STOP (48)
  - TB7-RD14 GENERATOR RUNNING (70R)
  - TB7-RD15 COOL DOWN (70C)
  - TB7-RD16 SYSTEM READY (60)
  - TB7-RD17 DEFINED COMMON FAULT (32A)
  - TB8-RD018 LOW COOLANT LEVEL
  - TB8-RD019 OVER VOLTAGE (26)
  - TB8-RD020 IDLE MODE RUNNING
  - TB8-RD021 DEFINED COMMON FAULT
  - TB8-RD022 DEFINED COMMON WARNING
  - TB8-RD023 LOAD SHED COMMON
  - TB8-RD025 PGEN COMMON WARNING
  - TB8-RD027 IN SYNC
  - TB8-RD028 CB COMMON FAULT
  - TB9-RD029 COMMON PROTECTIVE RELAY WARNING
  - TB9-RD030 BREAKER CLOSE CONTROL
  - TB9-RD031 BREAKER TRIP CONTROL
- NOTE: RDO-1 THRU RDO-31 ARE CUSTOMER DEFINABLE WITH FACTORY DEFAULTS LISTED. SEE CONTROLLER OPERATION MANUAL TO CHANGE. DEFINED COMMON FAULT FACTORY DEFAULT SETTING E-STOP, OVER SPEED, LOW OIL PRESSURE, HIGH COOLANT TEMPERATURE, & OVER CRANK.

|           |     |         |     |
|-----------|-----|---------|-----|
| APPROVALS |     | DATE    | BY  |
| DESIGNED  | CRS | 4-15-11 | CRS |
| CHECKED   | DPS | 4-15-11 | DPS |
| APPROVED  | CRS | 4-15-11 | CRS |

750-1000 KW MITSUBISHI  
DIAGRAM, WIRING

DATE: 4-15-11  
BY: GMB1322

WIRING BY OTHERS

380V+ ONLY

DELTA

FROM COMMON BUS

DECISION-MAKER 6000 CONTROLLER

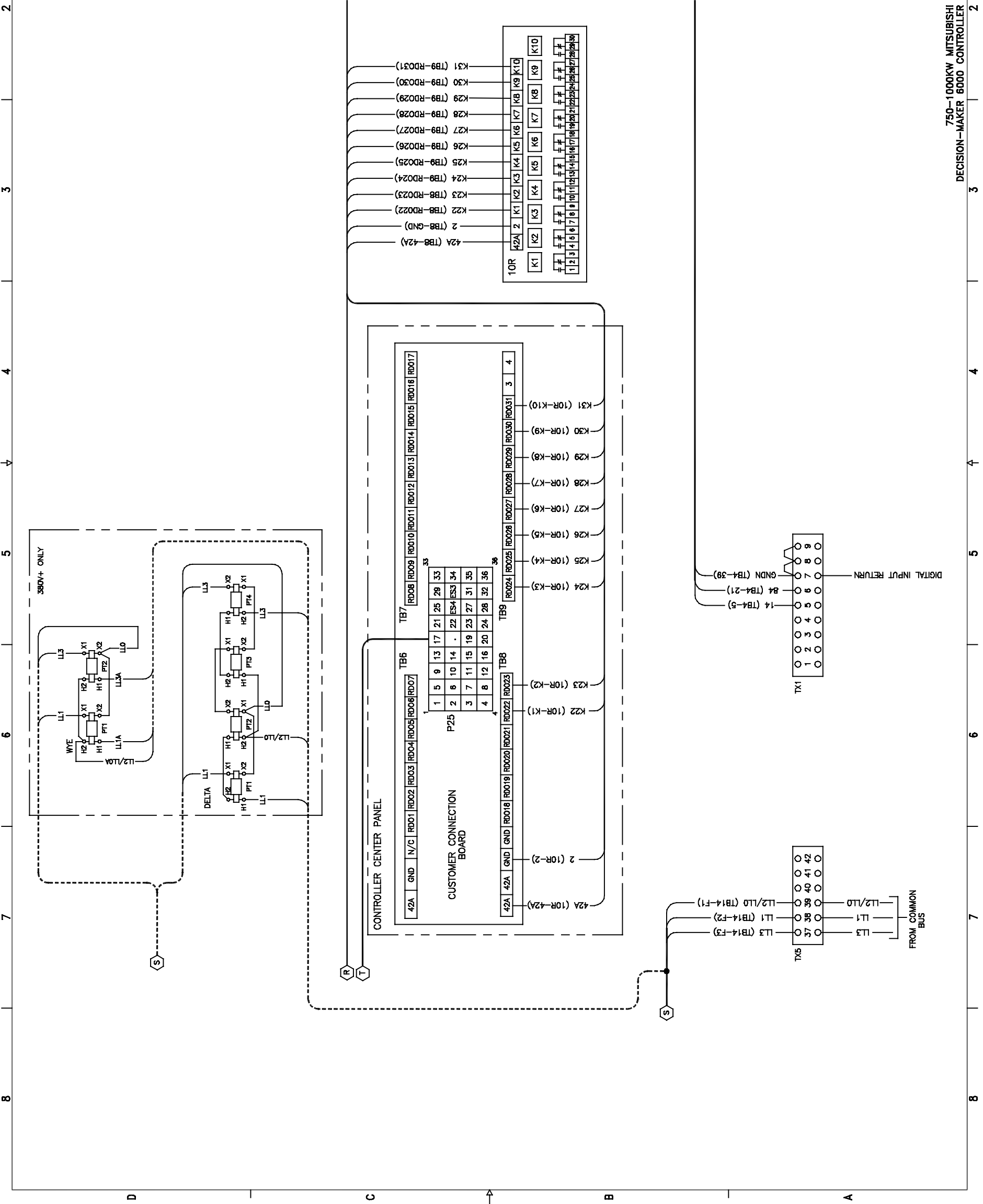
750-1000KW MITSUBISHI

TP-6813 3/12

Wiring Diagrams 55



| REV | DATE    | REVISION                                 | BY  |
|-----|---------|--|-----|
| -   | 4-15-11 | NEW DRAWING [D0464-4]                    | CRS |
| A   | 7-12-11 | DRK WIRING COMPLETELY REDESIGNED [D1764] | CRS |
|     |         |  |     |
|     |         |  |     |
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| REV | DATE    | REVISION                                 | BY  |
|-----|---------|--|-----|
| -   | 4-15-11 | NEW DRAWING [D0464-4]                    | CRS |
| A   | 7-12-11 | DRK WIRING COMPLETELY REDESIGNED [D1764] | CRS |
|     |         |  |     |
|     |         |  |     |
|     |         |  |     |

| APPROVALS   |     | DATE    |
|-------------|-----|---------|
| DESIGNED BY | CRS | 4-15-11 |
| CHECKED BY  | CRS | 4-15-11 |
| APPROVED BY | CRS | 4-15-11 |

**750-1000KW MITSUBISHI DECISION-MAKER 6000 CONTROLLER**

**DIAGRAM, WIRING**

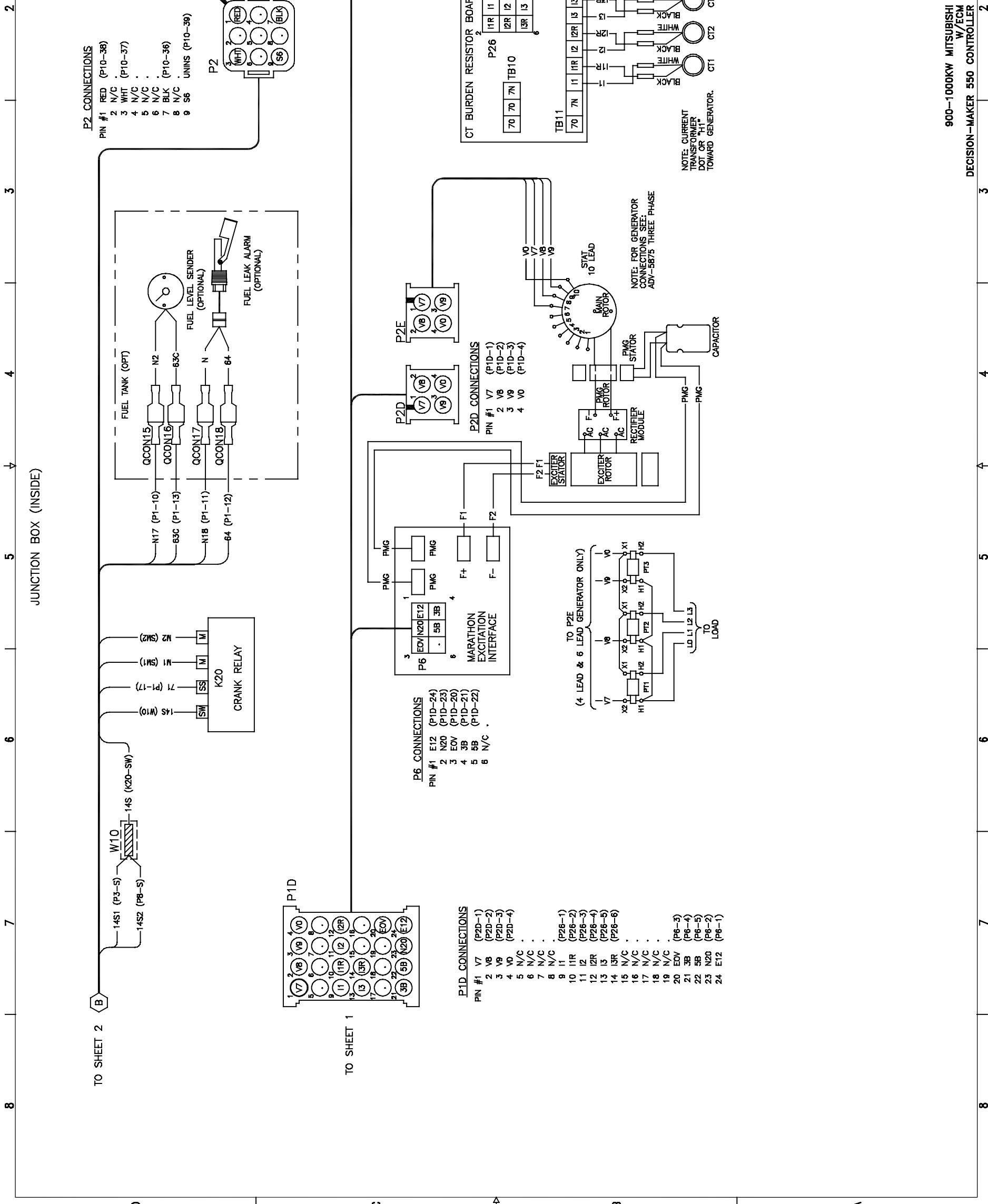
**750-1000 KW MITSUBISHI**

**GMB1322**





| REV | DATE   | DESCRIPTION           | BY  | CHK |
|-----|--------|-----------------------|-----|-----|
| -   | 8-3-11 | NEW DRAWING [80464-4] | CRS |     |
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**P2 CONNECTIONS**

- PIN #1 RED (P10-38)
- 2 N/C (P10-37)
- 3 WHT (P10-37)
- 4 N/C
- 5 N/C
- 6 N/C (P10-36)
- 7 BLK (P10-36)
- 8 N/C
- 9 56 UNINS (P10-39)

**P2B CONNECTIONS**

- PIN #1 11 (F1D-9)
- 2 11R (F1D-10)
- 3 12 (F1D-11)
- 4 12R (F1D-12)
- 5 13 (F1D-13)
- 6 13R (F1D-14)

**P2D CONNECTIONS**

- PIN #1 V7 (F1D-1)
- 2 V8 (F1D-2)
- 3 V9 (F1D-3)
- 4 V0 (F1D-4)

**P6 CONNECTIONS**

- PIN #1 E12 (P1D-24)
- 2 N20 (P1D-23)
- 3 EOV (P1D-20)
- 4 3B (P1D-21)
- 5 5B (P1D-22)
- 6 N/C

**P1D CONNECTIONS**

- PIN #1 V7 (P2D-1)
- 2 V8 (P2D-2)
- 3 V9 (P2D-3)
- 4 V0 (P2D-4)
- 5 N/C
- 6 N/C
- 7 N/C
- 8 N/C
- 9 11 (P2B-1)
- 10 11R (P2B-2)
- 11 12 (P2B-3)
- 12 12R (P2B-4)
- 13 13 (P2B-5)
- 14 13R (P2B-6)
- 15 N/C
- 16 N/C
- 17 N/C
- 18 N/C
- 19 N/C
- 20 EOV (P6-3)
- 21 3B (P6-4)
- 22 5B (P6-5)
- 23 N20 (P6-2)
- 24 E12 (P6-1)

| APPROVALS |     | DATE   | BY | CHK |
|-----------|-----|--------|----|-----|
| DESIGNED  | CRS | 8-3-11 |    |     |
| CHECKED   | DPS | 8-3-11 |    |     |
| APPROVED  | CRS | 8-3-11 |    |     |

**900-1000KW MITSUBISHI W/ECM W/550 CONTROLLER**

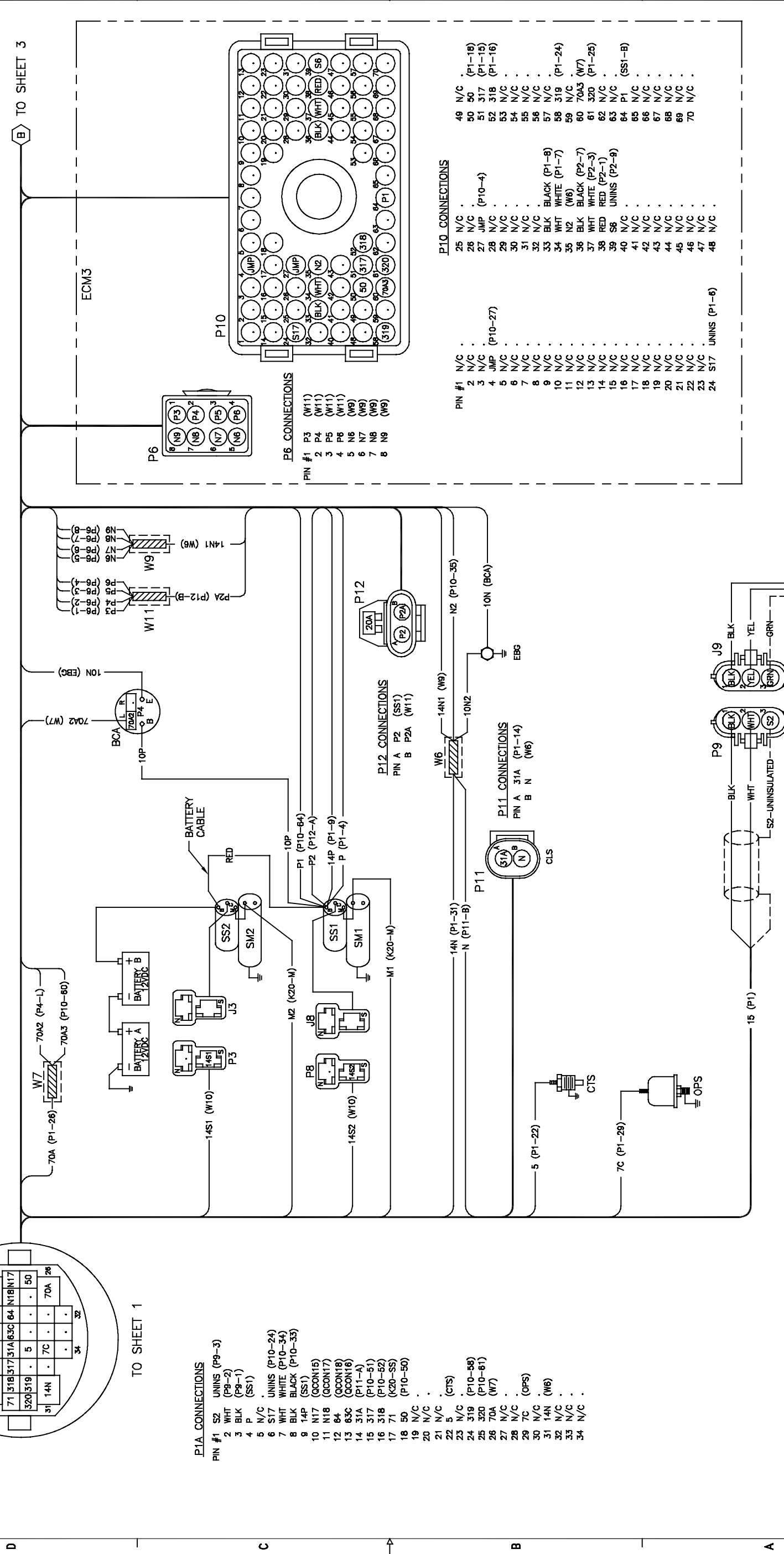
**DIAGRAM, WIRING**

**900-1000 KW MITSUBISHI**

**GM81329**



| REV | DATE   | REVISION              |
|-----|--------|-----------------------|
| 1   | 5-3-11 | NEW DRAWING [80464-4] |
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TO SHEET 1

TO SHEET 3

**P1A CONNECTIONS**

- PIN #1 S2 UNINS (P8-3)
- 2 WHT (P8-2)
- 3 BLK (P8-1)
- 4 P (SS1)
- 5 N/C
- 6 S17 UNINS (P10-24)
- 7 WHT WHITE (P10-34)
- 8 BLK BLACK (P10-33)
- 9 14P (SS1)
- 10 N17 (GCON15)
- 11 N18 (GCON17)
- 12 64 (GCON18)
- 13 63C (GCON16)
- 14 31A (P11-A)
- 15 317 (P10-51)
- 16 318 (P10-52)
- 17 71 (K20-SS)
- 18 50 (P10-50)
- 19 N/C
- 20 N/C
- 21 N/C
- 22 5 (CTS)
- 23 N/C
- 24 319 (P10-58)
- 25 320 (P10-61)
- 26 70A (W7)
- 27 N/C
- 28 N/C
- 29 7C (OPS)
- 30 N/C
- 31 14N (W6)
- 32 N/C
- 33 N/C
- 34 N/C

**P6 CONNECTIONS**

- PIN #1 P3 (W11)
- 2 P4 (W11)
- 3 P5 (W11)
- 4 P6 (W11)
- 5 N6 (W9)
- 6 N7 (W9)
- 7 N8 (W9)
- 8 N9 (W9)

**P10 CONNECTIONS**

- 25 N/C
- 26 N/C
- 27 JMP (P10-4)
- 28 N/C
- 29 N/C
- 30 N/C
- 31 N/C
- 32 N/C
- 33 BLK BLACK (P1-8)
- 34 WHT WHITE (P1-7)
- 35 N2 (W6)
- 36 BLK BLACK (P2-7)
- 37 WHT WHITE (P2-3)
- 38 RED RED (P2-1)
- 39 S6 UNINS (P2-8)
- 40 N/C
- 41 N/C
- 42 N/C
- 43 N/C
- 44 N/C
- 45 N/C
- 46 N/C
- 47 N/C
- 48 N/C
- 49 N/C
- 50 50 (P1-18)
- 51 317 (P1-15)
- 52 318 (P1-16)
- 53 N/C
- 54 N/C
- 55 N/C
- 56 N/C
- 57 N/C
- 58 319 (P1-24)
- 59 N/C
- 60 70A3 (W7)
- 61 320 (P1-25)
- 62 N/C
- 63 N/C
- 64 P1 (SS1-B)
- 65 N/C
- 66 N/C
- 67 N/C
- 68 N/C
- 69 N/C
- 70 N/C

**P11 CONNECTIONS**

- PIN A 31A (P1-14)
- B N (W6)

**P12 CONNECTIONS**

- PIN A P2 (SS1)
- B P2A (W11)

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 11111 W. WASHINGTON AVE., SUITE 100  
 DENVER, CO 80231  
 TEL: 303.733.1111 FAX: 303.733.1112  
 WWW.KOHLER.COM

DATE: 5-3-11  
 DRAWN BY: DRS  
 CHECKED BY: DRS  
 APPROVALS: [Signature] DATE: 5-3-11

**900-1000KW MITSUBISHI W/ECM W/ECM**  
**DIAGRAM, WIRING**  
**900-1000 KW MITSUBISHI**  
 PART NO. GMB1330

**900-1000KW MITSUBISHI W/ECM W/ECM**  
**DECISION-MAKER 3000 CONTROLLER**

PIN #1 BLK (P1-3)  
 2 WHT (P1-2)  
 3 S2 (P1-1)

**P9 CONNECTIONS**

PIN #1 BLK (P1-3)  
 2 WHT (P1-2)  
 3 S2 (P1-1)

**P11 CONNECTIONS**

PIN A 31A (P1-14)  
 B N (W6)

**P12 CONNECTIONS**

PIN A P2 (SS1)  
 B P2A (W11)

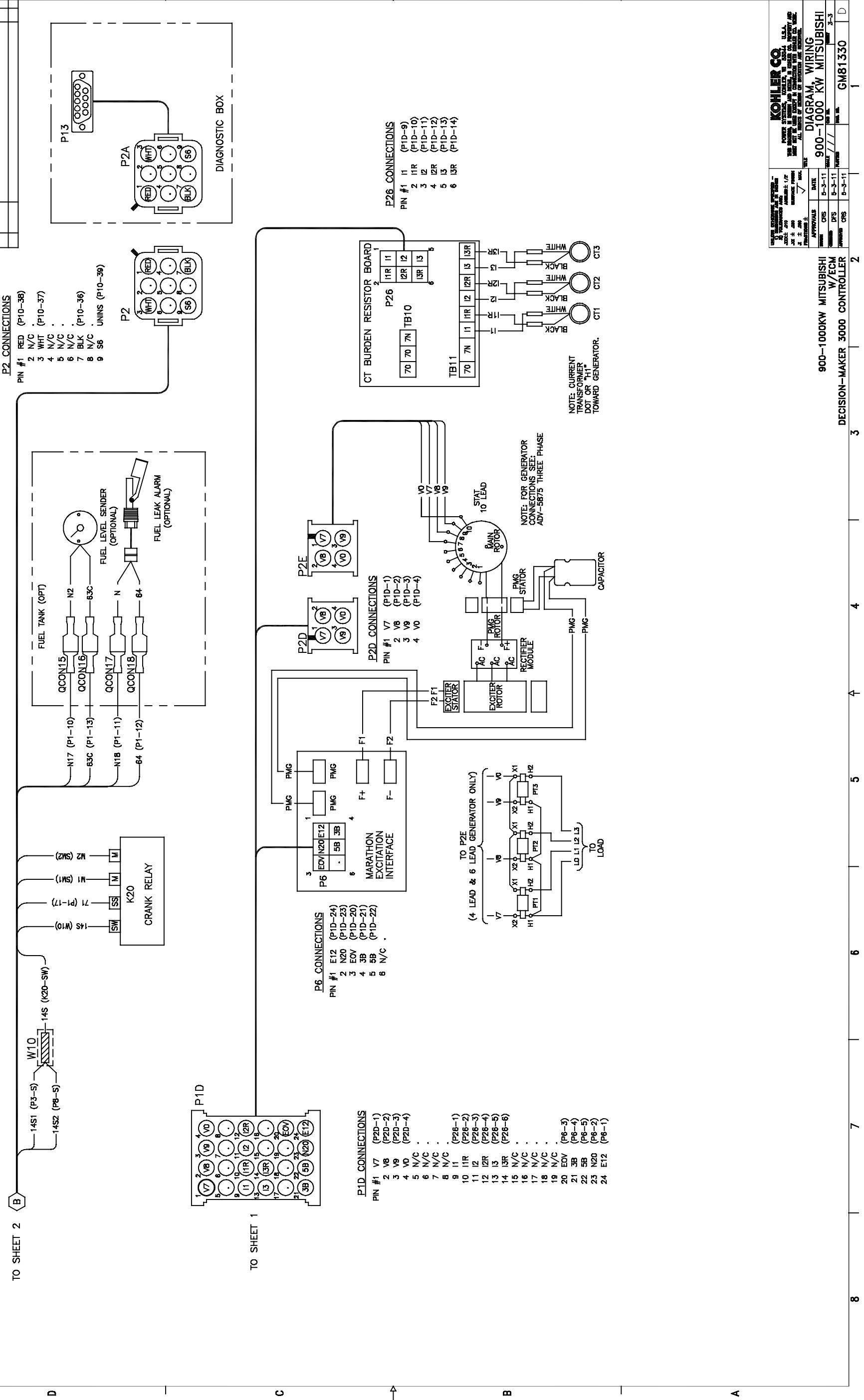
**P10 CONNECTIONS**

25 N/C  
 26 N/C  
 27 JMP (P10-4)  
 28 N/C  
 29 N/C  
 30 N/C  
 31 N/C  
 32 N/C  
 33 BLK BLACK (P1-8)  
 34 WHT WHITE (P1-7)  
 35 N2 (W6)  
 36 BLK BLACK (P2-7)  
 37 WHT WHITE (P2-3)  
 38 RED RED (P2-1)  
 39 S6 UNINS (P2-8)  
 40 N/C  
 41 N/C  
 42 N/C  
 43 N/C  
 44 N/C  
 45 N/C  
 46 N/C  
 47 N/C  
 48 N/C

**P1A CONNECTIONS**

PIN #1 S2 UNINS (P8-3)  
 2 WHT (P8-2)  
 3 BLK (P8-1)  
 4 P (SS1)  
 5 N/C  
 6 S17 UNINS (P10-24)  
 7 WHT WHITE (P10-34)  
 8 BLK BLACK (P10-33)  
 9 14P (SS1)  
 10 N17 (GCON15)  
 11 N18 (GCON17)  
 12 64 (GCON18)  
 13 63C (GCON16)  
 14 31A (P11-A)  
 15 317 (P10-51)  
 16 318 (P10-52)  
 17 71 (K20-SS)  
 18 50 (P10-50)  
 19 N/C  
 20 N/C  
 21 N/C  
 22 5 (CTS)  
 23 N/C  
 24 319 (P10-58)  
 25 320 (P10-61)  
 26 70A (W7)  
 27 N/C  
 28 N/C  
 29 7C (OPS)  
 30 N/C  
 31 14N (W6)  
 32 N/C  
 33 N/C  
 34 N/C

| REV | DATE   | REVISION              | BY | CHK |
|-----|--------|-----------------------|----|-----|
| -   | 5-3-11 | NEW DRAWING [80464-4] |    | CRS |
|     |        |                       |    |     |
|     |        |                       |    |     |
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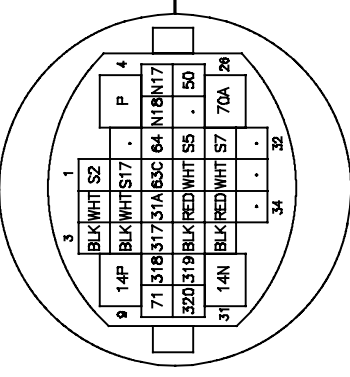


|   |   |
|---|---|
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| <b>900-1000KW MITSUBISHI W/ECM</b><br><b>DECISION-MAKER 3000 CONTROLLER</b>   | <b>DIAGRAM, WIRING</b><br><b>900-1000 KW MITSUBISHI</b> |
| APPROVALS: _____ DATE: 5-3-11<br>DESIGNED BY: _____ CHECKED BY: _____<br>DRAWN BY: _____  | SHEET: 1 OF 3<br>DATE: 5-3-11<br>PART NO.: GMB1330      |





| REV | DATE    | DESCRIPTION                              | BY  |
|-----|---------|--|-----|
| -   | 5-3-11  | NEW DRAWING [80464-3]                    | CRS |
| A   | 7-12-11 | DRG WIRING COMPLETELY REDESIGNED [81764] | CRS |
|     |         |  |     |
|     |         |  |     |
|     |         |  |     |



TO SHEET 1

**P1A CONNECTIONS**

- PIN #1 S2 UNINS (P9-3)
- 2 WHT (P9-2)
- 3 BLK (P9-1)
- 4 P (SS1)
- 5 N/C
- 6 S17 UNINS (P10-24)
- 7 WHT WHITE (P10-34)
- 8 BLK BLACK (P10-33)
- 9 14P (SS1)
- 10 N17 (QCON15)
- 11 N18 (QCON17)
- 12 64 (QCON18)
- 13 63C (QCON16)
- 14 31A (P11-A)
- 15 317 (P10-51)
- 16 318 (P10-52)
- 17 71 (K20-SS)
- 18 50 (P10-50)
- 19 N/C
- 20 S5 UNINS (P5)
- 21 WHT WHITE (P5-C)
- 22 RED (P5-B)
- 23 BLK BLACK (P5-A)
- 24 319 (P10-58)
- 25 320 (P10-61)
- 26 70A (W7)
- 27 S7 UNINS (P7)
- 28 WHT WHITE (P7-C)
- 29 RED (P7-B)
- 30 BLK BLACK (P7-A)
- 31 14N (W6)
- 32 N/C
- 33 N/C
- 34 N/C

**P6 CONNECTIONS**

- PIN #1 P3 (W11)
- 2 P4 (W11)
- 3 P5 (W11)
- 4 P6 (W11)
- 5 N6 (W9)
- 6 N7 (W9)
- 7 N8 (W9)
- 8 N9 (W9)

**P10 CONNECTIONS**

- 25 N/C
- 26 N/C
- 27 JMP (P10-4)
- 28 N/C
- 29 N/C
- 30 N/C
- 31 N/C
- 32 N/C
- 33 BLK BLACK (P1-8)
- 34 WHT WHITE (P1-7)
- 35 N2 (W6)
- 36 BLK BLACK (P2-7)
- 37 WHT WHITE (P2-3)
- 38 RED (P2-1)
- 39 S6 UNINS (P2-9)
- 40 N/C
- 41 N/C
- 42 N/C
- 43 N/C
- 44 N/C
- 45 N/C
- 46 N/C
- 47 N/C
- 48 N/C
- 49 N/C
- 50 50 (P1-18)
- 51 317 (P1-15)
- 52 318 (P1-16)
- 53 N/C
- 54 N/C
- 55 N/C
- 56 N/C
- 57 N/C
- 58 319 (P1-24)
- 59 N/C
- 60 70A3 (W7)
- 61 320 (P1-25)
- 62 N/C
- 63 N/C
- 64 P1 (SS1-B)
- 65 N/C
- 66 N/C
- 67 N/C
- 68 N/C
- 69 N/C
- 70 N/C

**P12 CONNECTIONS**

- PIN A P2 (SS1)
- B P2A (W11)

**P11 CONNECTIONS**

- PIN A 31A (P1-14)
- B N (W6)

**P7 CONNECTIONS**

- PIN A BLK (P1-30)
- B RED (P1-29)
- C WHT (P1-28)

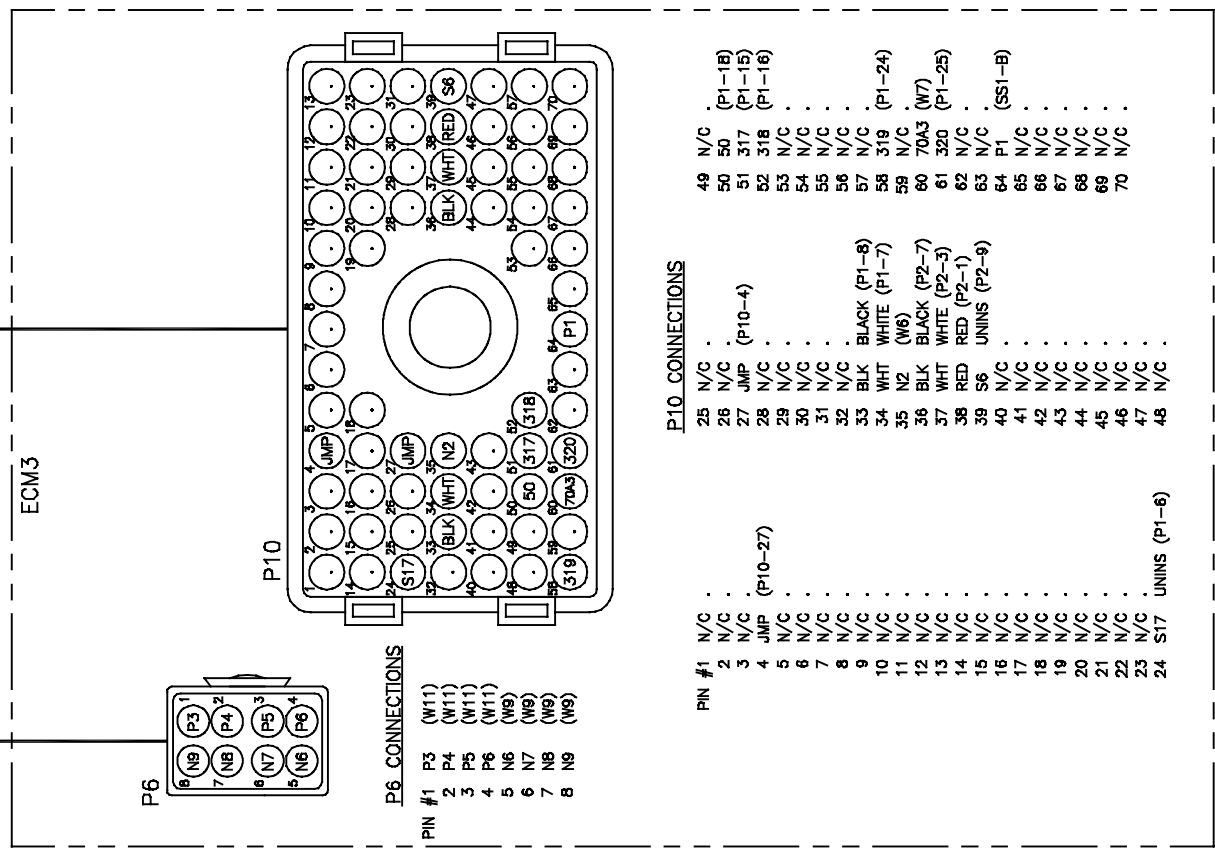
**P9 CONNECTIONS**

- PIN #1 BLK (P1-3)
- 2 WHT (P1-2)
- 3 S2 (P1-1)

**P5 CONNECTIONS**

- PIN A BLK (P1-23)
- B RED (P1-22)
- C WHT (P1-21)

B TO SHEET 3



| APPROVALS |     | DATE   | BY |
|-----------|-----|--------|----|
| DESIGN    | CRS | 5-3-11 |    |
| CHECKED   | CRS | 5-3-11 |    |
| APPROVED  | CRS | 5-3-11 |    |

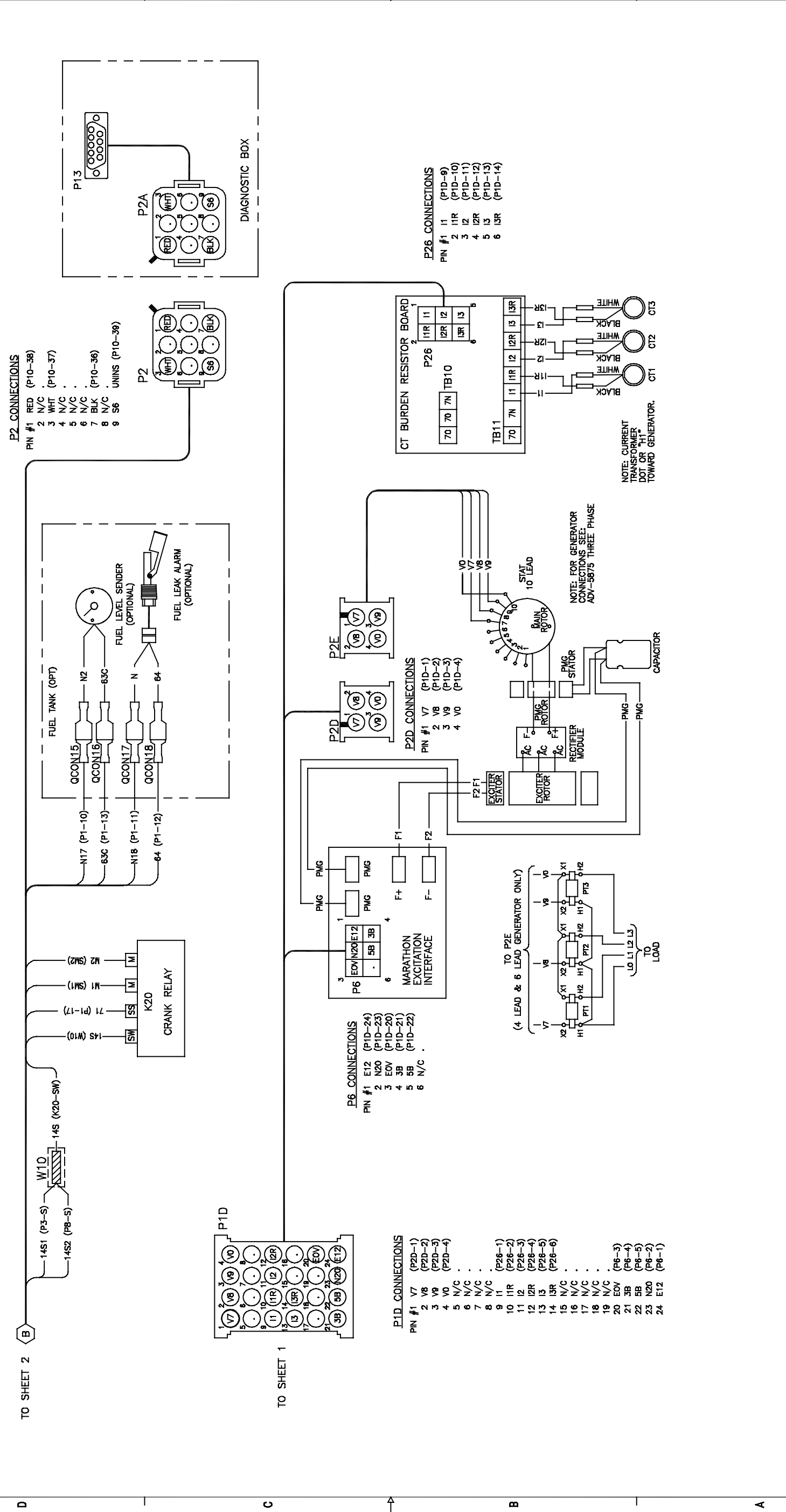
**900-1000KW MITSUBISHI W/ECM W/ECM**  
**DECISION-MAKER 8000 CONTROLLER**

**900-1000KW MITSUBISHI W/ECM**  
**DIAGRAM, WIRING**  
**900-1000 KW MITSUBISHI**

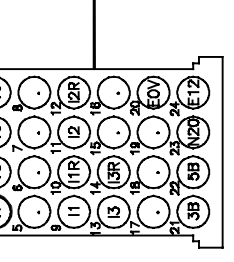
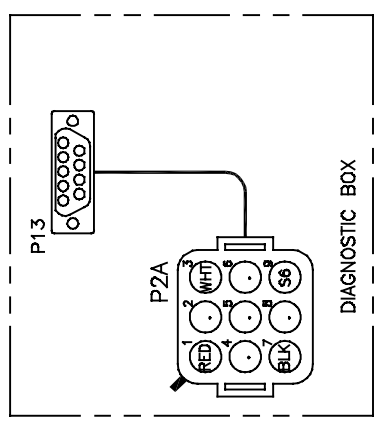
TP-6813 3/12

| REV | DATE    | DESCRIPTION                              | BY | CHK |
|-----|---------|--|----|-----|
| -   | 5-3-11  | NEW DRAWING [80464-4]                    |    | CRS |
| A   | 7-12-11 | DBK WIRING COMPLETELY REDESIGNED [81744] |    | CRS |
|     |         |  |    |     |
|     |         |  |    |     |
|     |         |  |    |     |

JUNCTION BOX (INSIDE)



**P2 CONNECTIONS**  
 PIN #1 RED (P10-38)  
 2 N/C (P10-37)  
 3 WHT (P10-37)  
 4 N/C  
 5 N/C  
 6 N/C (P10-36)  
 7 BLK (P10-36)  
 8 N/C  
 9 S6 UNINS (P10-39)



**P6 CONNECTIONS**  
 PIN #1 E12 (P1D-24)  
 2 N20 (P1D-23)  
 3 EOV (P1D-20)  
 4 3B (P1D-21)  
 5 5B (P1D-22)  
 6 N/C

**P1D CONNECTIONS**  
 PIN #1 V7 (P2D-1)  
 2 V8 (P2D-2)  
 3 V9 (P2D-3)  
 4 V0 (P2D-4)  
 5 N/C  
 6 N/C  
 7 N/C  
 8 N/C  
 9 I1 (P26-1)  
 10 I1R (P26-2)  
 11 I2 (P26-3)  
 12 I2R (P26-4)  
 13 I3 (P26-5)  
 14 I3R (P26-6)  
 15 N/C  
 16 N/C  
 17 N/C  
 18 N/C  
 19 N/C  
 20 EOV (P6-3)  
 21 3B (P6-4)  
 22 5B (P6-5)  
 23 N20 (P6-2)  
 24 E12 (P6-1)

**P2D CONNECTIONS**  
 PIN #1 V7 (P1D-1)  
 2 V8 (P1D-2)  
 3 V9 (P1D-3)  
 4 V0 (P1D-4)

**P26 CONNECTIONS**  
 PIN #1 I1 (P1D-9)  
 2 I1R (P1D-10)  
 3 I2 (P1D-11)  
 4 I2R (P1D-12)  
 5 I3 (P1D-13)  
 6 I3R (P1D-14)

**TO P2E & 6 LEAD GENERATOR ONLY**  
 V7, V8, V9, V0, X1, X2, H1, H2, P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14, P15, P16, P17, P18, P19, P20, P21, P22, P23, P24, P25, P26, P27, P28, P29, P30, P31, P32, P33, P34, P35, P36, P37, P38, P39, P40, P41, P42, P43, P44, P45, P46, P47, P48, P49, P50, P51, P52, P53, P54, P55, P56, P57, P58, P59, P60, P61, P62, P63, P64, P65, P66, P67, P68, P69, P70, P71, P72, P73, P74, P75, P76, P77, P78, P79, P80, P81, P82, P83, P84, P85, P86, P87, P88, P89, P90, P91, P92, P93, P94, P95, P96, P97, P98, P99, P100

NOTE: CURRENT TRANSFORMER DOT OR "H1" TOWARD GENERATOR.

NOTE: FOR GENERATOR CONNECTIONS SEE: ADV-5875 THREE PHASE

| APPROVALS | DATE   | BY | CHK |
|-----------|--------|----|-----|
| DESIGNED  | 5-3-11 |    | CRS |
| CHECKED   | 5-3-11 |    | CRS |
| APPROVED  | 5-3-11 |    | CRS |

900-1000KW MITSUBISHI W/ECM  
 DECISION-MAKER 6000 CONTROLLER

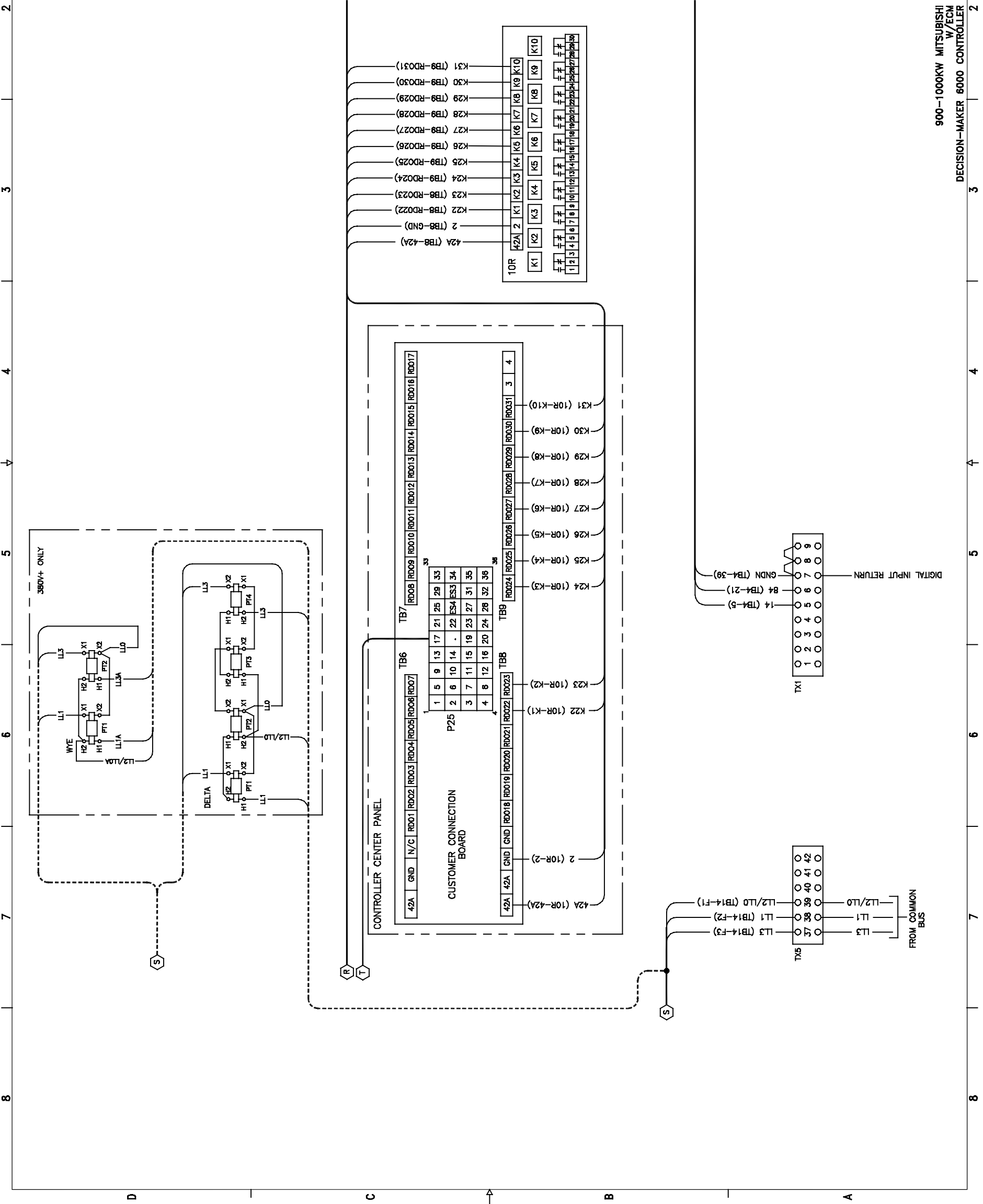
900-1000KW MITSUBISHI  
 DIAGRAM, WIRING  
 900-1000 KW MITSUBISHI

GM81331





| REV | DATE    | REVISION                                 | BY  |
|-----|---------|--|-----|
| -   | 5-3-11  | NEW DRAWING [R0464-4]                    | CRS |
| A   | 7-12-11 | DBK WIRING COMPLETELY REDESIGNED [R1764] | CRS |
|     |         |  |     |
|     |         |  |     |
|     |         |  |     |



| APPROVALS                       | DATE   |
|---------------------------------|--------|
| DESIGN: JPD                     | 5-3-11 |
| CHECK: JPD                      | 5-3-11 |
| DATE: JPD                       | 5-3-11 |
| BY: JPD                         | 5-3-11 |
| SCALE: 1/8"                     | 6-8    |
| PROJECT: 900-1000 KW MITSUBISHI |        |
| DRAWING NO: GMB1331             |        |

| REV | DATE    | REVISION                                 | BY  |
|-----|---------|--|-----|
| -   | 5-3-11  | NEW DRAWING [R0464-4]                    | CRS |
| A   | 7-12-11 | DBK WIRING COMPLETELY REDESIGNED [R1764] | CRS |
|     |         |  |     |
|     |         |  |     |
|     |         |  |     |

# Notes

# Notes





**TP-6813 3/12a**

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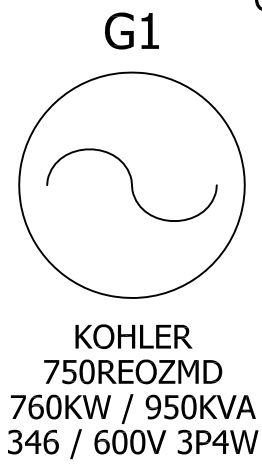
# **KOHLER**<sup>®</sup> POWER SYSTEMS

KOHLER CO. Kohler, Wisconsin 53044  
Phone 920-457-4441, Fax 920-459-1646  
For the nearest sales/service outlet in the  
US and Canada, phone 1-800-544-2444  
KohlerPower.com

Kohler Power Systems  
Asia Pacific Headquarters  
7 Jurong Pier Road  
Singapore 619159  
Phone (65) 6264-6422, Fax (65) 6264-6455

KOHLER GENERATOR CONTROL

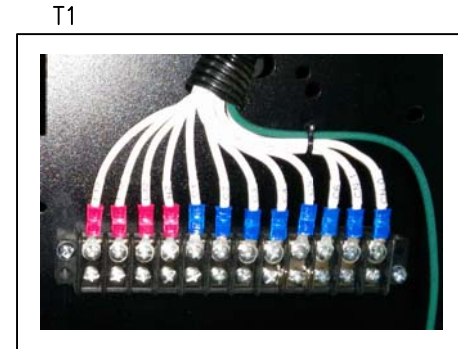
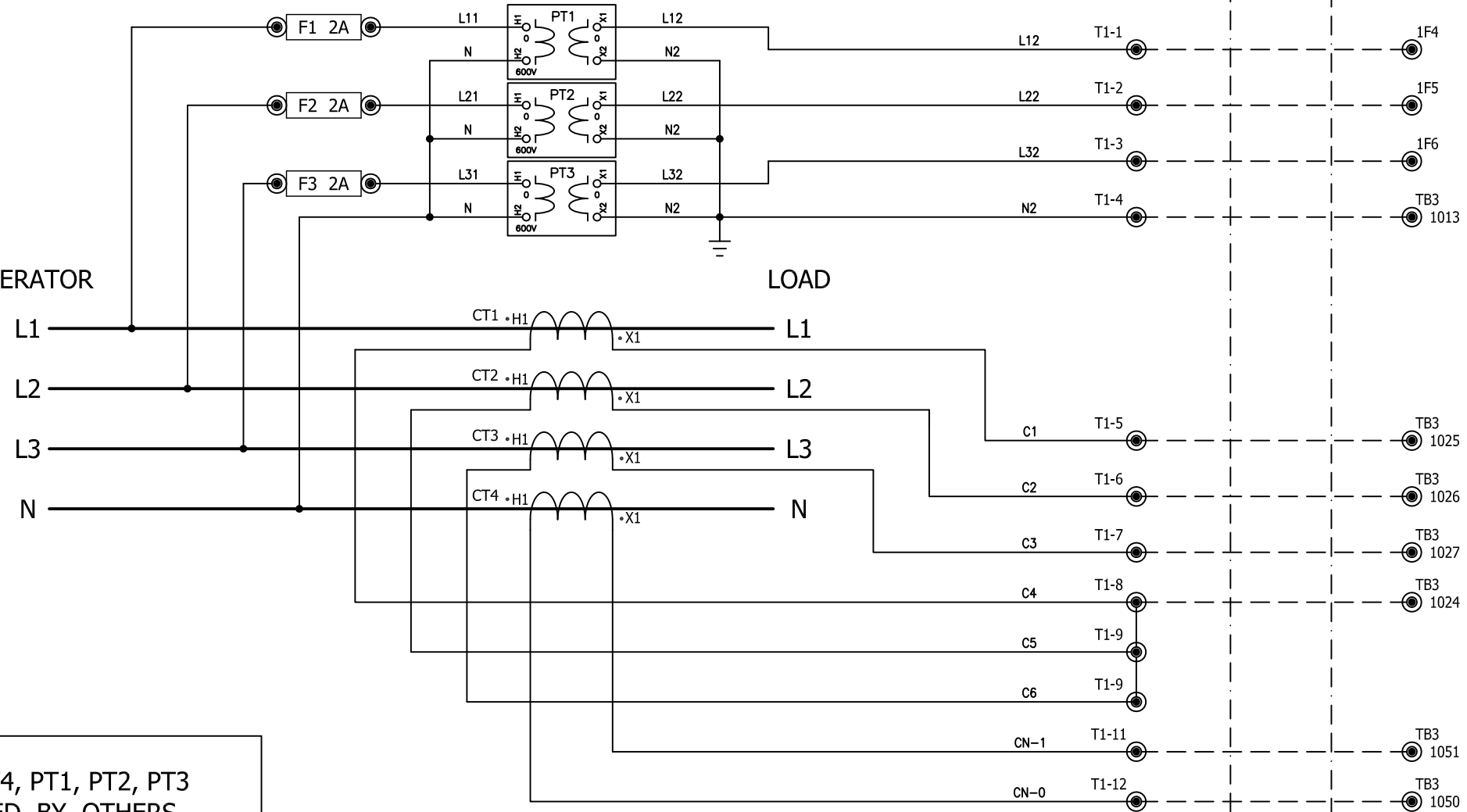
THOMSON POWER SYSTEMS SWITCHBOARD



GENERATOR

LOAD

CT1, CT2, CT3, CT4, PT1, PT2, PT3  
 TO BE PROVIDED BY OTHERS  
 FOR FRONTIER POWER PRODUCTS LTD.  
 TO INSTALL TO GENSET



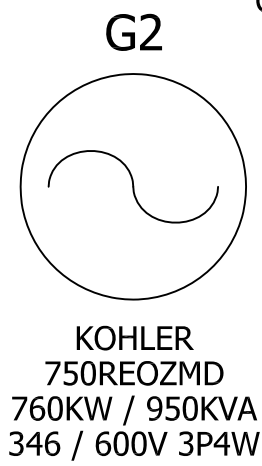
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|-------|----------------|
| REV 2 | CIRCUIT UPDATE |
| REV 1 | ADD PT         |
| REV 0 | INITIAL DRAFT  |



|        |  |       |             |
|--------|--|-------|-------------|
| DATE   | 5/DEC/2016   | DWG # | 10468       |
| REV    | 2  |       | 24/FEB/2017 |
| CLIENT | WESTERN PACIFIC ENTERPRISES LTD.   |       |             |
| TITLE  | INTERFACING DRAWING FOR VOLTAGE AND CURRENT SENSING BETWEEN G1 AND THOMSON POWER SWITCHBOARD |       |             |
| DRN BY | HO. K. CHUNG   | W/O # | 67060       |

KOHLER GENERATOR CONTROL

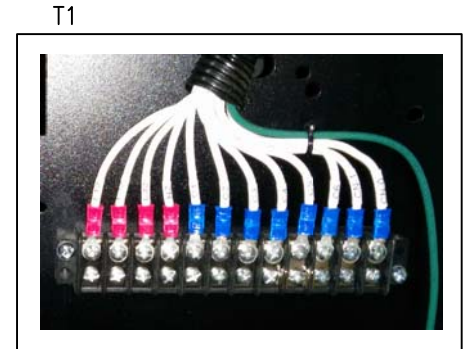
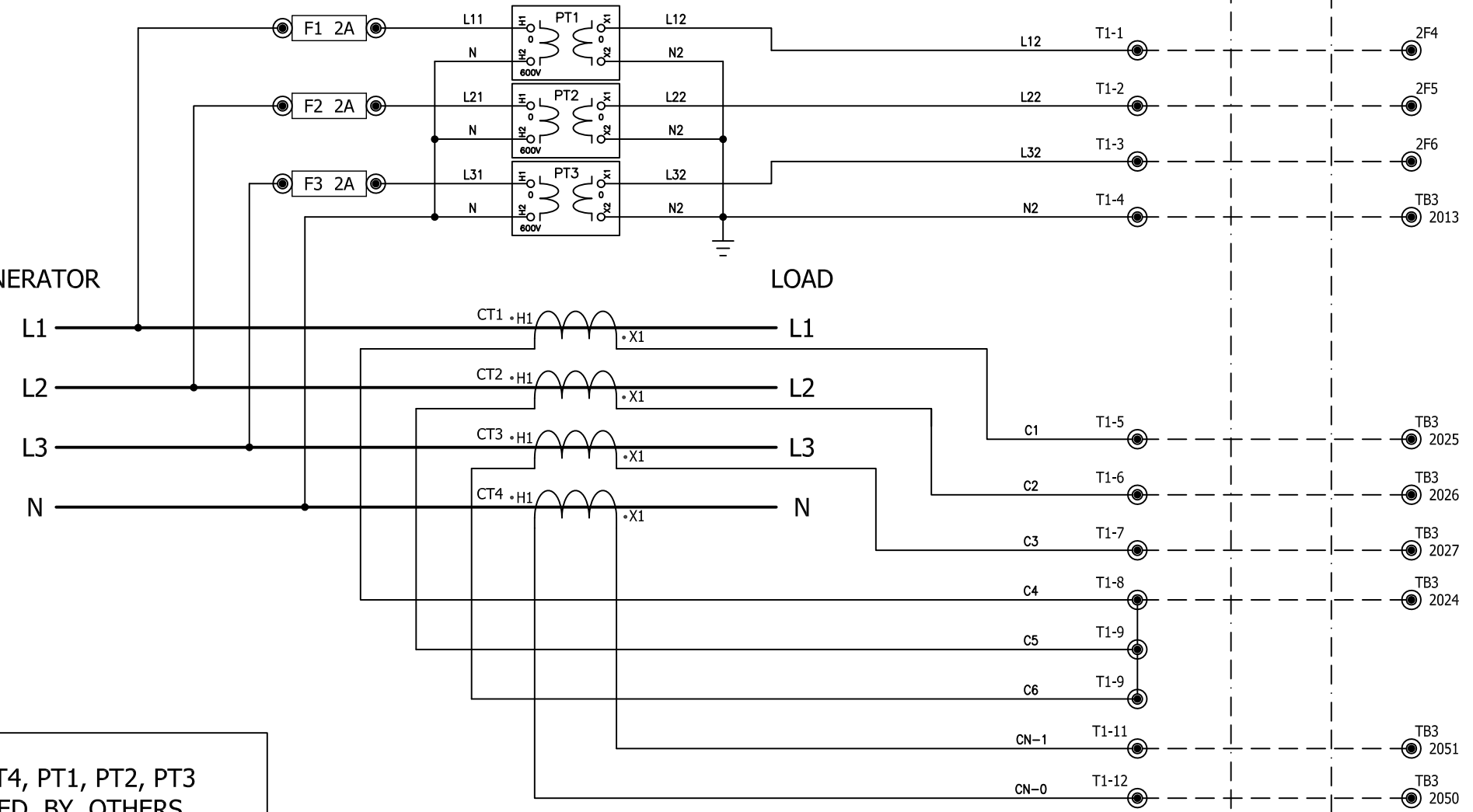
THOMSON POWER SYSTEMS SWITCHBOARD



GENERATOR

LOAD

CT1, CT2, CT3, CT4, PT1, PT2, PT3  
 TO BE PROVIDED BY OTHERS  
 FOR FRONTIER POWER PRODUCTS LTD.  
 TO INSTALL TO GENSET



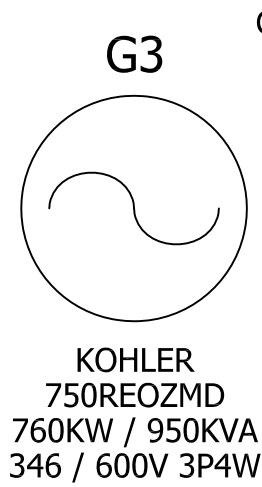
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| REV 1 | ADD PT         |
| REV 0 | INITIAL DRAFT  |



|        |  |       |             |
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| REV    | 2  |       | 24/FEB/2017 |
| CLIENT | WESTERN PACIFIC ENTERPRISES LTD.   |       |             |
| TITLE  | INTERFACING DRAWING FOR VOLTAGE AND CURRENT SENSING BETWEEN G2 AND THOMSON POWER SWITCHBOARD |       |             |
| DRN BY | HO. K. CHUNG   | W/O # | 67060       |

KOHLER GENERATOR CONTROL

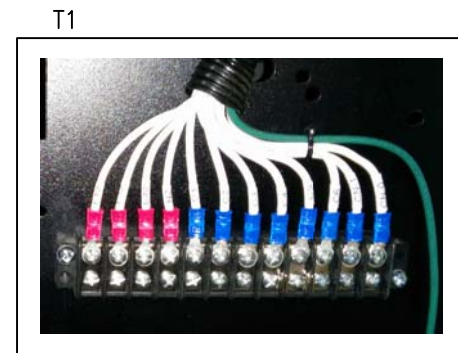
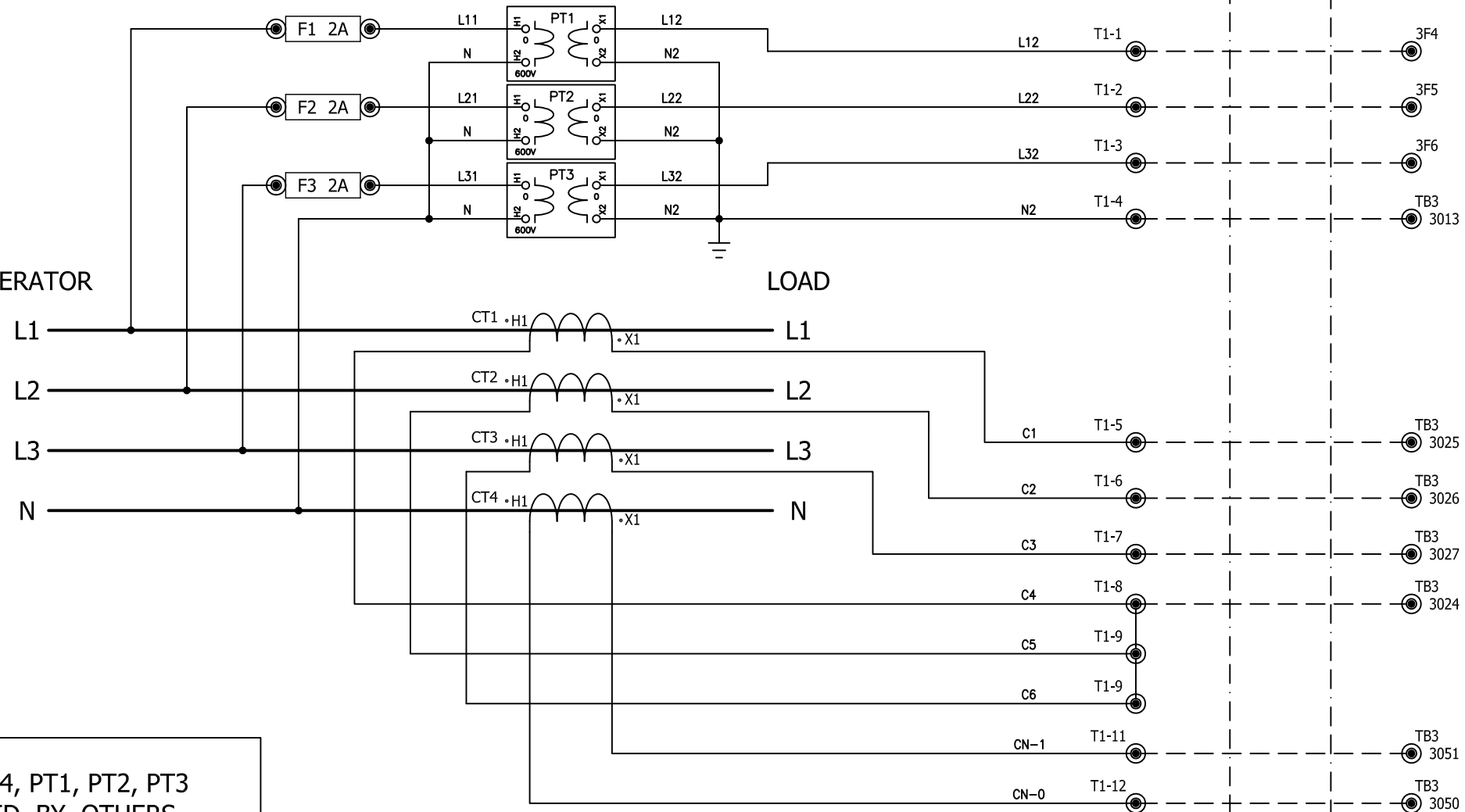
THOMSON POWER SYSTEMS SWITCHBOARD



GENERATOR

LOAD

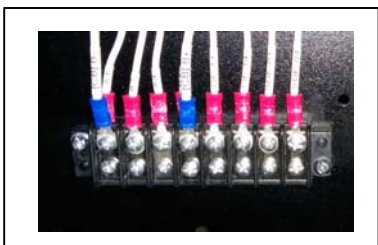
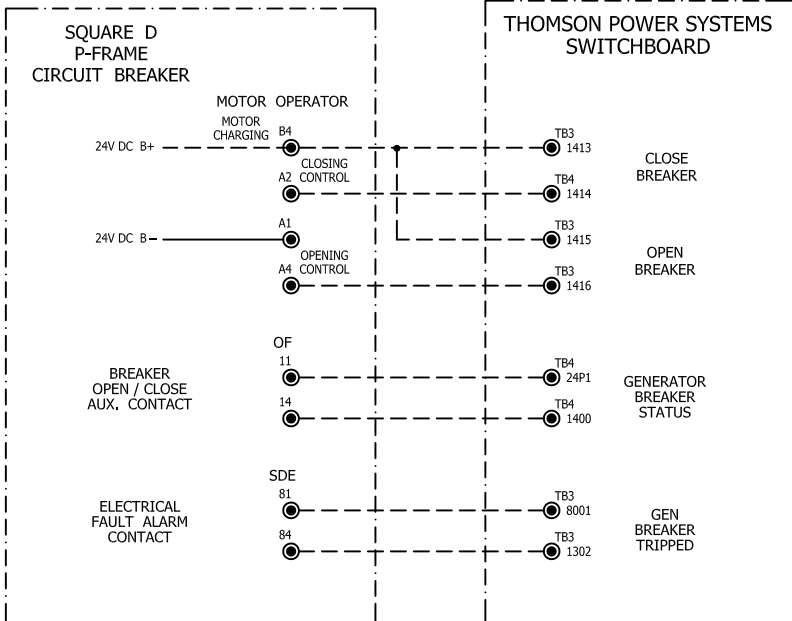
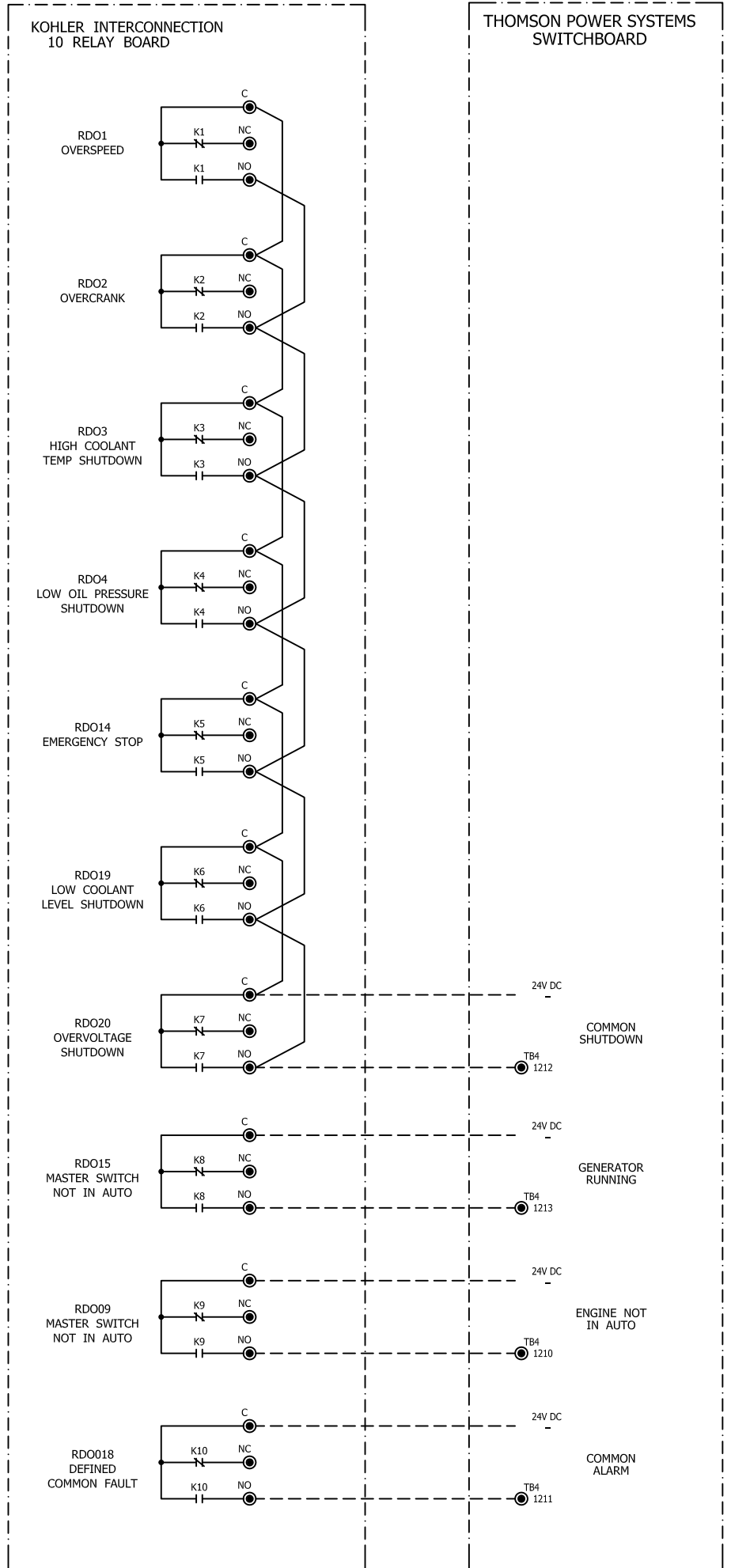
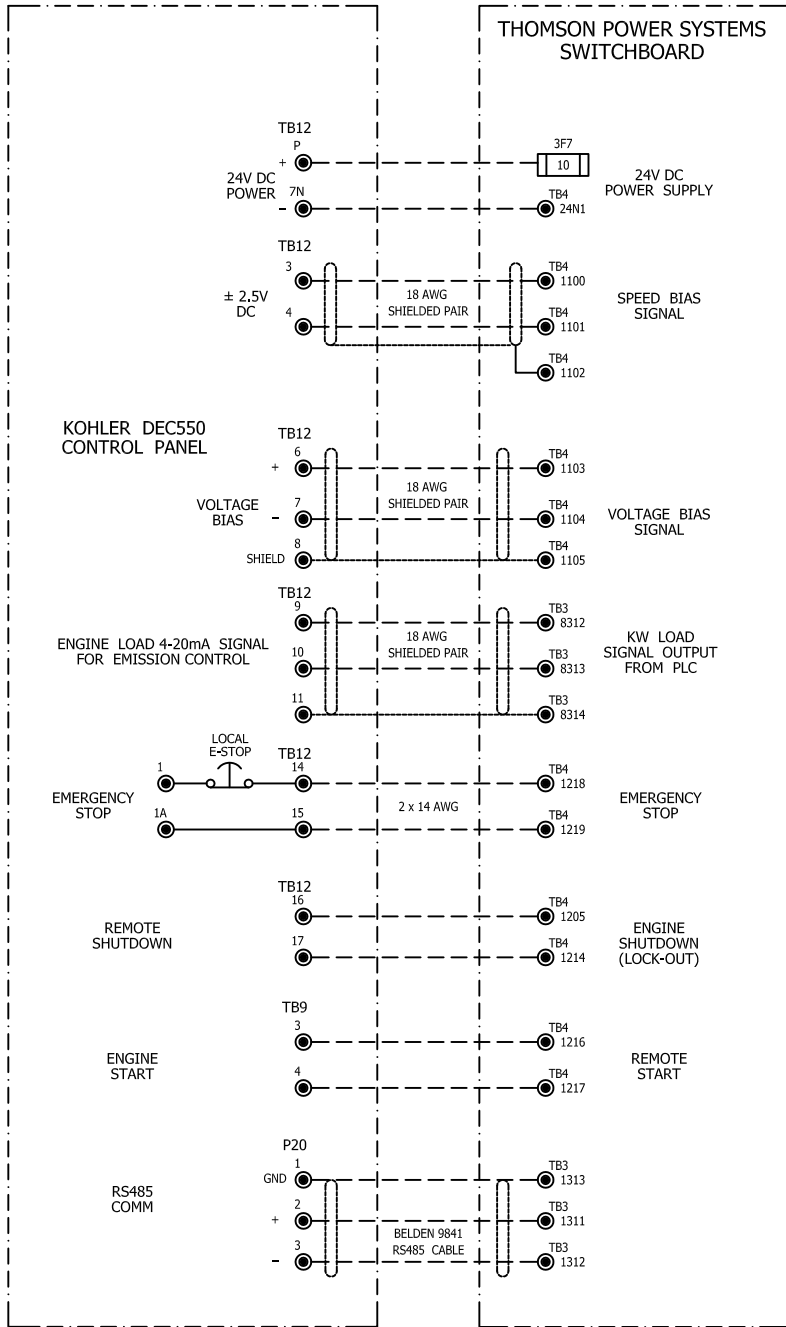
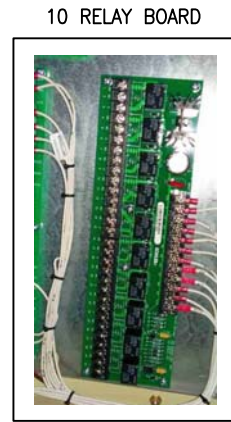
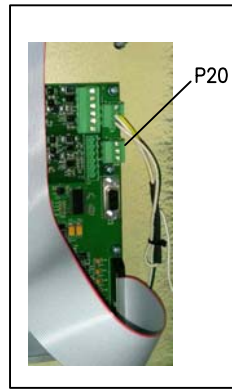
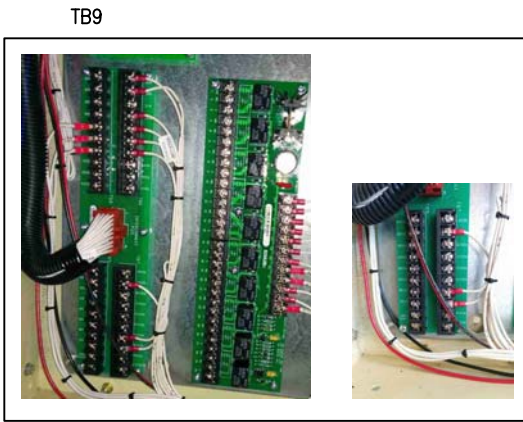
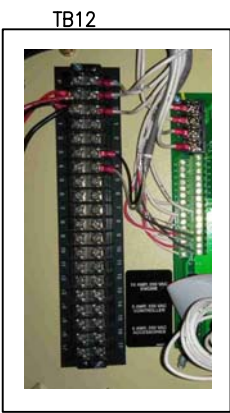
CT1, CT2, CT3, CT4, PT1, PT2, PT3  
 TO BE PROVIDED BY OTHERS  
 FOR FRONTIER POWER PRODUCTS LTD.  
 TO INSTALL TO GENSET



|       |                |
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| REV 2 | CIRCUIT UPDATE |
| REV 1 | ADD PT         |
| REV 0 | INITIAL DRAFT  |



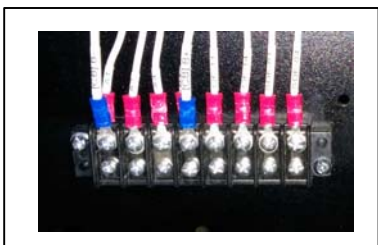
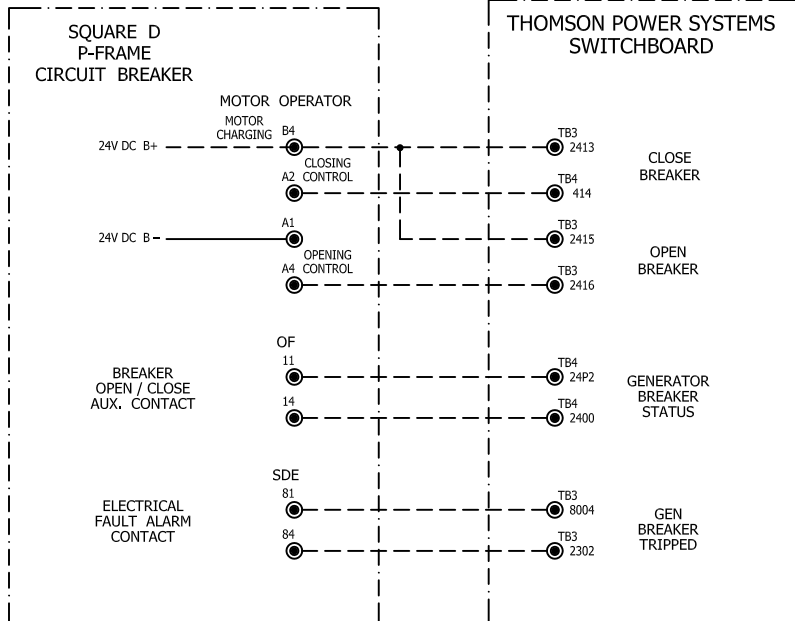
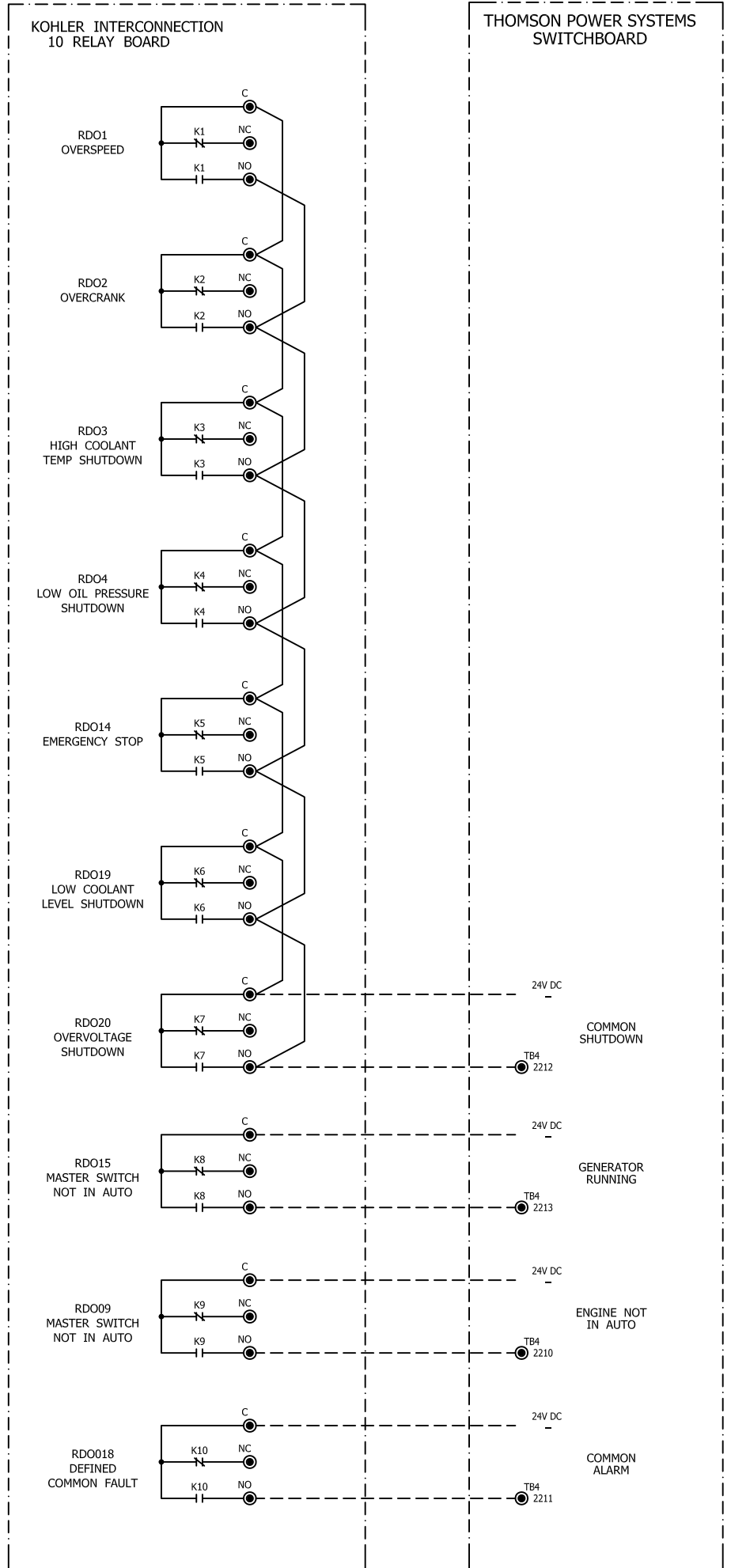
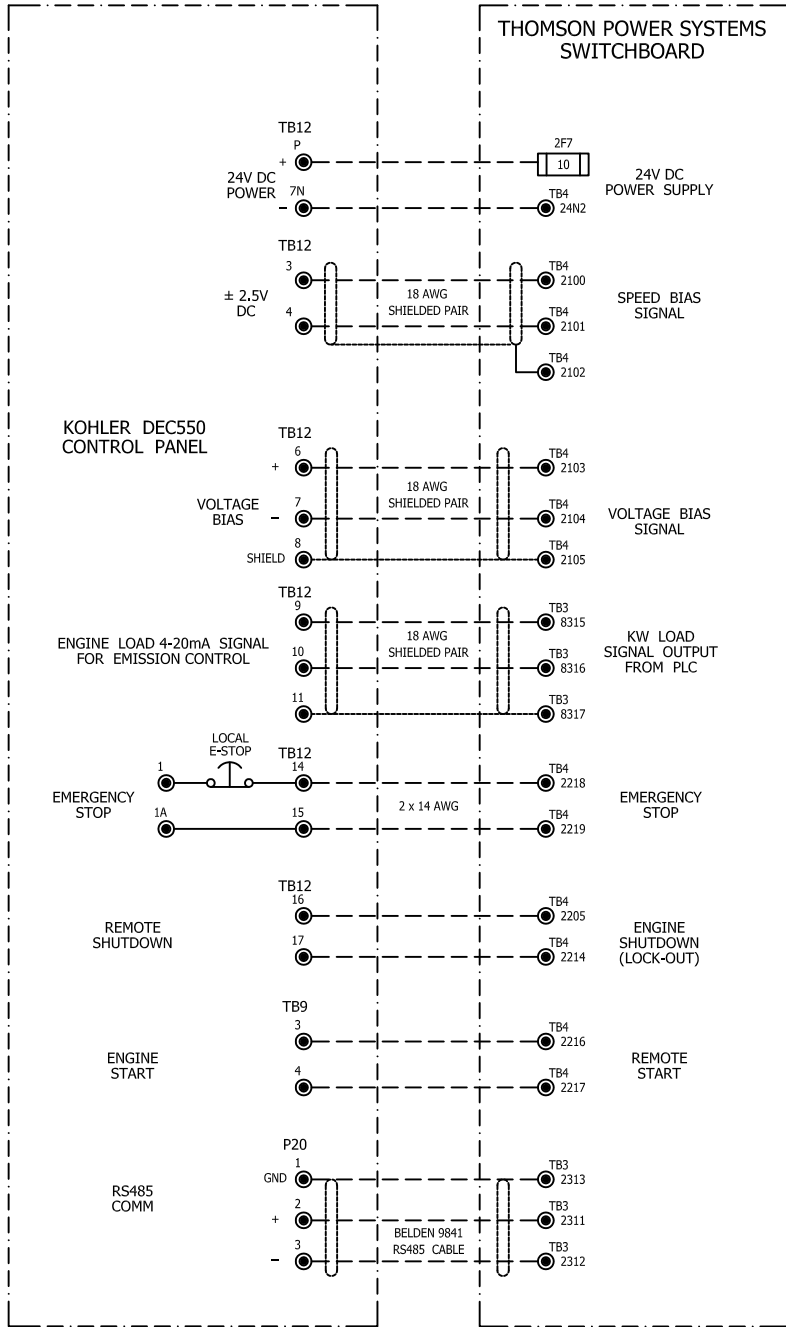
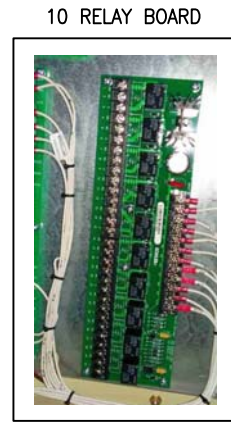
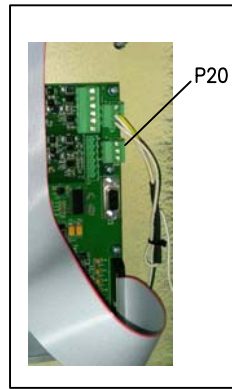
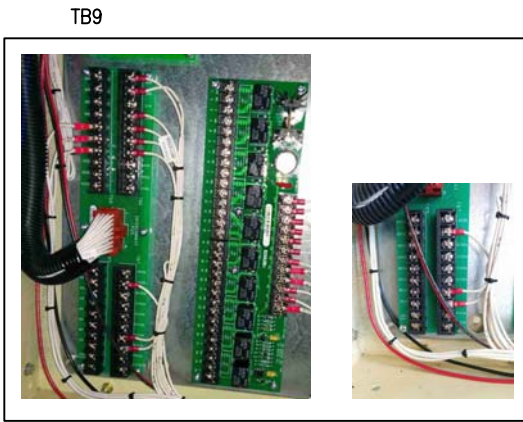
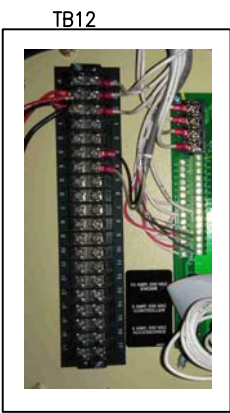
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| REV    | 2  |       | 24/FEB/2017 |
| CLIENT | WESTERN PACIFIC ENTERPRISES LTD.   |       |             |
| TITLE  | INTERFACING DRAWING FOR VOLTAGE AND CURRENT SENSING BETWEEN G3 AND THOMSON POWER SWITCHBOARD |       |             |
| DRN BY | HO. K. CHUNG   | W/O # | 67060       |



REV 1 CIRCUIT UPDATE  
REV 0 INITIAL DRAFT



|        |   |       |             |
|--------|---|-------|-------------|
| DATE   | 5/DEC/2016  | DWG # | 10471       |
| REV    | 1   |       | 23/FEB/2017 |
| CLIENT | WESTERN PACIFIC ENTERPRISES LTD.  |       |             |
| TITLE  | INTERFACING DRAWING FOR GENSET CONTROL BETWEEN G1 AND THOMSON POWER SWITCHBOARD |       |             |
| DRN BY | HO. K. CHUNG  | W/O # | 67060       |

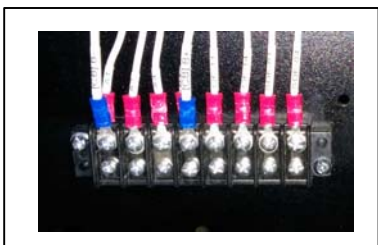
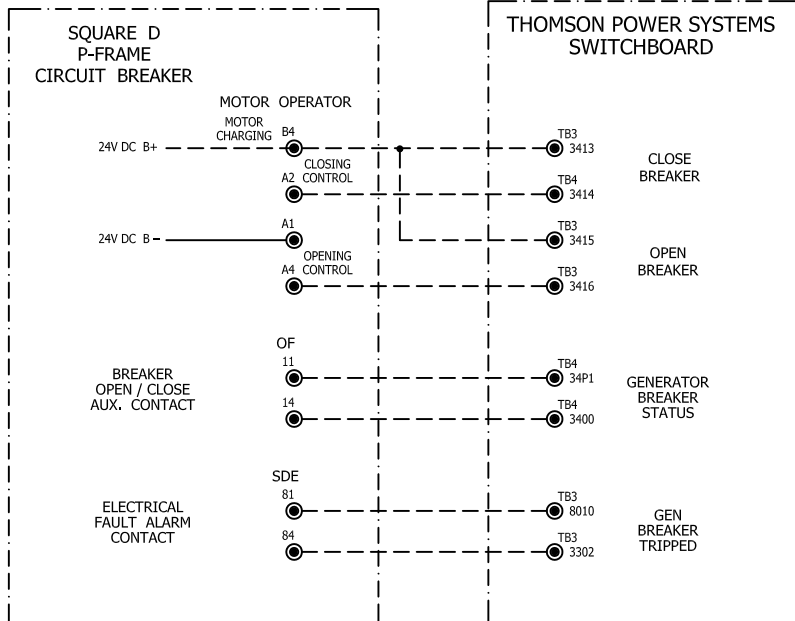
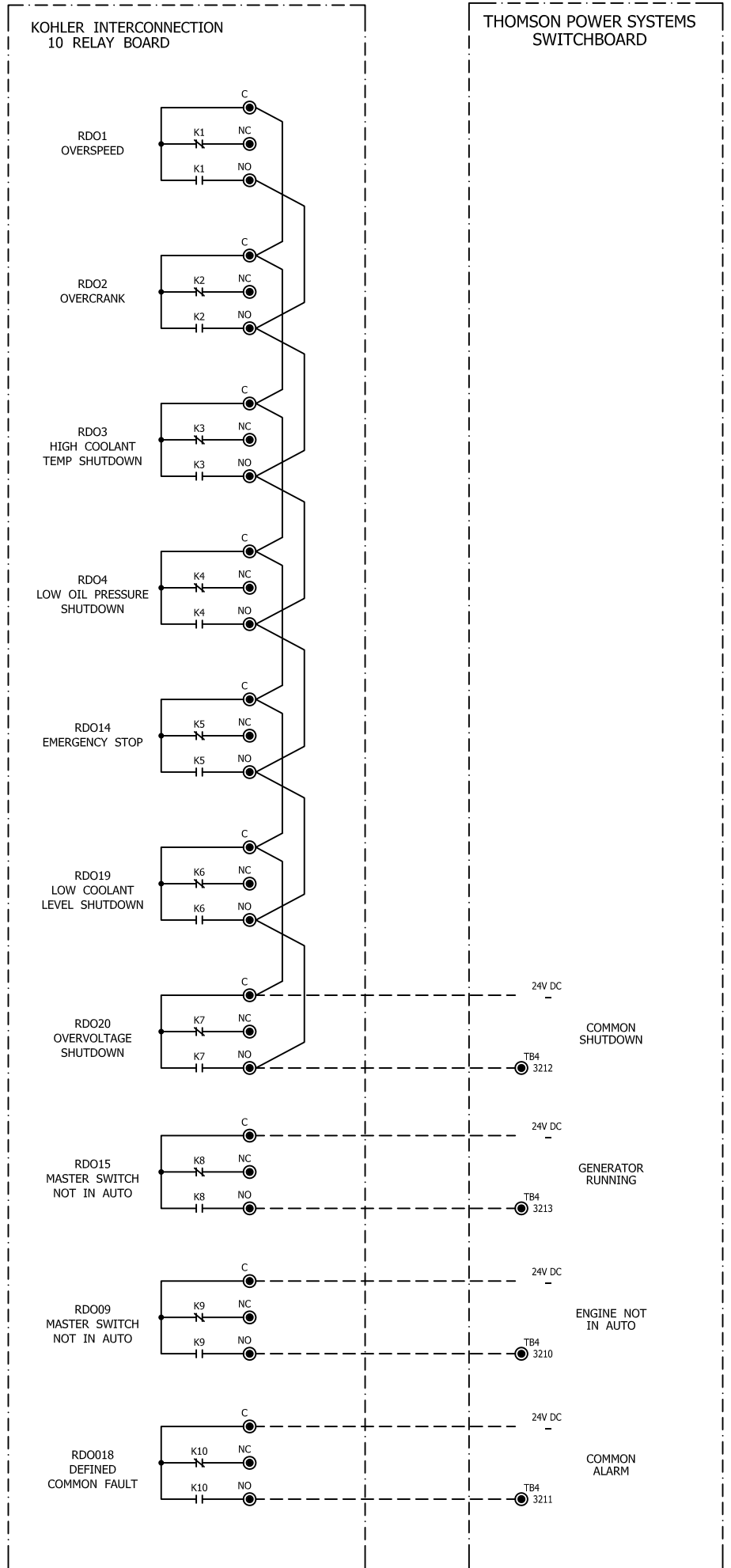
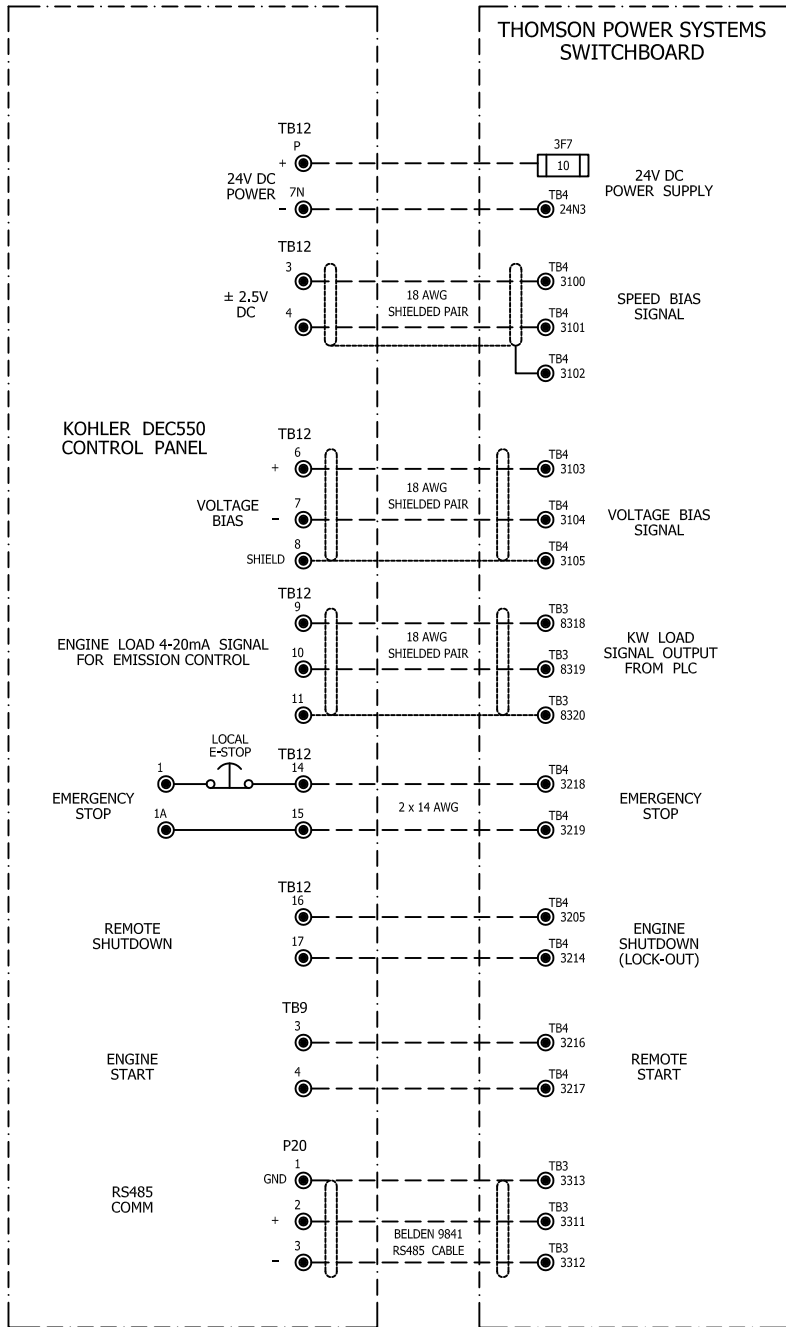
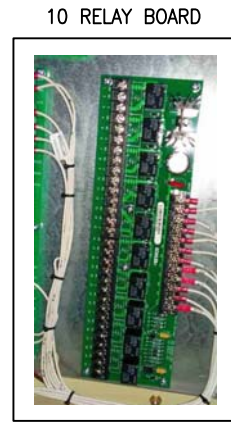
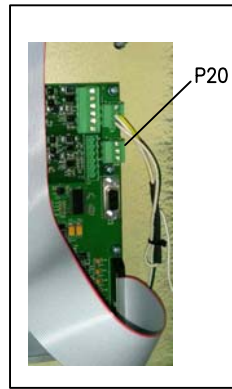
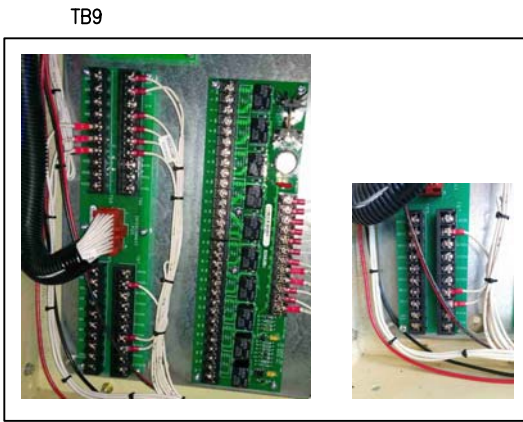
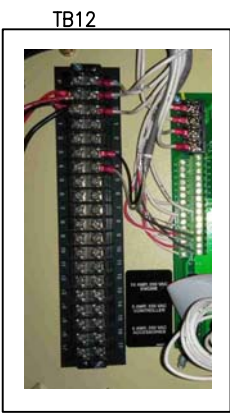


REV 1 CIRCUIT UPDATE  
REV 0 INITIAL DRAFT



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| REV    | 1   |       | 24/FEB/2017 |
| CLIENT | WESTERN PACIFIC ENTERPRISES LTD.  |       |             |
| TITLE  | INTERFACING DRAWING FOR GENSET CONTROL BETWEEN G2 AND THOMSON POWER SWITCHBOARD |       |             |
| DRN BY | HO. K. CHUNG  | W/O # | 67060       |





REV 1 CIRCUIT UPDATE  
REV 0 INITIAL DRAFT



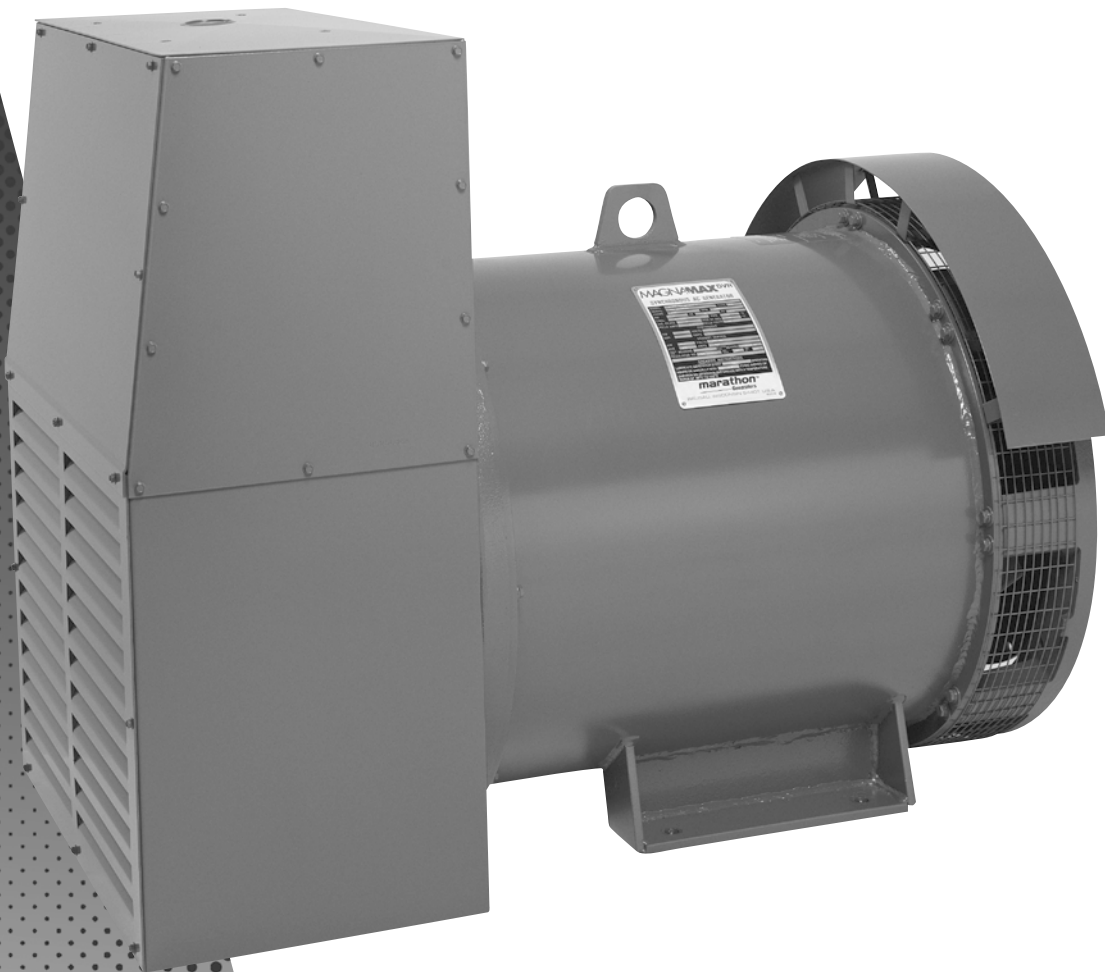
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| TITLE  | INTERFACING DRAWING FOR GENSET CONTROL BETWEEN G3 AND THOMSON POWER SWITCHBOARD |       |             |
| DRN BY | HO. K. CHUNG  | W/O # | 67060       |

# marathon™

Generators

MagnaMax<sup>DVR</sup>®

Installation, Operation, and  
Maintenance Manual



A Regal Brand

**REGAL**

TP-5578





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## A Few Words About Safety

**PLEASE REMEMBER SAFETY FIRST.** If you are not sure of the instructions or procedures, seek qualified help before continuing.

This service manual emphasizes the safety precautions necessary during the installation, operation and maintenance of the MAGNAMAX<sup>DVR</sup>® generator.

Each section has caution and warning messages. These messages are for your safety and the safety of the equipment involved. If any of the cautions or warnings are not readily understood, seek clarification from qualified personnel before proceeding.

Before any service work is done, disconnect all power sources and, where appropriate, lock out all controls to prevent an unexpected start-up of the generator set. Proper grounding in compliance with local and national electrical codes must be provided. These safety precautions are necessary to prevent potential serious personal injury, or even death.

The hazards associated with lifting or moving the MAGNAMAX<sup>DVR</sup>® generator are pointed out in the installation and service sections; incorrect lifting or moving can result in personal injury or property damage.

Whenever the generator is running, always assume and proceed as if voltage is present. Residual voltage is present at the generator leads and at the regulator panel connections, even with the regulator fuse removed. Caution must be observed. Otherwise, serious personal injury or death can result.

Whenever solvents, cleaners, or flammable liquids are present, adequate ventilation must be available to avoid fire, explosion, and health hazards. Always avoid breathing vapors and use suitable personal protective equipment to prevent personal injuries (such as eyes, face, and hand protection).

This manual is not intended to be a substitute for properly trained personnel. Repairs should only be attempted by qualified, trained people. The cautions and warnings point out known conditions that are potentially dangerous. Each installation will create its own set of circumstances. No manual can cover every possible situation.

When in doubt, ask. Don't be embarrassed to ask "dumb questions." Remember, dumb questions are much easier to handle than dumb mistakes.

# General Information

2

## Mechanical Design

### General

All single and two bearing units are manufactured with cast iron end brackets and adapters and fabricated steel frames. Flexible drive discs and SAE adapters are machined to SAE standards. Prelubricated, regreasable, shielded ball bearings are used on MAGNAMAX<sup>DVR</sup> generators. Standard units are fully guarded. Dripproof shields are available as an option.

### Conduit Box

The large, front end-mounted conduit box is constructed of formed sheet steel, which will allow the addition of top-mounted control packages. Refer to Marathon Electric for top mounted controls of more than 240 lbs. There is ample room inside the conduit box for a circuit breaker (through 800 amp ratings) and other options. The conduit box cover properly directs outside vent-tilating air through the generator.

### MAGNAMAX<sup>DVR</sup> Uni-rotor Construction

An aluminum die cast rotor core affords high mechanical integrity and low vibration at operating speeds. Amortisseur winding and coil supports are die cast as an integral part of the rotor. Laminations are 4-pole, one piece laminations which are shrunk fit and keyed to the shaft. No dovetails, cross bolts or other pole to shaft connecting devices are used. The cast unidirectional aluminum alloy ventilating fan provides even air distribution to maximize cooling and generator efficiency.

### Adapters and Drive Discs

All single bearing units are available with several adapter and drive disc arrangements. These can be shipped to order or can be changed in the field with standard shop tools. When changing flexible drive discs, spacers are used between the discs and the cast iron hub to maintain SAE standard dimensions.

## Electrical Design

### General

All standard products have 2/3 pitch main windings to eliminate the third harmonic. This serves to lower operating temperatures, give lower harmonic content and better wave form, and extend the overall life of the generator. The phase sequence is ABC when rotated counterclockwise viewing exciter end.

### Temperature Rise

All ratings and frame sizes are based on NEMA and CSA Class F and Class H temperature rises on both the rotor and stator windings. Ratings for international and marine applications are available.

### Standby Generator

Synchronous generators used on emergency backup power can have temperature rises up to 25°C above those for continuous operation (NEMA MG1-22.40 and MG 1-22.84).

### Premium Insulation System

All MAGNAMAX<sup>DVR</sup> generators are built with Class H or better insulation materials. All standard generators are suitable for continuous duty at Class F temperature rise and will give equivalent or better winding life expectancy to generators supplied with Class A or B insulation systems operated within their temperature limits. The varnishes and epoxies used are synthetic, non-hygroscopic. Multiple dip and bake cycles of the main winding, plus a final coat of epoxy, make the standard winding moisture and fungus resistant. The MAGNAMAX<sup>DVR</sup> rotor is wet wound with thermosetting epoxy applied between each layer, plus a final coating of epoxy for moisture and abrasion resistance. MAGNAMAX<sup>DVR</sup> generators can be ordered with an epoxy vacuum pressure impregnated (VPI) insulation system as an option (MAGNAMAX<sup>DVR</sup> generators with form wound coils include VPI as standard).

### Power Factor

All standard generators are designed for operation at rated kVA at 0.8 lagging power factor but can be operated at rated kVA over the 0.8 to 1.0 power factor range.

### MAGNAMAX<sup>DVR</sup> Voltage Regulator

The standard voltage regulator is a fully encapsulated, static type with a solid state build up circuit. Standard features include 3 phase RMS sensing, paralleling, adjustable underfrequency protection, and overexcitation protection. Refer to the regulator manual for more information.

## How to Read a Model Number

It is extremely important to properly identify the machine when requesting parts or service.

Always have available the generator model number and serial number when requesting information from the factory. We cannot help you without this information. It is also beneficial to know the mounting arrangement code (see figure 2-1).

### An Example for MAGNAMAX<sup>DVR®</sup> Generators

Example:    431        RSL        4000        AA  
                   ①        ② ③ ④    ⑤ ⑥        ⑧

- ① Frame Number
- ② R – Random Wound  
F – Form Wound
- ③ S – 1 Bearing  
D – 2 Bearings
- ④ L – Up to 480 volts  
S – 600 volts  
M – 1000-6900 volts
- ⑤ Style  
4-Magna (slant type conduit box)  
8-Magna (square conduit box)
- ⑥ Model in Series
- ⑧ Electrical/mechanical modification—minor modification, used in sequence A, B, C, etc. (must specify when requesting WK<sup>2</sup>)

| Arrangement | Adapter SAE Size | Drive Disc SAE Size |
|-------------|------------------|---------------------|
| A           | 3                | 11-1/2              |
| B           | 2                | 11-1/2              |
| C           | 4                | 8                   |
| D           | 3                | 10                  |
| E           | 1                | 11-1/2              |
| F           | 1                | 14                  |
| G           | 4                | 7-1/2               |
| H           | 1                | Delco               |
| J           | 1/2              | 14                  |
| K           | 2                | 10                  |
| L           | 1/2              | Delco               |
| M           | 0                | 14                  |
| N           | 2                | Small Delco         |
| O           | None             | None                |
| P           | 0                | 18                  |
| S           | 0                | Delco               |
| U           | 00               | 18                  |
| V           | 4                | 6-1/2               |
| W           | 00               | 21                  |
| Y           | 4                | 10                  |

Figure 2-1

# Installation

3

## Receiving Your MAGNAMAX<sup>DVR</sup>® Generator

Upon receipt of the generator, it is recommended that it be carefully examined for possible damage incurred in shipment. The generator was given to the freight company in good condition, and they are responsible for the product from our dock to yours. Any damage should be noted on the freight bill before accepting the shipment. Claims for damage must be promptly filed with the freight company.

## Unpacking and Handling

Read all instruction cards carefully. When lifting, attach an overhead crane to the lifting lugs on the generator frame. Apply lifting forces in a vertical direction.

**⚠️WARNING** The lifting lugs on the generator are designed to support the generator only. Do not lift complete generator set by means of lifting lugs on generator. Personal injury or equipment damage may result.

## Storage

In the event that the generator is not to be installed on the prime mover immediately, it is recommended that it be stored in a clean, dry area which is not subject to rapid changes in temperature and humidity. See Section 11 for more information.

## Preparation for Use

Although the generator is carefully inspected and tested in operation before it leaves the factory, it is recommended that the unit be thoroughly inspected. The insulation on the wire should be inspected and all bolts should be checked for tightness.

Remove all shipping tapes, bags, blocks, and skids which are used to prevent vibration and rotor movement during shipment. Dry, low-pressure compressed air of approximately 30 psi (206 KPa) can be used to blow out the interior of the generator. In the case of two bearing machines, it is possible to turn the rotor by hand to make sure that it rotates smoothly without binding.

If the machine has been in storage for a year or longer, it is recommended that it be lubricated according to the lubrication instructions and chart found in Section 5.

If the machine has been exposed to damp, humid conditions, the insulation resistance should be checked. Refer to Section 8.

## Generator Mounting – Single Bearing

Single bearing generators are provided with an SAE flywheel adapter and flexible drive discs. Very close tolerances are maintained in the manufacture of the generator so that the alignment procedure is extremely simple. A coupling hub of nodular iron is shrunk onto the shaft and special steel drive discs are bolted to the hub. Holes are provided in the periphery of the coupling disc which correspond to tapped holes in the flywheel. The outside diameter of the discs fits in a rabbet in the flywheel so that concentricity is assured in all cases.

**⚠️WARNING** Do not apply any force to generator fan for lifting or rotating generator rotor. Disregarding these instructions may cause personal injury or equipment damage.

**⚠️CAUTION** Grade 8 capscrews and heavy series lockwashers or grade 8 placebolts and hardened washers are recommended to mount the drive discs to the flywheel.

The SAE adapter and the flywheel housing are designed to match each other with no further alignment necessary. Shims may be necessary under the feet of the generator to insure a solid mounting. See Section 6 for more information.

## Generator Mounting – Two Bearing

Two bearing generators are provided with a shaft extension and keyway. For direct-coupled units, the assembler furnishes a flexible coupling which is installed between the driver and the generator shaft.

**Important:** Aligning the two machines as accurately as possible will reduce the vibration, increase bearing life, and insure minimum coupling wear. It may be necessary to shim the generator feet for proper support and alignment. Consult the coupling manufacturer's instructions for alignment specifications and procedures.

## Belt Drive

430 frame, two bearing generators can be belt driven. Please refer to Marathon Electric for application assistance involving belt driven installations. Sheave diameters should be chosen according to the table below.

### MAGNAMAX<sup>DVR</sup>® Sheave Application for Two Bearing Units <sup>①</sup>

| Model      | Min. Sheave Dia. In Inches @ 10,000 Hr. B-10 Life <sup>③</sup> |       | Min. Sheave Dia. In Inches @ 20,000 Hr. B-10 Life <sup>③</sup> |                   | Max. Sheave Width Inches |
|------------|--|-------|--|-------------------|--------------------------|
|            | 60 Hz  | 50 Hz | 60 Hz  | 50 Hz             |                          |
| 431RDL4005 | 13.0 <sup>②</sup>  | 10.9  | 16.9 <sup>②</sup>  | 14.2              | 8.5                      |
| 431RDL4007 | 15.2 <sup>②</sup>  | 13.3  | 19.8 <sup>②</sup>  | 17.3 <sup>②</sup> | 8.5                      |
| 432RDL4009 | 17.0 <sup>②</sup>  | 14.8  | 22.5 <sup>②</sup>  | 19.5 <sup>②</sup> | 8.5                      |

<sup>①</sup> Assumptions:


- A. Belting factor is 1.3.
- B. The drive and the driven sheaves are the same diameter.
- C. The sheave load is located at the center of the shaft extension.
- D. Based upon continuous kW ratings.

<sup>②</sup> These sheave diameters exceed the maximum recommended belt speed of 6000 ft/min.

<sup>③</sup> B-10 Life means 90% of the bearings will last this long or longer.

## Environmental Considerations

Dirt, moisture, heat, and vibration are enemies of electrical equipment. Excessive exposure to the elements will shorten the life of the generator. The ambient temperature should not exceed the value shown on the generator nameplate. The MAGNAMAX<sup>DVR</sup>® is built in a NEMA open type enclosure. Generators for outdoor application should be protected from the elements by housings with proper openings for ventilation. This protection should be designed to prevent the direct contact of wind driven rain, snow, or dust with the generator. In moist or humid areas, such as the tropics and marine service, additional protection is recommended. Although the standard windings are humidity and moisture resistant, special insulations and accessories such as space heaters can increase generator life significantly. In extremely dirty and dusty environments, a means of providing filtered cooling air to the generator is

recommended. When generators are marked , II, 3, G, T3, X they must be installed in a clean environment. If not possible, a means to providing filtered cooling air to the generator is mandatory for safe use. Refer to Marathon Electric for more information.

## Electrical Connections

The generator conduit box construction allows conduit to enter the top, bottom, or either side of the box. A hole-saw or any suitable tool can be used to provide for the conduit entrance. Protect the interior of the generator from shavings when drilling or sawing. An approved connector must be used in conjunction with the conduit.

To minimize the transmission of vibration, it is essential that flexible conduit be used for all electrical entrance to the generator.


Refer to the connection diagram supplied with the generator and/or the proper diagrams shown in this section. Install all intercomponent and external wiring in accordance with the regulations of the national and local electrical codes. Clean all contact surfaces to assure good electrical bonding with the generator lugs or bus bars. Use heavy duty terminal lugs or good quality clamps for making all connections. Insulate all connections in accordance with national and local regulations.

Be sure the generator frame is grounded to all the other components of the system with a ground wire in accordance with national and local regulations.

## Generator Lead Connections

The electrical connections in the conduit box should be made in accordance with the appropriate "connection diagram." Use the diagram appropriate for the number of leads and voltage range required. Refer to the drawings supplied with the generator and to drawings in this section.

The final voltage setting is established within the selected range by an adjustment of the voltage regulator.

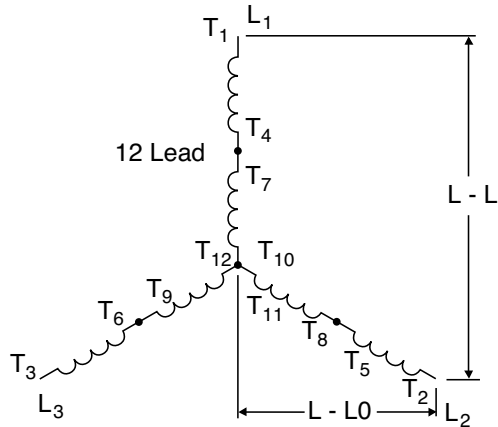
 **CAUTION** Some generators have multiple, identically marked cables for each lead. Connect all identically marked cables together when making connections.



# Installation

3

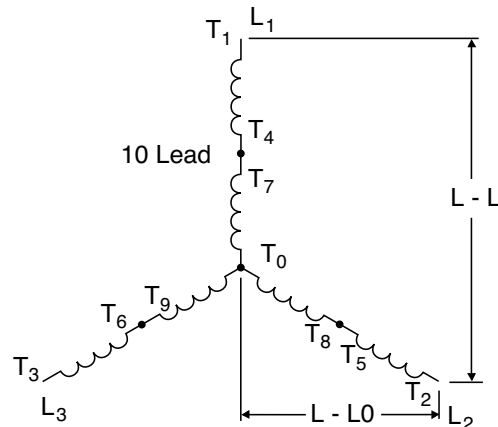
## 12 Lead High Wye



Twelve lead generators are dual voltage generators with six coils which don't have the connection of the three inner coils. There are 12 or 24 cables coming out of the generator.

|          |     | Voltage |   | Connect        | L <sub>1</sub> | L <sub>2</sub> | L <sub>3</sub>  | L-L0 |
|----------|-----|---------|---|----------------|----------------|----------------|-----------------|------|
|          |     | L-L     | L-L0  |                |                |                |                 |      |
| 60<br>HZ | 380 | 219     | T <sub>10</sub> T <sub>11</sub> T <sub>12</sub> | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> | T <sub>10</sub> |      |
|          | 416 | 240     |   |                |                |                |                 |      |
|          | 440 | 254     |   |                |                |                |                 |      |
|          | 460 | 266     |   |                |                |                |                 |      |
| 50<br>HZ | 380 | 219     | T <sub>4</sub> T <sub>7</sub>                   | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> | T <sub>11</sub> |      |
|          | 400 | 231     |   |                |                |                |                 |      |
|          | 416 | 240     |   |                |                |                |                 |      |
|          |     |         |   |                |                |                |                 |      |

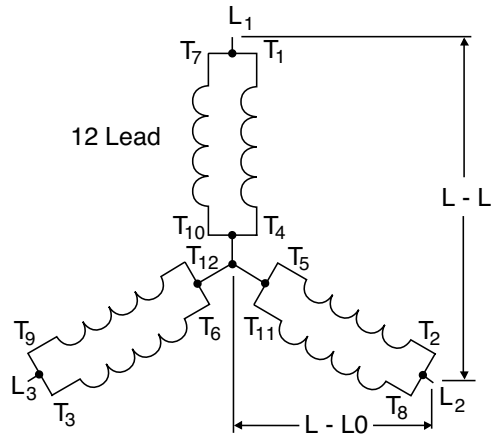
## 10 Lead High Wye



Ten lead generators are dual voltage generators with six coils. One end of the three inner coils is connected together. There are 10 or 20 cables coming out of the generator.

|          |     | Voltage |                               | Connect        | L <sub>1</sub> | L <sub>2</sub> | L <sub>3</sub> | L-L0 |
|----------|-----|---------|-------------------------------|----------------|----------------|----------------|----------------|------|
|          |     | L-L     | L-L0                          |                |                |                |                |      |
| 60<br>HZ | 380 | 219     | T <sub>4</sub> T <sub>7</sub> | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> | T <sub>0</sub> |      |
|          | 416 | 240     |                               |                |                |                |                |      |
|          | 440 | 254     |                               |                |                |                |                |      |
|          | 460 | 266     |                               |                |                |                |                |      |
| 50<br>HZ | 380 | 219     | T <sub>5</sub> T <sub>8</sub> | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> | T <sub>0</sub> |      |
|          | 400 | 231     |                               |                |                |                |                |      |
|          | 416 | 240     |                               |                |                |                |                |      |
|          |     |         |                               |                |                |                |                |      |

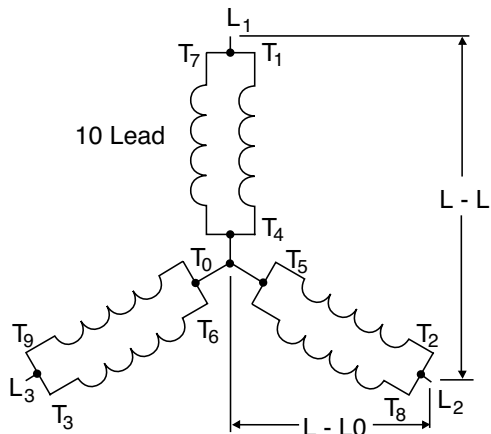
## 12 Lead Low Wye



Twelve lead generators are dual voltage generators with six coils which don't have the connection of the three inner coils. There are 12 or 24 cables coming out of the generator.

| Voltage  |     | L-L | L-L0  | Connect        | L <sub>1</sub> | L <sub>2</sub> | L <sub>3</sub> | L-L0                          |
|----------|-----|-----|---|----------------|----------------|----------------|----------------|-------------------------------|
|          |     |     |   |                |                |                |                |                               |
| 60<br>HZ | 190 | 110 | T <sub>10</sub> T <sub>11</sub> T <sub>12</sub> | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> |                | T <sub>10</sub>               |
|          | 208 | 120 | T <sub>4</sub> T <sub>5</sub> T <sub>6</sub>    |                |                |                |                | T <sub>11</sub>               |
|          | 220 | 127 |   |                |                |                |                | T <sub>12</sub>               |
|          | 230 | 133 |   |                |                |                |                | T <sub>1</sub> T <sub>7</sub> |
|          | 240 | 139 | T <sub>5</sub>                                  |                |                |                |                |                               |
| 50<br>HZ | 190 | 110 | T <sub>2</sub> T <sub>8</sub>                   | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> |                | T <sub>6</sub>                |
|          | 200 | 115 |   |                |                |                |                | T <sub>5</sub>                |
|          | 208 | 120 |   |                |                |                |                | T <sub>3</sub> T <sub>9</sub> |

## 10 Lead Low Wye

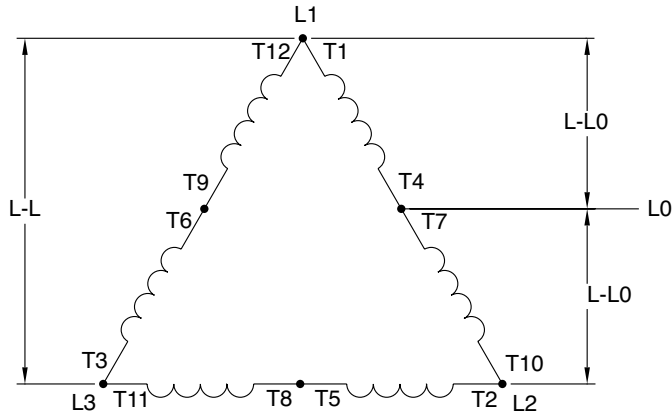


Ten lead generators are dual voltage generators with six coils. One end of the three inner coils is connected together. There are 10 or 20 cables coming out of the generator.

| Voltage  |     | L-L | L-L0  | Connect        | L <sub>1</sub> | L <sub>2</sub> | L <sub>3</sub> | L-L0                          |
|----------|-----|-----|---|----------------|----------------|----------------|----------------|-------------------------------|
|          |     |     |   |                |                |                |                |                               |
| 60<br>HZ | 190 | 110 | T <sub>1</sub> T <sub>7</sub>                               | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> |                | T <sub>4</sub>                |
|          | 208 | 120 | T <sub>2</sub> T <sub>8</sub>                               |                |                |                |                | T <sub>5</sub>                |
|          | 220 | 127 |   |                |                |                |                | T <sub>6</sub>                |
|          | 230 | 133 |   |                |                |                |                | T <sub>3</sub> T <sub>9</sub> |
|          | 240 | 139 | T <sub>0</sub>  |                |                |                |                |                               |
| 50<br>HZ | 190 | 110 | T <sub>4</sub> T <sub>5</sub> T <sub>6</sub> T <sub>0</sub> | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> |                | T <sub>0</sub>                |
|          | 200 | 115 |   |                |                |                |                |                               |
|          | 208 | 120 |   |                |                |                |                |                               |

# Installation

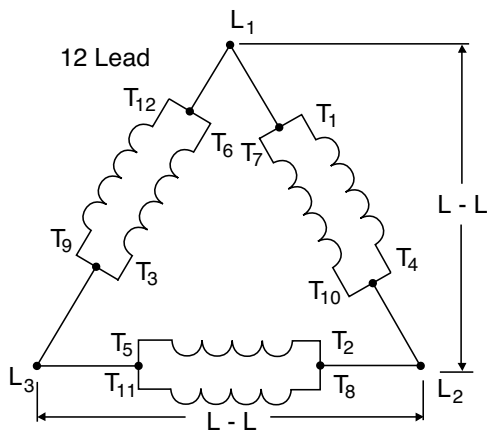
## 12 Lead High Delta



Delta connection with 12 lead generators only.

|          | Voltage |      | Connect                        | L <sub>1</sub> | L <sub>2</sub> | L <sub>3</sub> |
|----------|---------|------|--------------------------------|----------------|----------------|----------------|
|          | L-L     | L-L0 |                                |                |                |                |
| 60<br>HZ | 240     | 120  | T <sub>4</sub> T <sub>7</sub>  | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> |
|          | 277     | 139  | T <sub>5</sub> T <sub>8</sub>  |                |                |                |
| 50<br>HZ | 200     | 100  | T <sub>6</sub> T <sub>9</sub>  |                |                |                |
|          | 220     | 110  | T <sub>1</sub> T <sub>12</sub> |                |                |                |
|          | 240     | 220  | T <sub>2</sub> T <sub>10</sub> |                |                |                |
|          |         |      | T <sub>3</sub> T <sub>11</sub> |                |                |                |

## 12 Lead Low Delta



Delta connection with 12 lead generators only.

|          | Voltage |      | Connect  | L <sub>1</sub> | L <sub>2</sub> | L <sub>3</sub> |
|----------|---------|------|--|----------------|----------------|----------------|
|          | L-L     | L-L0 |  |                |                |                |
| 60<br>HZ | 120     |      | T <sub>1</sub> T <sub>7</sub> T <sub>6</sub> T <sub>12</sub> | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> |
|          | 139     |      | T <sub>2</sub> T <sub>8</sub> T <sub>4</sub> T <sub>10</sub> |                |                |                |
| 50<br>HZ | 100     |      | T <sub>3</sub> T <sub>9</sub> T <sub>5</sub> T <sub>11</sub> |                |                |                |
|          | 120     |      |  |                |                |                |
|          |         |      |  |                |                |                |

## 6 Lead Wye

Six lead generators have 3 coil groups with 6 or 12 cables or bus bars coming out of the generator.

|          | Voltage |      | Connect                                      | L <sub>1</sub> | L <sub>2</sub> | L <sub>3</sub> | L-0  |
|----------|---------|------|--|----------------|----------------|----------------|--|
|          | L-L     | L-L0 |  |                |                |                |  |
| 60<br>HZ | 190     | 110  | T <sub>4</sub> T <sub>5</sub> T <sub>6</sub> | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> | T <sub>4</sub><br>T <sub>5</sub><br>T <sub>6</sub> |
|          | 203     | 120  |  |                |                |                |  |
|          | 220     | 127  |  |                |                |                |  |
|          | 230     | 133  |  |                |                |                |  |
|          | 240     | 139  |  |                |                |                |  |
|          | 3300    | 1905 |  |                |                |                |  |
| 50<br>HZ | 4160    | 2400 |  |                |                |                |  |
|          | 190     | 110  |  |                |                |                |  |
|          | 200     | 115  |  |                |                |                |  |
|          | 208     | 120  |  |                |                |                |  |
|          | 3300    | 1905 |  |                |                |                |  |

3

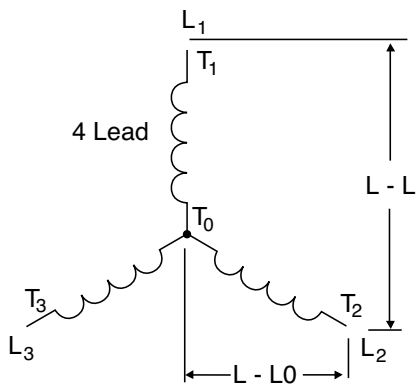
## 6 Lead Delta

Six lead generators have 3 coil groups with 6 or 12 cables coming out of the generator.

|          | Voltage |                               | Connect                       | L <sub>1</sub> | L <sub>2</sub> | L <sub>3</sub> |
|----------|---------|-------------------------------|-------------------------------|----------------|----------------|----------------|
|          | L-L     |                               |                               |                |                |                |
| 60<br>HZ |         | 2400                          | T <sub>1</sub> T <sub>6</sub> | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> |
|          |         |                               | T <sub>2</sub> T <sub>4</sub> |                |                |                |
| 50<br>HZ | 1905    | T <sub>3</sub> T <sub>5</sub> |                               |                |                |                |

# Installation

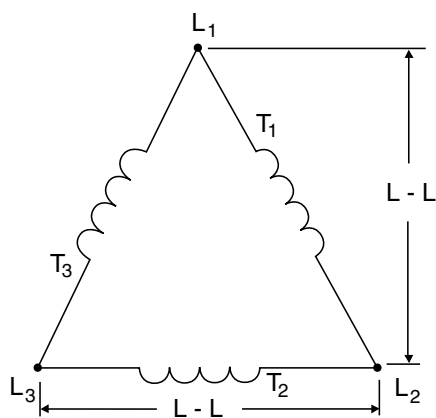
## 4 Lead Wye



Four lead generators have 3 coil groups with one end of each group connected together. There are 4, 8, or 16 cables or 4 bus bars coming out of the generator.

|          |  | Voltage |      | L <sub>1</sub> | L <sub>2</sub> | L <sub>3</sub> | L-L0           |
|----------|--|---------|------|----------------|----------------|----------------|----------------|
|          |  | L-L     | L-L0 |                |                |                |                |
| 60<br>HZ |  | 380     | 219  | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> | T <sub>0</sub> |
|          |  | 416     | 240  |                |                |                |                |
|          |  | 440     | 254  |                |                |                |                |
|          |  | 460     | 266  |                |                |                |                |
|          |  | 480     | 277  |                |                |                |                |
|          |  | 600     | 346  |                |                |                |                |
| 50<br>HZ |  | 380     | 219  |                |                |                |                |
|          |  | 400     | 231  |                |                |                |                |
|          |  | 416     | 240  |                |                |                |                |
|          |  | 480     | 277  |                |                |                |                |

## 3 Lead Delta



Three lead generators have 3 coil groups with one end of each group connected into a Delta internally. There are 3, 6, or 12 cables or 3 bus bars coming out of the generator.

|          |     | Voltage        |                |                |
|----------|-----|----------------|----------------|----------------|
|          |     | L <sub>1</sub> | L <sub>2</sub> | L <sub>3</sub> |
| 60<br>HZ | L-L | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> |
|          | 480 |                |                |                |

## 12 Lead Zigzag

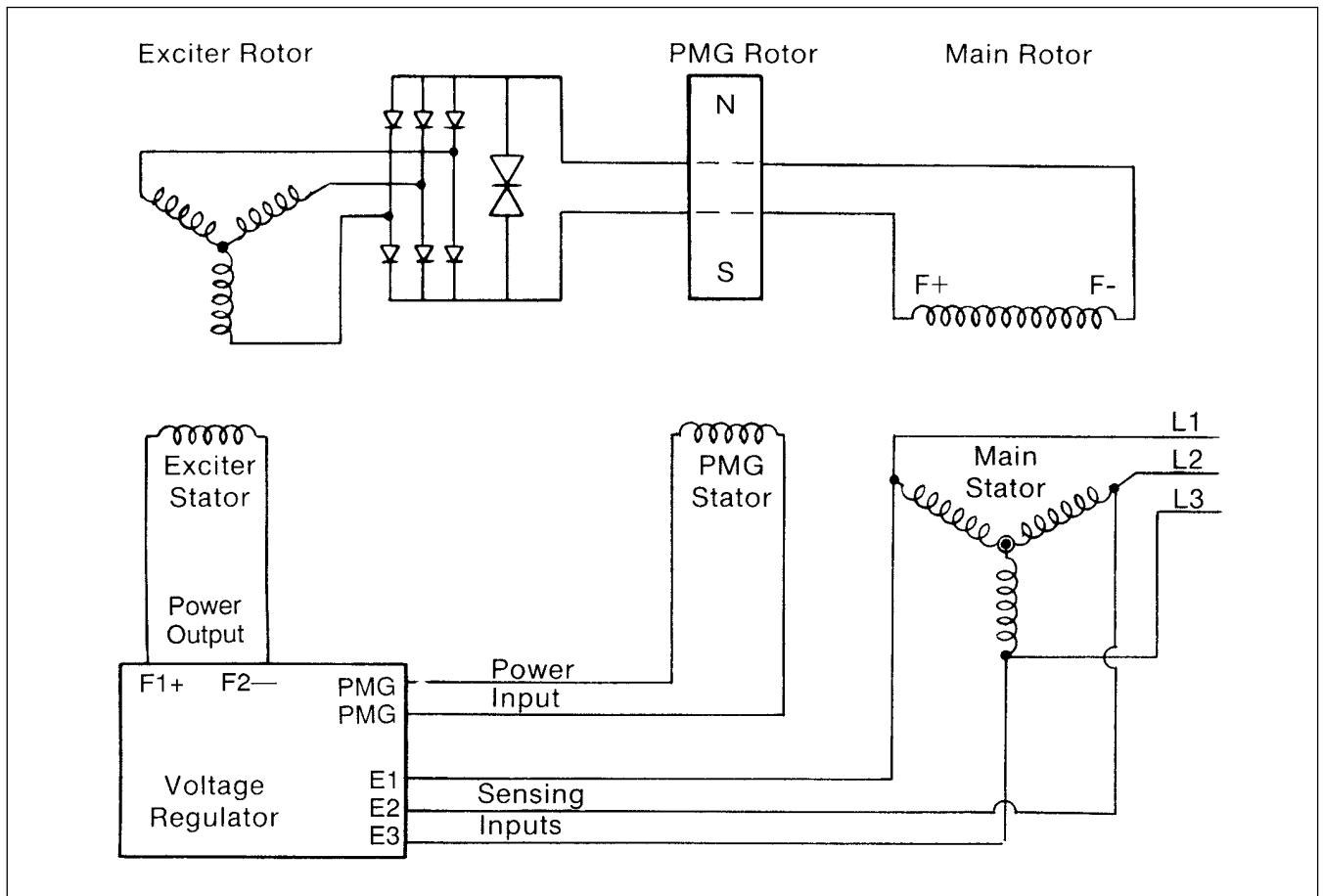
Zigzag connection with 12 lead machine only.

| Voltage | L-L     | Connect   | L <sub>1</sub> | L <sub>2</sub> | L-L0           |
|---------|---------|---|----------------|----------------|----------------|
|         |         |   |                |                |                |
| 60 HZ   | 120/240 | T <sub>1</sub> T <sub>7</sub>                                 | T <sub>1</sub> | T <sub>3</sub> | T <sub>4</sub> |
|         |         | T <sub>2</sub> T <sub>8</sub> T <sub>6</sub> T <sub>12</sub>  |                |                |                |
|         |         | T <sub>4</sub> T <sub>10</sub> T <sub>5</sub> T <sub>11</sub> |                |                |                |
|         |         | T <sub>3</sub> T <sub>9</sub>                                 |                |                |                |

**CAUTION** The generator kW/kVA rating is approximately 50% of its 3 phase rating when connected for single phase.

3

## Typical System Diagram



# Installation

3

## Paralleling Operations

MAGNAMAX<sup>DVR</sup>® generators come standard with amortisseur windings die cast as an integral part of the rotor. This exclusive uni-rotor construction makes all MAGNAMAX<sup>DVR</sup>® generators suitable for paralleling operations when the proper control equipment is added. Paralleling with other generator sets and/or with the utility power grid offers a number of advantages. Multiple unit installations increase power capacity; they can be added or removed from the line depending on the load requirements; they can be better maintained and repaired (since single source breakdown would mean total loss of power), and they often provide more reliable, efficient, and economical operation.

Successful parallel operation means that the generators deliver power to the external system without delivering power to each other, or accepting power from the load bus or power grid. Additional equipment is necessary to insure safe and successful operation.

### Prime Mover

The prime mover provides the speed and torque which will be necessary to keep the machines in synchronized operation. The governor will directly control the watt or kW load and frequency of the unit. The prime mover speed is controlled by a governor. The governor must have special paralleling provisions to permit parallel operation with the other machines.

### Voltage Regulator

The voltage regulator controls the generator output voltage and the reactive power supplied by the generator. When two or more AC generators operate in parallel, the voltage regulator must have paralleling provisions (either internally or external to the regulator) to allow the voltage regulator to control the reactive or VAR load while it is in parallel operation. A separate paralleling current transformer is required to sense the reactive current and signal the voltage regulator. This additional paralleling circuitry is absolutely necessary to control the reactive current flowing between the generator sets.

### Switchgear

There are additional relays and breaker controls which are necessary to insure safe, trouble free operation of paralleled units. Reverse power relays monitor the direction of power flow to insure that the generator is delivering the power, not accepting it. These power relays control breakers, which are a means of connecting and disconnecting the generator from the load. The total system can include over-voltage, over-current protection, under frequency protection, power factor correction provision and various associated control equipment from manual switchgear to microprocessors. The amount of control gear and level of sophistication will be determined by the needs and requirements of the particular application.

### Paralleling Basics

The following points are basic criteria which must be met before two units can be paralleled. THIS IS NOT MEANT TO BE SPECIFIC INSTRUCTIONS FOR PARALLELING OPERATION.

1. Additional paralleling circuitry
  - A. Voltage regulator-paralleling provisions
  - B. Paralleling current transformer(s)
  - C. Paralleling provisions on governor controls
  - D. Switchgear
2. The voltage and frequency must be the same for all sets with voltages in phase.
3. The voltage regulation characteristics of the individual generators should be similar.
4. The generators must have the same phase rotation.
5. The driving engines should have the same speed regulation characteristics and the governors should be adjusted to give the same speed regulation.

Before operating generator sets in parallel, each set should be checked by starting, operating, and adjusting the sets as individual units before attempting paralleling.

### Reactive Load Control

When two identical generators are operating together in parallel and an unbalance occurs in field excitation, circulating currents begin to flow between

the generators. This current will appear as a lagging power factor or inductive load to the highly excited generator, and as a leading power factor or capacitive load to the generator with the lower field current. This is known as the reactive circulating current, and there are two methods of controlling it in parallel operation:

1. Reactive droop compensation (formerly known as parallel droop compensation) – the bus voltage droops, or decreases, as the reactive lagging power factor load is increased.
2. Reactive differential compensation (formerly known as cross current compensation) – the reactive differential compensation circuit allows parallel generators to share reactive loads with no decrease or droop in generator voltage. The circuit must meet the following criteria:
  - A. All paralleling current transformers for all the generators being paralleled must be included in the secondary interconnection loop.
  - B. When different size generators are paralleled, all paralleling current transformers must have the same or proportional ratios that give approximately the same secondary current.
  - C. Voltage regulator paralleling circuitry must be the same.
  - D. Current transformer secondaries and the generator lines must be isolated electrically.

Because of the preceding criteria, reactive differential compensation cannot be used when paralleling with the utility power grid. There is no limit, however, in the number of generators that can be included in this type of circuit.
  - E. It is also desirable to have an auxiliary contact on the main generator breaker to short the parallel CT secondary when that breaker is open (not connected to the load bus).

## Paralleling Circuitry

Because of the number of variables involved in paralleling generator sets, every installation will have its own circuitry and methods or procedure of

bringing paralleled units on line. There are numerous ways of connecting paralleled units and an almost unlimited variety of applications and associated equipment.

When parallel operation is desired, it is important that the control manufacturer, the generator manufacturer, and the systems engineer work together to insure the proper selection of all components. Please refer to Marathon Electric for application assistance.

## Thyristor or SCR Loading

Solid state electronic control devices which utilize thyristors or SCR firing circuits (such as variable frequency induction motor controls, precision motor speed controls, no-break powered battery chargers, etc.) can introduce high frequency harmonics which adversely affect or destroy the normal waveform of the generator. This creates additional heat in the generator stator and rotor and can cause overheating. These devices can and do present problems to non-utility power generating equipment or any limited power bus system. The problems which can occur are not limited to the generator itself, but can effect the solid state control device, the equipment it controls, other associated loads, monitoring devices, or a number of combinations over the entire system.

MAGNAMAX<sup>DVR</sup>® generators can supply power to thyristor or SCR loads when properly applied. When SCR loads are more than 25% of the total load, select the generator based on the 80°C R/R rating. The standard voltage regulator is PMG powered and senses 3 phase RMS voltages for maximum stability against severely distorted wave forms. SCR type applications such as cranes, shovels, etc., require special consideration of the generator insulation system due to greater dielectric stress and severe environmental conditions. It is important that the control manufacturer, the generator manufacturer, and the systems engineer work together to insure the proper selection of all components. Please refer to Marathon Electric for application assistance.



# Operation

4

## Pre-Start Inspection

Before operating the generator for the first time, the following checks are recommended:

1. A visual inspection should be made to check for any loose parts, connections, or foreign materials. Refer to section 8.
2. Check for clearance in the generator and exciter air gap. Be sure the generator set turns over freely. Bar the generator over by hand at least 2 revolutions to be sure there is no interference.

**⚠️ WARNING** Do not apply any force to generator fan when rotating generator rotor. Disregarding these instructions may cause personal injury or equipment damage.

3. Check all wiring against the proper connection diagrams and make sure all connections are properly insulated. Support and tie leads to keep them from being damaged by rotating parts or by chafing on sharp corners.
4. Be sure the equipment is properly grounded.
5. Inspect for any remaining packing materials and remove any loose debris, building materials, rags, etc., that could be drawn into the generator.
6. Check fasteners for tightness.
7. Check to be sure no tools or other hardware have been left inside or near the machine.
8. Install and check to be sure all covers and guards are in place and secure.

**⚠️ WARNING** Residual voltage is present at the generator leads and at the regulator panel connections, even with the regulator fuse removed. Caution must be observed or serious personal injury or death can result. Consult qualified personnel with any questions.

## Starting Up the Generator

The following procedure should be followed for starting up the generator for the first time:

1. The generator output must be disconnected from the load. Be certain that the main circuit breaker is open.
2. Disable the voltage regulator by removing the fuse.

**⚠️ WARNING** Do not overspeed the generator. Excessive centrifugal forces could damage the rotating fields. Be prepared for an emergency shut-down.

3. Follow the manufacturer's instructions and start the prime mover. Check the speed and adjust the rpm shown on the generator nameplate.
4. Replace the regulator fuse and adjust the voltage to the required value (figure 4-2). Check all line to line and line to L0 voltages to be sure they are correct and balanced. If the voltages are not correct, shut down immediately and recheck all connections. See section 3.
5. Close the main circuit breaker and apply the load.
6. Monitor the generator output current to verify it is at or below nameplate amps.
7. Adjust engine speed at full load to 1800 rpm for 60 Hz, 1500 rpm for 50 Hz (refer to prime mover/governor instruction manuals).
8. Before stopping the engine, remove the load by tripping the main circuit breaker.

## Voltage Adjustments

The generator output voltage is controlled by the voltage regulator. There is a cover to access the control panel on the side of the generator conduit box (figures 4-1 and 4-2). Refer to the regulator manual for detailed information. In cases where special or remote mounted regulators are used, refer to instructions supplied by the generator set assembler and to the voltage regulator manual.

## Other Adjustments

Depending upon application, adjustments to other protective and control gear may be required. Refer to instructions supplied by the generator set manufacturer.

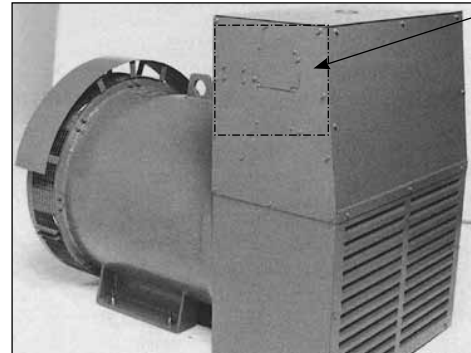
The standard MAGNAMAX<sup>DVR</sup>® voltage regulator also has many protective and control circuits built in. Refer to the regulator manual for further details.

## Field Flashing

The standard MAGNAMAX<sup>DVR</sup>® generator is supplied with a PMG (permanent magnet generator). It will never require field flashing.

In rare cases where a special generator may be furnished without a PMG, refer to the factory for more detailed information. Include the complete generator model and serial number (see page 3).

## Regulator Access



See Figure 4-2 for enhanced view of this area.

Figure 4-1

## Standard Marathon Electric Regulator



Figure 4-2

# Maintenance

## Maintenance – General Information

Dirt, heat, moisture, and vibration are common enemies of a generator. Keeping the generator clean and dry, maintaining proper alignment of the generator and its prime mover, and preventing overloads will result in efficient operation and long life.

Generators that are outdoors should be protected from the elements by suitable houses or enclosures.

Dirt and dust will conduct electricity between points of different electrical potential. Moisture will aggravate the problem further. Insulation system failure can result if corrective action is not taken. The condition of the insulation system can be tested by measuring insulation resistance (see section 8 - Generator Testing).

Insulation resistance should be checked when putting the generator into service after it has been in storage and any time contamination by moisture and dirt is suspected. Normally, moisture buildup is not a problem when the generator is running since heat produced internally will tend to keep it dry. Moisture can collect in the generator when it is shut down. The problem will be worse in humid environments or in areas where extreme temperature changes cause condensation (dew) to form inside the generator. Space heaters, air filters, and premium insulation systems, such as our VPI process, should be considered in difficult environments.

Accumulations of dust and dirt not only contribute to insulation breakdown, but they can also increase temperature by restricting ventilation and by blocking the dissipation of heat. Some machines are exposed to accumulations of materials such as talc, lint, rock dust, or cement dust which may obstruct the ventilation. The most harmful type of foreign materials include carbon black, metallic dust and chips, and similar substances which not only impede the ventilation, but also form a conductive film over the insulation, increasing the possibility of insulation failure. Machines operating in dirty places should be disassembled and cleaned periodically.

## Air Intake and Exhaust

Check the area around the air intake and exhaust openings to be sure they are clean and unobstructed. Remove all foreign material and clean all screens (figure 5-1).

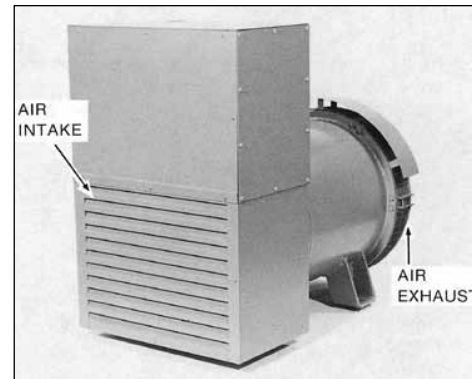


Figure 5-1

## Electrical Connections and Windings

Inspect for loose or contaminated connections. Check wires for cracked or frayed insulation. Tighten connections and replace defective or oil-soaked insulation.

If inspection shows that varnish coatings on the windings have deteriorated, they should be recoated with insulating varnish. Please refer to Marathon Electric for insulation system requirements.

## Lubrication

All generators are lubricated before leaving the factory and are ready for operation. As a general rule, bearings should be relubricated annually or at the indicated intervals in table 5-3, whichever occurs first. Unusually severe operating conditions, such as high ambient or dusty environments, require more frequent lubrication (every six months or one-half the table intervals, whichever occurs first).

Use Mobil® Polyrex® EM or equivalent anti-friction type, high quality grease with a lubrication temperature range of -22° to +350°F (-30° to +175°C).

During an overhaul, the grease reservoir should be thoroughly cleaned and new grease added. The reservoir should be 1/3 to 1/2 filled with new grease.

**NOTE:** Mobil and Polyrex are registered trademarks of Exxon Mobil Corporation or one of its subsidiaries.

## Lubrication

**CAUTION** Follow the generator nameplate recommendations for grease interval and amount. Table 5-3 intervals and amounts are general guidelines.

**CAUTION** Generators are pre-greased with Mobil® Polyrex® EM NGLI 2 grease unless stated otherwise on the generator nameplate. Non-compatible lubricants can break down polyurea thickened grease and cause bearing failure. Compatible greases include, but are not limited to, Chevron® SRI, Shell® Gadus® S5 T100, Rykon® Premium EP NLGI 2, Texaco® Polystar® RB NLGI 2, and Shell® Oil Dolium R. Use only non-contaminated grease and prevent contamination while regreasing.

**CAUTION** Overgreasing bearings can cause premature bearing and/or generator failure. The quantity of grease added must be carefully controlled.

Generators are properly lubricated at the time of manufacture. It is not necessary to lubricate at the time of installation unless the generator has been in storage for a period of 12 months or longer.

## Lubrication Procedure

1. Read CAUTION statements at left.
2. Stop generator and lock-out of service.
3. Remove contaminants from fill and drain plugs and surrounding area.
4. Remove fill and drain plugs. (Figure 5-2)
5. Check fill and drain holes for blockage and clean as necessary to allow unobstructed grease flow.
6. Insert 1/8" N.P.T. grease fitting in fill pipe.
7. Add proper type and amount of grease per generator nameplate or see Table 5-3
8. Start unit with drain plug removed. Allow unit to run 15 minutes to allow excess grease to drain.
9. Wipe off excess grease and replace fill and drain plugs. Generator is ready for operation.

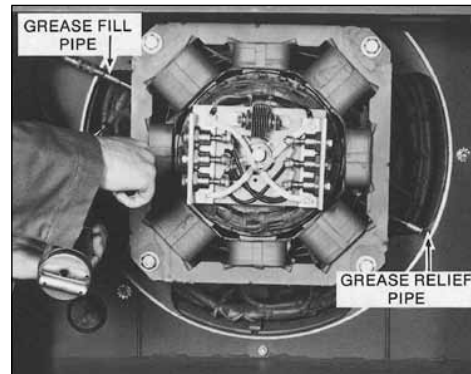


Figure 5-2

Table 5-3

| Type                 | Frame Size           | Bearing Size | Amount of Grease |              |           | Intervals ① |       |
|----------------------|----------------------|--------------|------------------|--------------|-----------|-------------|-------|
|                      |                      |              | Ounces           | Cubic Inches | Teaspoons | 60 Hz       | 50 Hz |
| Single Bearing Units | 431, 432<br>433      | 314          | 1.2              | 2.1          | 7.0       | 6500        | 8400  |
|                      | 571, 572<br>573, 574 | 316          | 1.5              | 2.6          | 8.3       | 5600        | 7200  |
|                      | 741, 742<br>743, 744 | 322          | 2.4              | 4.2          | 14.0      | 3000        | 4500  |
| Double Bearing Units | 431, 432<br>433      | 318          | 1.7              | 3.0          | 9.9       | 4600        | 6200  |
|                      | 571, 572<br>573, 574 | 318          | 1.7              | 3.0          | 9.9       | 4600        | 6200  |
|                      | 741, 742<br>743, 744 | 322          | 2.4              | 4.2          | 14.0      | 3000        | 4500  |

① Hours of running time or annually, whichever occurs first.

# Maintenance

## Drying Electrical Insulation

Electrical components must be dried before placing in operation if tests indicate that the insulation resistance is below a safe value (see section 8 – generator testing for test procedure).

Machines that have been idle for sometime in unheated and damp locations may have absorbed moisture. Sudden changes in temperature can cause condensation or the generator may have become wet by accident. Windings should be dried out thoroughly before being put into service. The following are recommended drying methods.

### Space Heaters

Electric space heaters can be installed inside of the generator. When energized (from a power source other than the generator), they will heat and dry the inside of the generator. If an alternate source of electricity is not available, enclose the generator with a covering and insert heating units to raise the temperature 15–18°F (8–10°C) above the temperature outside of the enclosure. Leave a hole at the top of the enclosure to permit the escape of moisture.

### Oven

Place the machine in an oven and bake it at a temperature not to exceed 194°F (90°C). The voltage regulator and any electronic component accessories must be removed from the generator when using this method.

### Forced Air

A portable forced air heater can be used by directing heat into the air intake (conduit box) and running the generator with no load and without excitation (this can be accomplished by removing the regulator fuse). Heat at point of entry should not exceed 150°F (66°C).

### “Short Circuit” Method

The generator can be dried out quickly and thoroughly by using this method.

**⚠️ WARNING** Be sure that all of the following steps are performed and all precautions taken as personal injury or serious damage to the generator could result.

1. Disconnect exciter leads F1 and F2 from the regulator.
2. Connect a battery or other DC power source of approximately 20–35 volts to the exciter leads F1 and F2. An adjustable voltage source is desirable, however a rheostat (rated approximately 2 amps) in series with the DC power source will work.
3. Short circuit the generator output lead wires to each other (L1 to L2 to L3). If using jumpers, be sure they are large enough to carry full load amperage.
4. Start the generator and measure the current through the output leads with a clip-on ammeter.
5. Adjust the voltage source to produce approximately 80% of the rated AC nameplate amps, but in no case exceed nameplate amps. If an adjustable source is not available and current is excessive, use a lower DC source voltage or a larger resistor in series with the source.

Running time will be determined by the amount of moisture present in the machine. Insulation resistance checks should be taken every one to four hours until a fairly constant value is obtained (see section 8 – Generator Testing for instructions on measuring insulation resistance).

6. After the generator is dry and the insulation resistance is brought up to specifications, remove the short circuit from the line leads, disconnect the DC source, and reconnect the F1 and F2 leads at the regulator. Be sure all connections are tight and correct before attempting to run the generator.

## Cleaning Methods

When electrical components get dirty, the insulation must be cleaned. There are a number of acceptable methods for cleaning the generator, each of which will necessitate disassembly of the unit. The method of cleaning will be determined by the kind of dirt and when the unit must be returned to service. Drying after cleaning is necessary.

Whenever the generator is disassembled, the windings should be given a thorough inspection and the insulation cleaned, if necessary. The inspection should include the connection of the windings, insulation, and varnish coverage. Check the winding ties and coil supports. Look for any signs of coil movement or looseness and repair as required.

An electric motor repair shop in your area can normally assist with the proper cleaning of the generator windings. They may also be experienced in special problems (such as seacost, marine, oil rig, mining, etc.) that may be peculiar to a certain area.

### Solvents

A solvent is usually required to remove accumulated soil containing oil or grease.

Only petroleum distillates should be used for cleaning electrical components.

Petroleum solvents of the safety type with a flash point greater than 100°F (38°C) are recommended.

**CAUTION** Winding varnishes are epoxy or polyester based. A solvent that does not attack these materials should be used.

**WARNING** Adequate ventilation must be available to avoid fire, explosion, and health hazards where solvents are used. Avoid breathing solvent vapors. Rubber gloves or other suitable protection for the hands should be used. Wear eye protection.

Apply the solvent with a soft brush or rag. Be careful not to damage the magnet wire or insulation on the windings.

Dry components thoroughly with moisture-free, low pressure compressed air.

### Cloth and Compressed Air

Cleaning with a dry cloth may be satisfactory when components are small, the surfaces are accessible, and only dry dirt is removed.

Blowing dirt out with compressed air is usually effective particularly when the dirt has collected in places which cannot be reached with a cloth. Use clean dry air at 30 psi (206 KPa).

### Brushing and Vacuum Cleaning

Dry dust and dirt may be removed by brushing with bristle brushes followed by vacuum cleaning. **Do not use wire brushes.** Vacuum cleaning is an effective and desirable method of removing dry and loose dirt.

### Shell Blasting

Air blasting with ground nut shells may be satisfactory for removal of hard dirt deposits from insulation. Use mild abrasives such as 12–20 mesh ground walnut shells.

### Steam Cleaning

If the generator is completely disassembled, including bearings and electronic components, steam cleaning of the major parts and windings is very effective. However, before the generator can be put back into service, the machine must be thoroughly dried in an oven to remove all moisture.

# Service

## Removal from Prime Mover

**⚠️WARNING** Be sure all power is off before servicing. Failure to follow all safety instructions can result in serious personal injury or death.

**Note:** Before disconnecting any electrical wiring, be sure it is marked and can be identified for reinstallation. Remark as required.

1. Remove conduit box covers (figures 6-1 and 6-2).
2. Disconnect all external wiring from the generator leads (or bus bars) inside the conduit box.
3. Remove all conduit or ducting from the conduit box.
4. Attach a suitable hoist to the generator lifting lugs.
5. a. For single bearing generators, remove the bolts mounting the screen assembly to the SAE adapter and remove the screen (figure 6-3). (**Note:** Do not remove the dripcover from the screen assembly if so equipped.) Remove the capscrews attaching the drive discs to the flywheel and remove the capscrews attaching the SAE adapter to the flywheel housing.  
b. For two-bearing generators, disconnect the coupling or sheave and belts between the generator and prime mover (follow the coupling manufacturer's instructions for disconnection).

**⚠️WARNING** Do not apply any force to the generator fan for lifting or rotating the generator rotor. Disregarding these instructions may cause personal injury or equipment damage.

6. Remove the mounting bolts which secure the generator to the base. To make reinstallation easier, note the position of and save any shims that were used under the feet for alignment.
7. Raise the generator slightly and move the generator away from the prime mover. Raise or lower the generator to take pressure off of the drive discs so they slide easily out of the flywheel.
8. On single bearing generators, if generator is to be shipped, see Shipping Instructions (section 11) for proper rotor support.



Figure 6-1

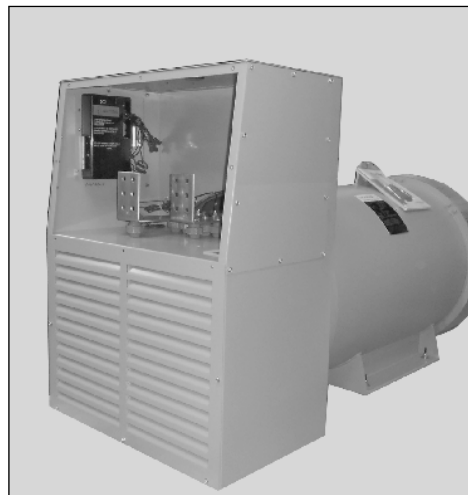


Figure 6-2

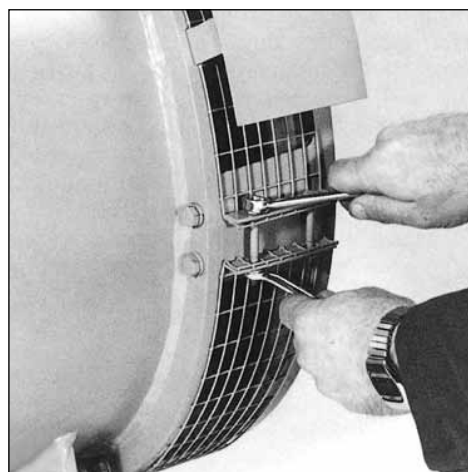


Figure 6-3

## Conduit Box Removal

1. Note the location and markings (remark as required) and remove connections from voltage regulator, capacitor, and any other conduit box mounted control (figures 6-4 and 6-5).
2. On generators equipped with bus bars, mark all connections and disassemble main stator (power) leads from the generator side of the bus bars.
3. Remove bolts holding conduit box in place (figure 6-6).
4. Remove conduit box (figure 6-7).



Figure 6-6



Figure 6-4

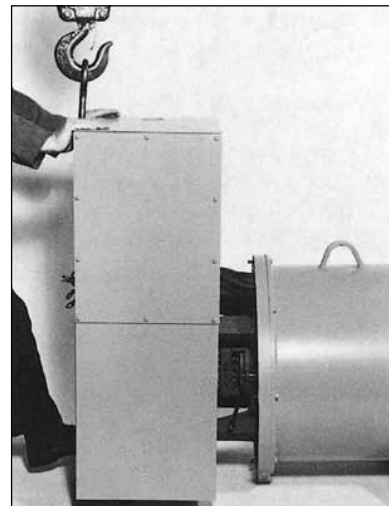


Figure 6-7

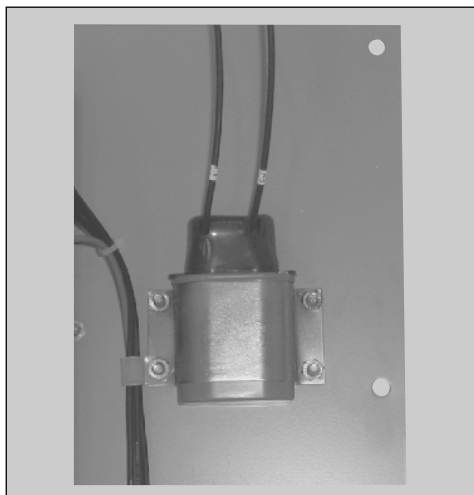


Figure 6-5



# Service

## Exciter Stator (Field) Removal

1. Disconnect F1 and F2 leads from the corresponding F1 and F2 terminals on the regulator.
2. Remove all cable ties so the F1 and F2 leads can be removed with the exciter stator. Remove the four capscrews and belleville washers holding the exciter stator in place (figure 6-8). Remove the exciter stator using a lifting strap or fixture (figure 6-9).

## Exciter Armature (Rotor) Removal

1. Note markings and disconnect the main rotor leads coming out of the aluminum standoff plate lead hole from the rectifier aluminum angle (figure 6-10).
2. Remove the capscrew and belleville washer which holds the exciter (rotor) armature to the generator shaft (figure 6-11).
3. Use a six inch, 7/8-14NF capscrew for a puller (see section 9). The hole that the mounting bolt goes through is threaded. Screw the puller bolt into the hole and it will push against the end of the shaft (figure 6-12). Carefully feed the main rotor leads through the hole as the exciter armature is removed (figure 6-13).

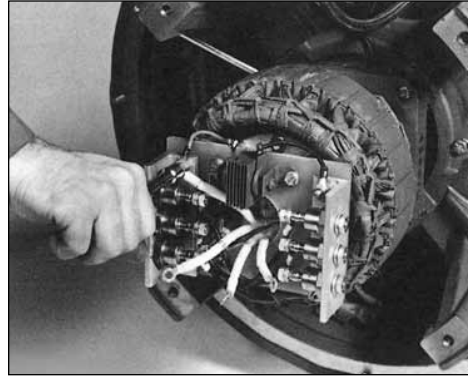


Figure 6-10

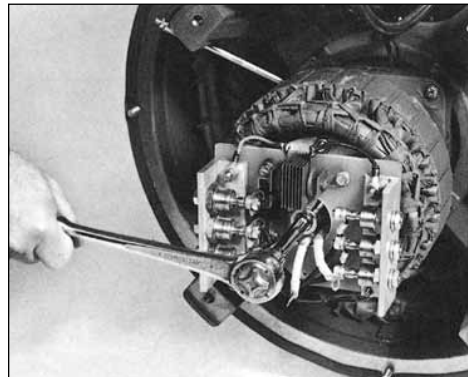


Figure 6-11

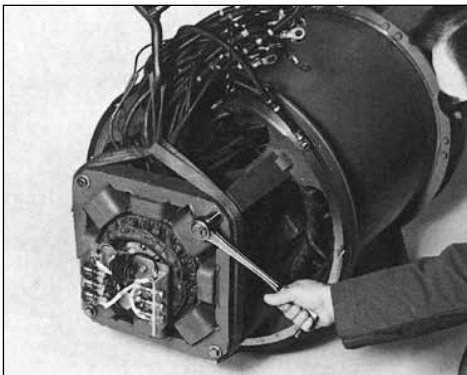


Figure 6-8

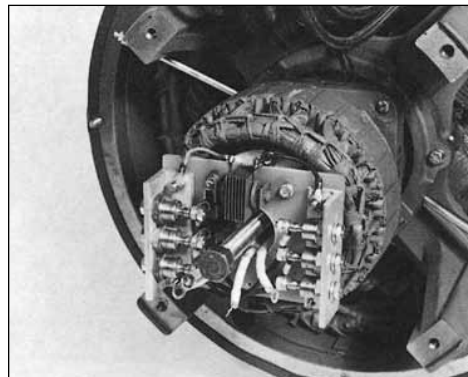


Figure 6-12

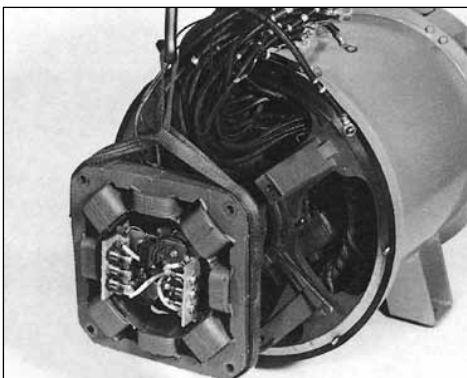


Figure 6-9

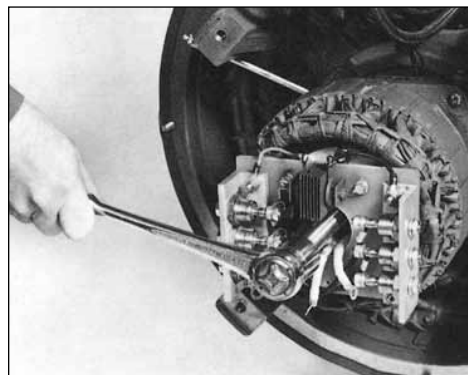


Figure 6-13

**CAUTION** Do not tighten the puller bolt beyond the end of the threads. If a bolt with sufficient thread length cannot be found, use a piece of threaded rod with a nut welded on the end.

## PMG Stator Removal

1. Remove exciter armature (follow instructions found earlier in this section).
2. Remove the PMG output leads from the capacitor (figure 6-14) and loosen all cable ties so the leads can be removed with the PMG stator.
3. Note the position of the PMG stator leads which exit at the left inboard side or mark the stator so it can be reinstalled in the same position.
4. Remove the four mounting capscrews (see figure 6-15).
5. Carefully remove the PMG stator from its mounting pads and slide over the PMG rotor. The magnets used in the PMG are very strong. They will resist removal of the PMG stator (figure 6-16).

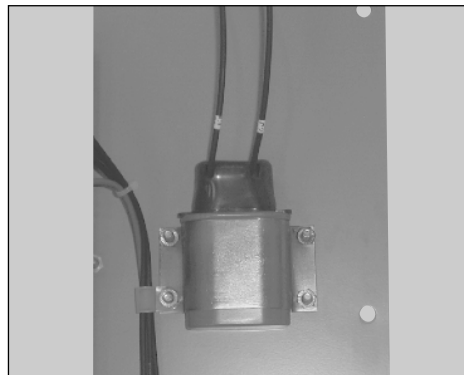


Figure 6-14

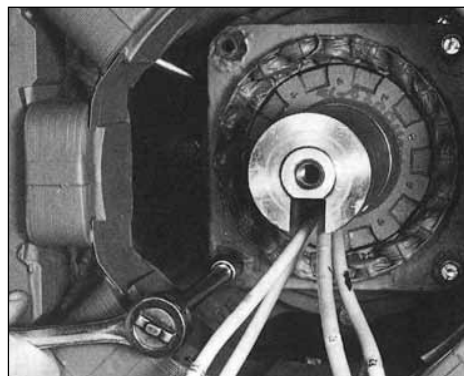


Figure 6-15

## PMG Rotor Removal

1. Remove the exciter armature and PMG stator (follow instructions found earlier in this section).
2. Remove the snap ring which holds the PMG rotor in place on the shaft (figures 6-17 and 6-18).

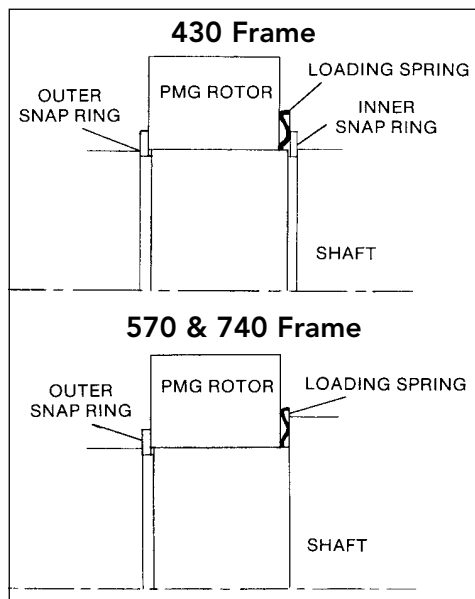


Figure 6-18



Figure 6-16

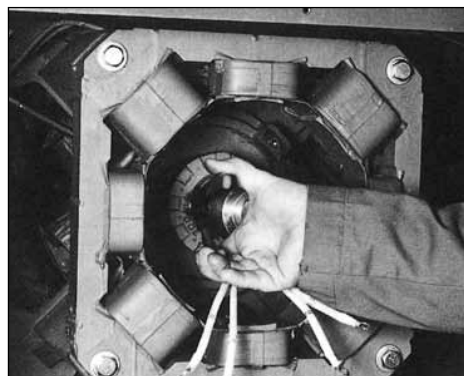


Figure 6-17

3. Slide the PMG rotor off of the shaft (figure 6-19).
4. Remove the loading spring (if the loading spring is not on the shaft, check to see if it is stuck on the back of the PMG rotor).
5. On 430 frame generators, a second snap ring is used inboard of the PMG rotor (larger generators have a step on the shaft). This snap ring must be removed before the generator's main rotor can be removed (figure 6-20).

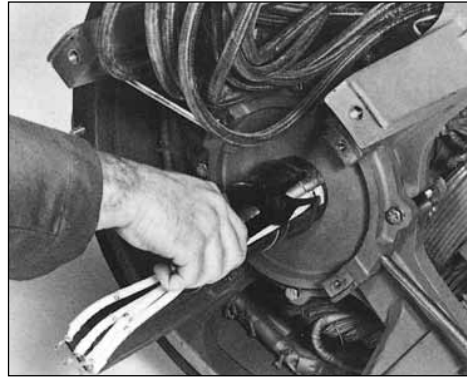


Figure 6-20

## Main Rotor Removal

1. Remove the exciter armature and PMG (follow instructions found earlier in this section).
2. a. For single bearing generators, remove the four capscrews holding the bearing caps to the front end bracket (figure 6-21). Remove the outer cap (figure 6-22).
- b. For two-bearing generators, remove the drive coupling or sheave and key from the shaft extension. Remove the four capscrews holding the bearing lock to the drive end bracket (figure 6-23). Remove the four capscrews holding the bearing caps to the front end bracket (figure 6-21). Remove the outer cap (figure 6-22).

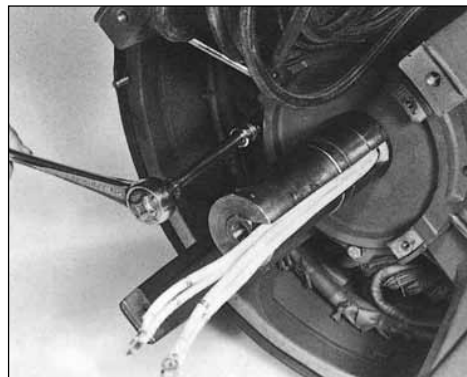


Figure 6-21

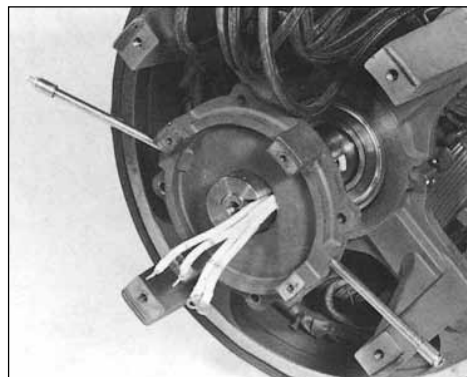


Figure 6-22



Figure 6-19

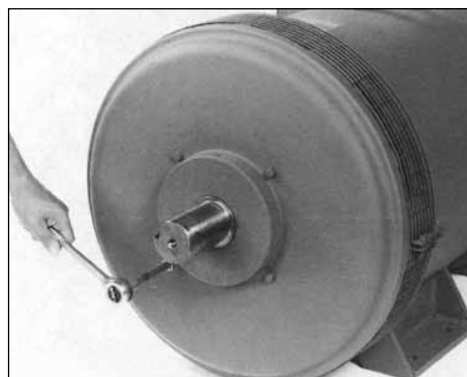


Figure 6-23

3. If the screen assembly is still mounted, remove the bolts securing the screen assembly to the drive end bracket or the SAE adapter and remove the screen assembly (figure 6-24). (**Note:** Do not remove the drip cover from the screen assembly if so equipped).
4. For single bearing generators, remove the capscrews and hardened washers holding the drive discs to the drive hub (figure 6-25). Remove all drive discs (and spacers, if any).
5.
  - a. For single bearing generators, remove the capscrews holding the SAE adapter to the generator and remove the adapter (figures 6-26 and 6-27).
  - b. For two-bearing generators, remove the capscrews holding the drive end bracket to the generator and remove the bracket (figures 6-26 and 6-28).

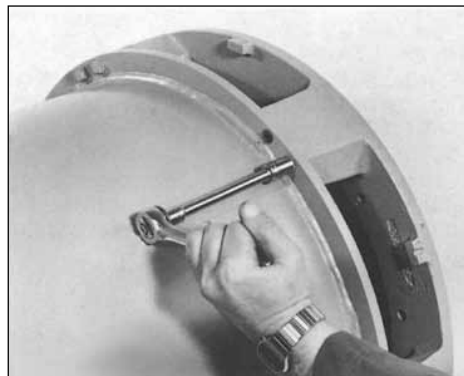


Figure 6-26

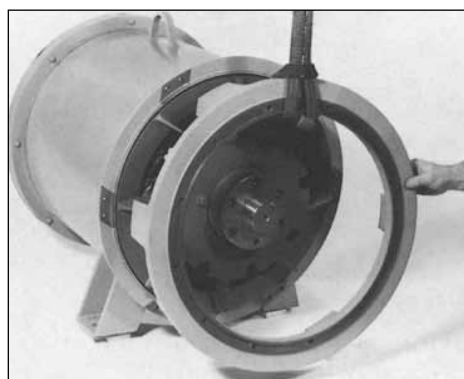


Figure 6-27

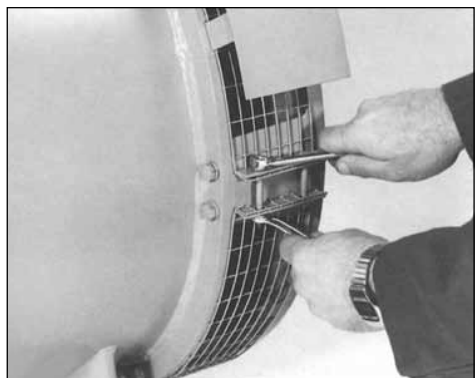


Figure 6-24

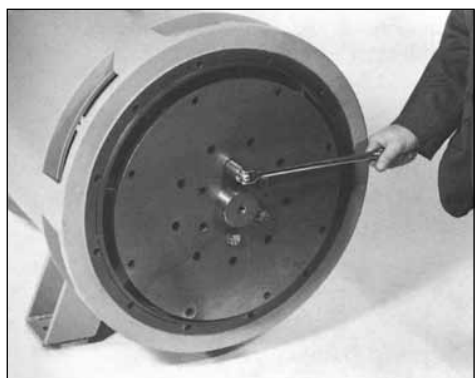


Figure 6-25

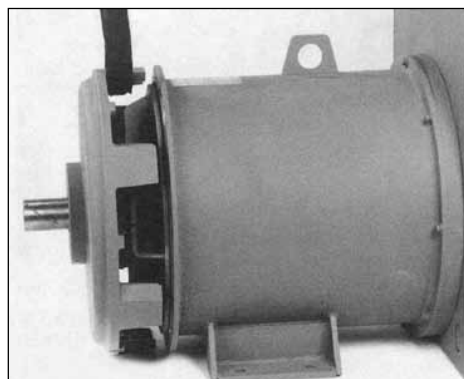


Figure 6-28

# Service

**CAUTION** On large generators, a hoist and lifting strap should be used to assist in drive end bracket or SAE adaptor removal.

- Using a rotor lifting fixture and a suitable hoist, carefully remove the rotor assembly from the main stator and frame assembly through the drive end (figure 6-29).

**CAUTION** Special care should be taken when removing the main rotor, winding damage could result if the rotor is allowed to hit the main stator.

**WARNING** Do not apply any force to the generator fan for lifting or rotating the generator rotor. Disregarding these instructions may cause personal injury or equipment damage.

## Front End Bracket Removal

- Remove front bracket mounting screws (figure 6-30).
- Remove the front end bracket from the main stator assembly (figure 6-31).

**CAUTION** On large generators, a hoist and lifting strap should be used to assist in the front end bracket removal.

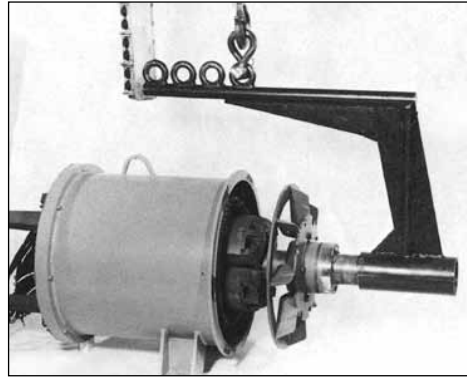


Figure 6-29

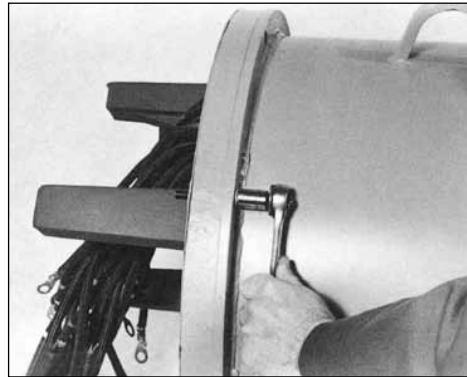


Figure 6-30

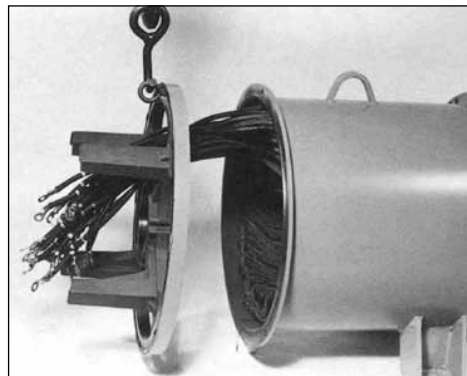


Figure 6-31

## Exciter Inspection

### A. Exciter Stator

1. Clean dust and dirt from the stator winding (see figure 6-32 and section 5).
2. Check the exciter stator for a loose, frayed, or burnt winding. Measure winding resistance and insulation resistance (see section 8). Repair or replace as necessary. If field repair of the winding is necessary, contact Marathon Electric for special winding procedures and materials.
3. Look for score marks in the bore of the exciter core caused by rubbing (this could indicate bearing or assembly problems and should be investigated).

### B. Exciter (Rotor) Armature

1. Clean dust and dirt from the exciter armature and rectifier assembly (see figure 6-32 and section 5).
2. Check the exciter armature for burrs on the mating surfaces.
3. Check the rectifiers and surge protector for proper operation (see section 8). Replace defective parts.

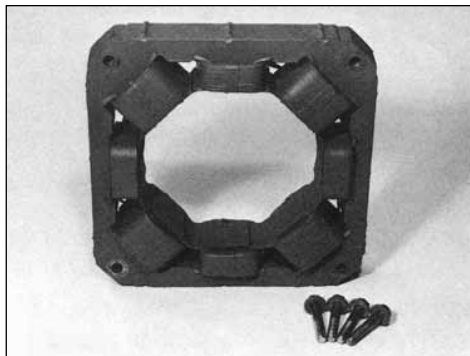


Figure 6-32

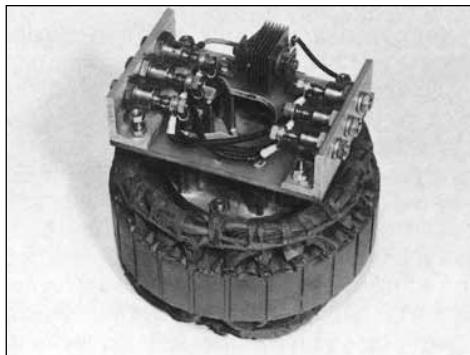


Figure 6-33

**CAUTION** Three forward polarity and three reverse polarity diodes are used. Be sure you have the correct part installed in the correct location. The surge suppressor is polarized. Observe polarity markings when changing the surge suppressor (figure 6-34).

Torque mounting nuts to 80 in-lb.

Torque lead terminal nuts to 25 in-lb.

Never torque against the diode terminal – use a 7/16 inch wrench to support the terminal (figure 6-35).

4. Check the exciter armature and rectifier assembly for a loose, frayed, or burnt winding or loose connections. Measure winding resistance and insulation resistance (see section 8). DO NOT megger diodes or surge suppressor. Repair or replace as necessary. If field repair of the winding is necessary, contact Marathon Electric for special winding procedures and materials.
5. Look for score marks on the outside diameter of the armature core caused by rubbing (this could indicate bearing or assembly problems and should be investigated).

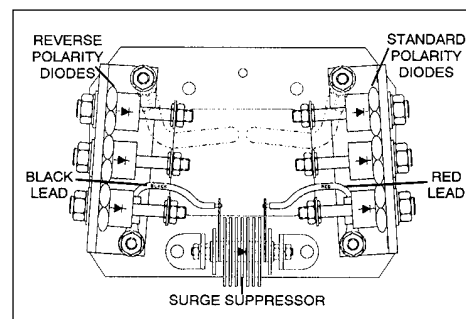


Figure 6-34

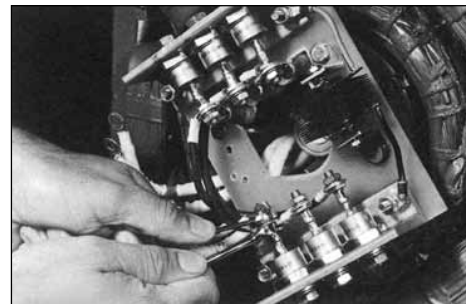


Figure 6-35

## PMG Inspection

### A. PMG Stator (figure 6-36)

1. Clean dust and dirt from the PMG stator winding (see section 5).
2. Check PMG stator for a loose, frayed, or burnt winding. Measure winding resistance and insulation resistance (see section 8). Repair or replace as necessary. Contact Marathon Electric for special winding procedures and materials.
3. Look for score marks in the bore caused by rubbing (this could indicate bearing or assembly problems and should be investigated).

### B. PMG Rotor (figure 6-37)

**⚠️WARNING** The PMG rotor uses very strong magnets. Keep away from iron and steel parts that could be drawn to the magnets. Keep away from other components that can be damaged by strong magnetic fields.

1. Clean dust and dirt from the PMG rotor (see section 5).
2. Check to be sure all magnets are tightly bonded to the PMG rotor.
3. Check for burrs or corrosion in the bore and keyway where the rotor mounts to the shaft.
4. Look for score marks on the outside diameter caused by rubbing (this could indicate bearing or assembly problems and should be investigated).
5. Inspect snap rings and loading spring; replace as required.

## Main Rotor Inspection

### A. Bearing

1. Check the bearing for damage or wear. Clean the old grease from the bearing cap, and fill the bearing cap grease cavity 1/3 to 1/2 full of new Mobil® Polyrex® EM (or equivalent-see page 17).

**⚠️CAUTION** If the bearing needs to be removed for any reason, always install a new bearing.

2. If the bearing is to be replaced, remove with a suitable puller (figure 6-38).
3. **Be sure the inner bearing cap is on the shaft before installing the new bearing.**
4. Heat the new bearing in an oven to a maximum temperature of 212°F (100°C). Apply a thin coat of clean lubricating oil to the press-fit area of the rotor shaft. Using suitable heat resistant gloves, install the bearing over the end of the shaft until it seats against the shaft shoulder (figure 6-39). The bearing should slide on the shaft and be seated without excessive force. If the bearing binds on the shaft before being fully seated, a piece of tubing, slightly larger than the press-fit area, can be used to drive the bearing into place. Using light taps with a soft mallet, apply pressure to the inner race only.

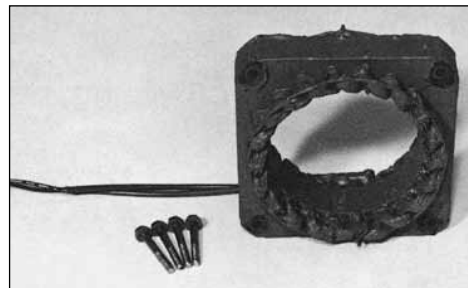


Figure 6-36



Figure 6-37

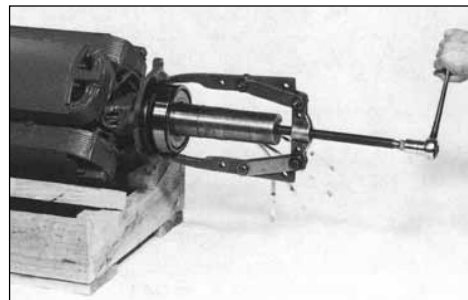


Figure 6-38

**NOTE:** Mobil and Polyrex are registered trademarks of Exxon Mobil Corporation or one of its subsidiaries.

**CAUTION** Under no circumstances should pressure be applied to the outer race of the bearing, as permanent bearing damage could result.

Allow the bearing to cool for one hour before attempting to assemble the generator.

## B. Fan

1. Check the fan for cracks or broken blades. Replace the fan if defective.
2. Mark the hub and fan for alignment. This is necessary to be sure the balance weights will be in the same position when the fan is reinstalled.
3.
  - a. For single bearing generators, remove the fan mounting capscrews (figure 6-40) and slide the fan off the shaft (figure 6-41).
  - b. For two-bearing generators, remove the drive end bearing and bearing cap (see bearing removal instructions). Remove the fan mounting capscrews and slide fan off the shaft (figure 6-40 & 6-41).
4. To install, slide the fan on the shaft making sure the fan mounting surface is toward the drive hub. Align reference marks (this is important for assembly balance) and mount the fan to the drive hub with the capscrews and belleville washers (figure 6-42). Torque the capscrews to 60 ft-lb (81 N-m).
5. **Note:** Balance weights on the fan are for balance of the complete rotor assembly. The rotor assembly should be rebalanced if a new fan has been installed.
6. On two-bearing generators, install bearing cap and new bearing according to the bearing assembly instructions (Item A).

## C. Drive Hub (Single Bearing Generators Only)

1. Check the drive hub for cracks or stripped drive disc mounting holes. Replace the hub if defective.



Figure 6-39



Figure 6-40

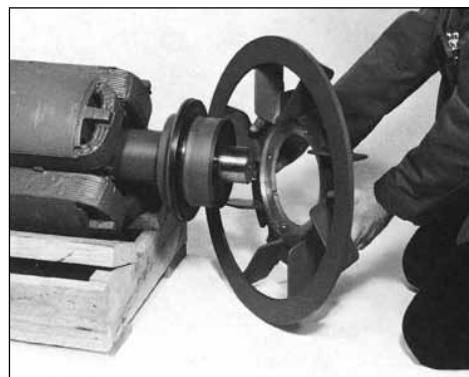


Figure 6-41

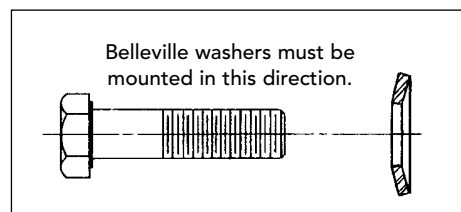


Figure 6-42



2. If the hub is to be replaced, remove the fan (see Item B) and install a suitable puller to the hub. Remove the two setscrews in the hub over the key. Using a torch, rapidly heat the hub at the outer diameter while tightening the puller (this must be done rapidly before the heat can expand the shaft). Remove the hub (figure 6-43).
3. To insure proper fan location, mark the new hub in the same place as the old hub relative to the keyway. Install key in shaft. Heat the new hub in an oven to 500-600°F (260-316°C). Using suitable heat resistant gloves, slide the hub over the key in the shaft until it seats against the shaft shoulder (figure 6-44).
4. Allow the hub to cool for one hour. After the hub has cooled, tighten the setscrews in the hub to 50 ft-lb (68 N-m) torque. Match the alignment marks on the fan and hub and mount the fan (see Item B).
5. Rebalancing the rotor assembly is not necessary if only the hub is replaced and the fan is mounted in the same location relative to the hub and shaft.

#### D. Main Rotor Core and Windings

1. Clean all parts. Remove dust and dirt from the rotor windings (see section 5).

Remove any accumulated dust or dirt in the winding air passages with a piece of wire or with low-pressure, moisture-free air (figure 6-45).

**CAUTION** If a piece of wire is used for cleaning the air passages, care must be taken not to scratch the winding as this could cause an insulation failure.

2. Check the rotor for loose, frayed, or burnt windings. Measure winding resistance and insulation resistance (see section 8). Test for shorted turns using an AC impedance test (see section 8). A defective rotor winding must be rewound by Marathon Electric. The rotor assembly must be rebalanced after any rework or repair has been completed.

#### E. Drive Discs (Single Bearing Generators Only)

1. Inspect the drive discs for distorted or bent edges (figure 6-46). Inspect for worn mounting holes. Replace all defective discs as necessary.
2. Inspect the drive disc mounting capscrews for damaged threads. Replace capscrews if damaged.



Figure 6-43



Figure 6-44



Figure 6-45

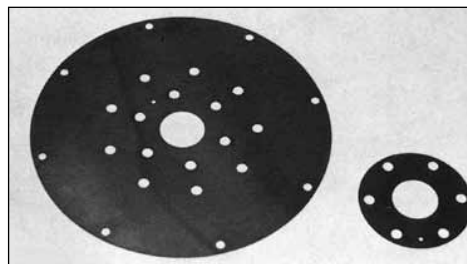


Figure 6-46

## Front (Exciter) End Bracket Inspection

1. Remove the filler and drain grease pipes and the grease plugs from outer bearing cap (figure 6-47).
2. Clean the end bracket, outer bearing cap, grease pipes, and capscrews to remove all dust, dirt, and grease.
3. Inspect the capscrews for stripped threads and replace if defective.
4. Inspect the end bracket for stripped threads, cracks, and burred or rough mating surfaces. Inspect the bearing bore for burrs or wear. If the bracket shows excessive bearing bore wear, it should be repaired or replaced (figure 6-48).
5. Inspect the mounting pads for the PMG stator and exciter stator. Be sure they are smooth, clean, and free of any burrs or rust that could interfere with proper alignment (figures 6-47 and 6-48).
6. Reassemble the grease pipes and fittings to the bearing cap.

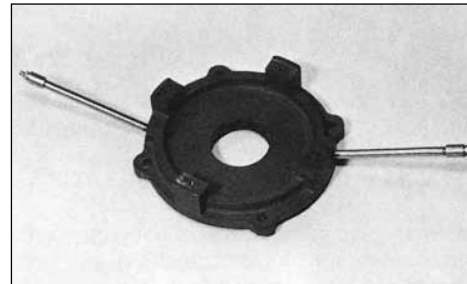


Figure 6-47



Figure 6-48

## Drive End Bracket or SAE Adapter Inspection

1. For two-bearing generators, remove the grease plugs from the bracket.
2. Clean the bracket or adapter, capscrews, and screen assembly to remove all dust, dirt, and grease.
3. Inspect the capscrews for stripped threads and replace if defective.
4. Inspect the bracket or adapter for stripped threads, cracks, and burred or rough mating surfaces (figures 6-49 and 6-50).
5. For two-bearing generators, inspect the bearing bore for burrs or wear. If the drive end bracket shows excessive bearing bore wear, it should be repaired or replaced.

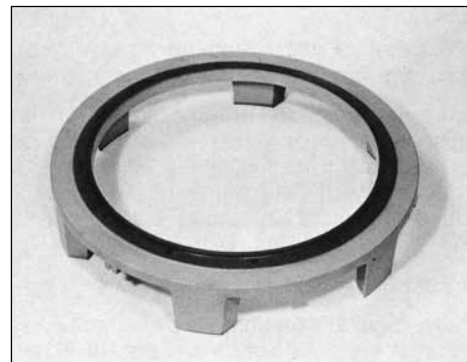


Figure 6-49

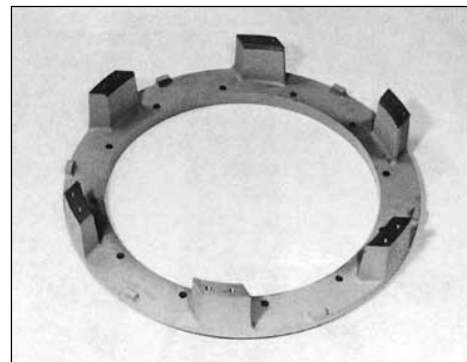


Figure 6-50

# Service

## Main Stator Inspection

1. Clean dust and dirt from the stator frame and winding (see figure 6-51 and section 5).
2. Inspect the frame for stripped threads, cracks, burred mating surfaces, or other damage.
3. Inspect the stator for a loose, frayed, or burnt winding. Measure winding resistance and insulation resistance (see section 8). Repair or replace as necessary. If field repair of the winding is necessary, contact Marathon Electric for winding data.

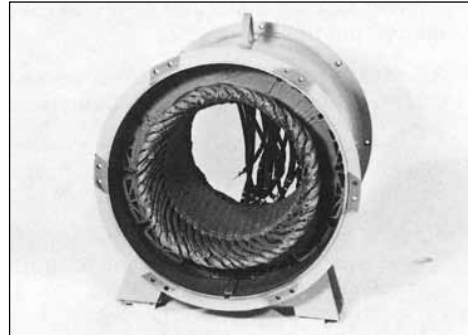


Figure 6-51

## Front End Bracket Installation

1. Install two guide pins (threaded rod can be used) into the generator side of the end bracket mounting holes. Align the guide pins with the holes in the generator frame and slide the bracket onto the frame (figure 6-52). Install bracket mounting capscrews (figure 6-53).

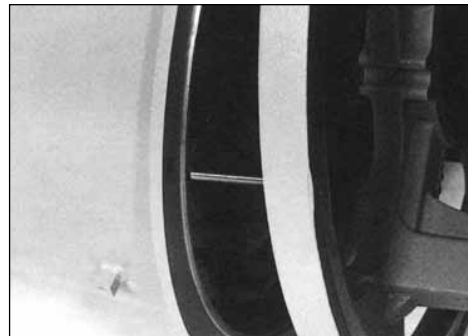


Figure 6-52

**CAUTION** On large generators, a hoist and lifting strap should be used to assist in the front end bracket installation.

2. Remove the two guide pins and insert the remaining capscrews and torque to specifications given in section 12.



Figure 6-53

## Main Rotor Installation

1. Grease bearing cavity and bearing with Mobil® Polyrex® EM grease (or equivalent - see page 17).
2. Using a rotor lifting fixture and a suitable hoist, carefully install the rotor assembly into the main stator assembly through the drive end (figure 6-54). Carefully feed the rotor leads through the front end bracket shaft hole as the rotor is installed.

**CAUTION** Special care should be taken when installing the rotor assembly. Winding damage could result if the rotor is allowed to hit the main stator.

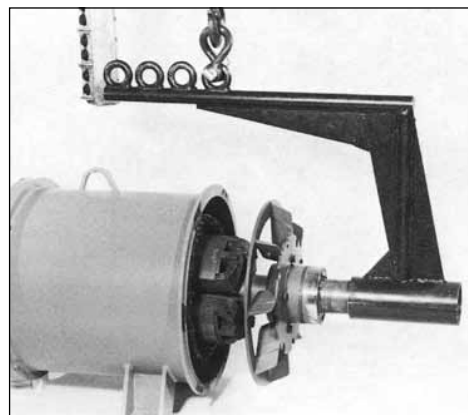


Figure 6-54

**NOTE:** Mobil and Polyrex are registered trademarks of Exxon Mobil Corporation or one of its subsidiaries.

**⚠ WARNING** Do not apply any force to the generator fan for lifting or rotating the generator rotor. Disregarding these instructions may cause personal injury or equipment damage.

3. a. For single bearing generators, slide the SAE adapter over the fan and secure to the main stator and frame assembly with capscrews torqued per section 12 (figures 6-55 and 6-56). It may be necessary to raise the rotor assembly slightly to allow the mounting of the SAE adapter.
- b. For two-bearing generators, insert two guide pins in the rear bearing lock holes (figure 6-57). Fill the grease cavity of the drive end bracket 1/3 to 1/2 full of Mobil® Polyrex® EM grease (or equivalent - see page 17). Assemble all grease plugs in the bracket. Mount the bracket on the bearing and guide the bearing lock pins through the bracket holes (figure 6-58). Align the drive end bracket and mount with the capscrews (figure 6-59). Insert two capscrews with lockwashers into the bearing lock and tighten. Remove the guide pins and replace with the remaining two capscrews with lock washers. Torque bearing cap screws to 25 ft-lb (34 N-m). Torque bracket mounting capscrews per specifications given in section 12.

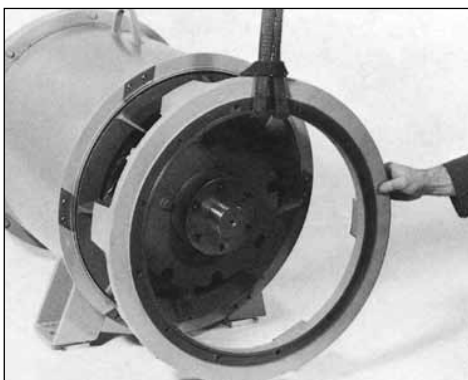


Figure 6-55

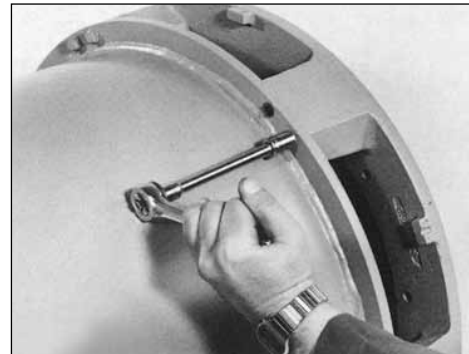


Figure 6-56

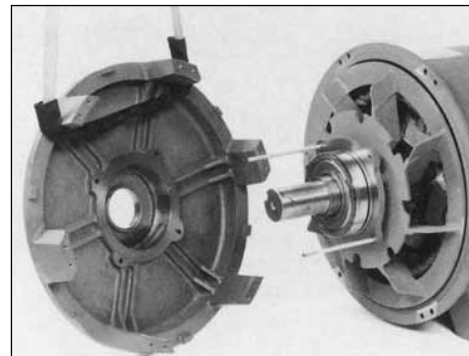


Figure 6-57

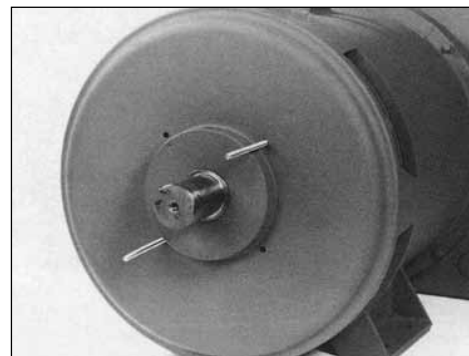


Figure 6-58

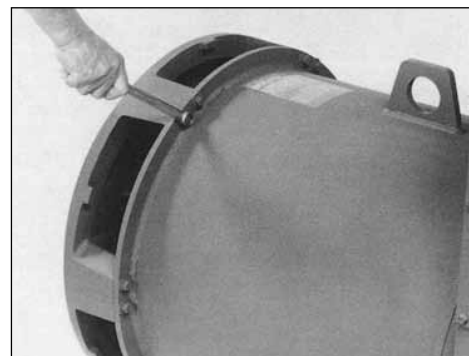


Figure 6-59

**NOTE:** Mobil and Polyrex are registered trademarks of Exxon Mobil Corporation or one of its subsidiaries.

# Service

**CAUTION** On large generators, a hoist and lifting strap should be used to assist in the drive end bracket or the SAE adapter assembly.

4. a. For single bearing generators, insert a guide stud into the drive hub. Position all spacers (if any), then all drive discs, one at a time until all discs are installed (figure 6-61). Make sure that all disc mounting holes at the inner and outer diameter are properly aligned. Secure the discs with the grade 8 5/8-18 capscrews and hardened washers. Torque to 192 ft-lb (260 N-m) (see figure 6-62 for torquing sequence).
5. Install the outer bearing cap on the exciter end (figure 6-63). Align holes in inner and outer bearing cap and install cap screws. Torque to 25 ft-lb (34 N-m) – see figure 6-64.

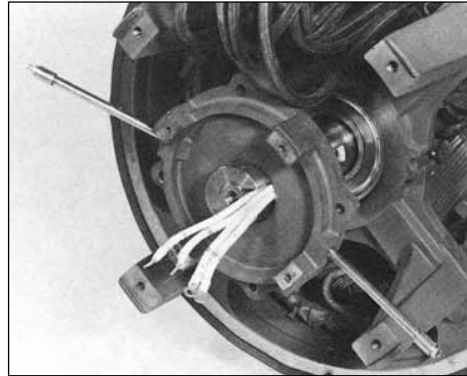


Figure 6-63

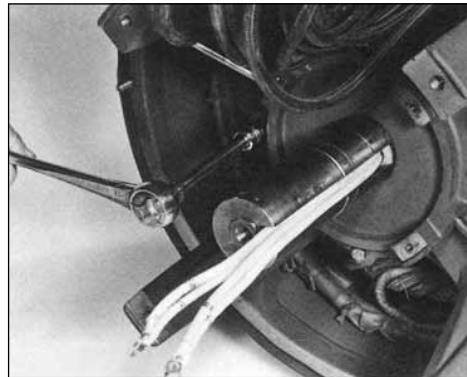


Figure 6-64

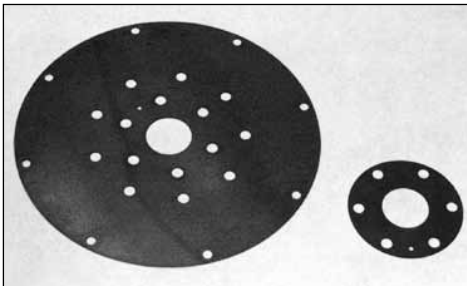


Figure 6-61

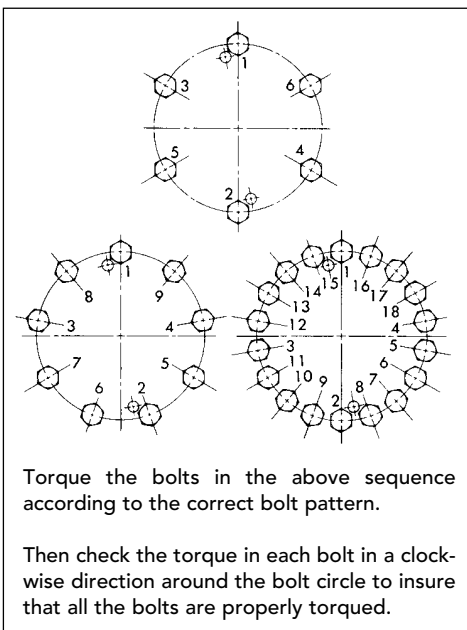


Figure 6-62

## PMG Installation

1. Install inboard snap ring (430 frame generators) and loading spring on shaft (figure 6-65).
2. Slide PMG rotor onto shaft (figure 6-66).
3. Install snap ring (figure 6-67). Use a piece of pipe slightly larger than the shaft (2-3/4 inches) to push the rotor back against the loading spring until the snap ring seats in the slot (figure 6-68).
4. Install the PMG stator on it's mounting pads, with the leads in the left (9 o'clock) inboard position, and secure with the four mounting capscrews and belleville washers (figures 6-69 and 6-72). Torque to 6 ft-lb (8 N-m).
5. Route and secure PMG stator leads away from moving parts.



Figure 6-65



Figure 6-66

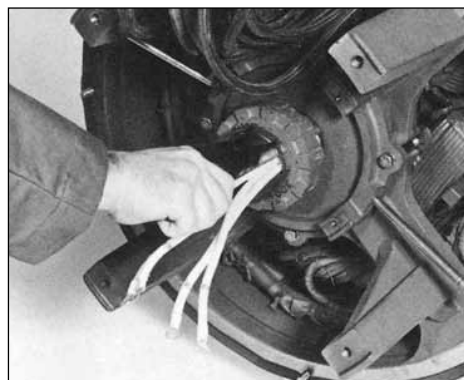


Figure 6-67

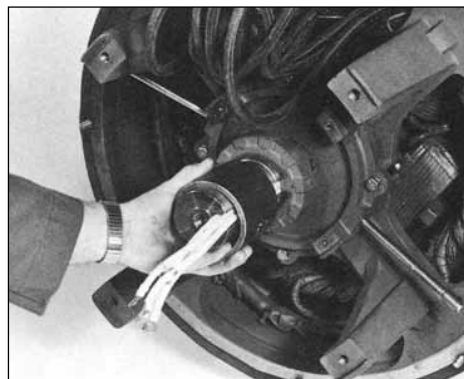


Figure 6-68



Figure 6-69

## Exciter Installation

1. Attach a wire to the main rotor leads and feed the wire through the armature bore and out the lead hole in the aluminum standoff plate. On larger exciters, it will be helpful to install a guide pin in the end of the shaft to support the armature while fishing the rotor leads through (figure 6-70). Align the key in the armature bore to the keyway in the shaft. Slide the armature on the shaft while feeding the main rotor leads through the lead hole in the aluminum standoff plate (figure 6-71).

Insert the capscrew and belleville washer (figure 6-72) through the mounting hole in the aluminum standoff plate and secure to the shaft (figure 6-73). Tighten the capscrew until the armature seats on the shaft. Torque to 84 ft-lb (114 N-m) for 1/2" bolt or 300 ft-lb (407 N-m) for 3/4" bolt.

2. Observe the polarity markings and connect the main rotor leads to the rectifier assembly (figure 6-74). Torque the nuts to 4 ft-lb (5.4 N-m).
3. Position the exciter field leads at the left (9 o'clock) inboard position. Using a suitable lifting device, mount the exciter stator on the front end bracket mounting pads and align the mounting holes (figure 6-75). Mount with the capscrews and belleville washers (figure 6-72). Torque the capscrews to 60 ft-lb (81 N-m). Route and secure the exciter stator leads away from any moving parts.

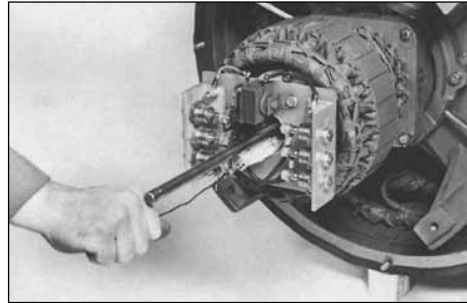


Figure 6-71

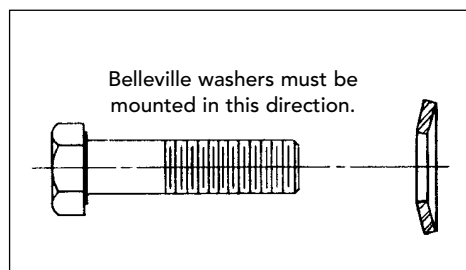


Figure 6-72

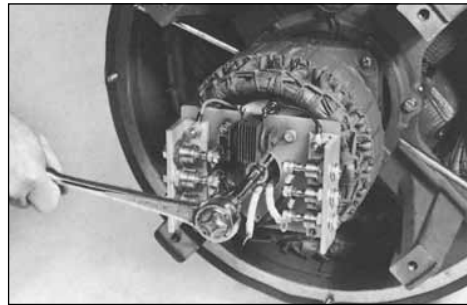


Figure 6-73

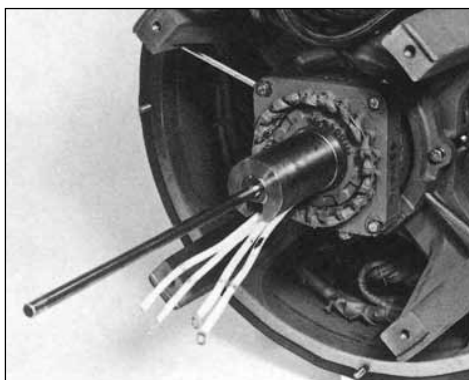


Figure 6-70

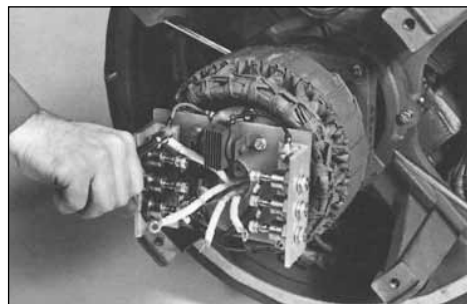


Figure 6-74

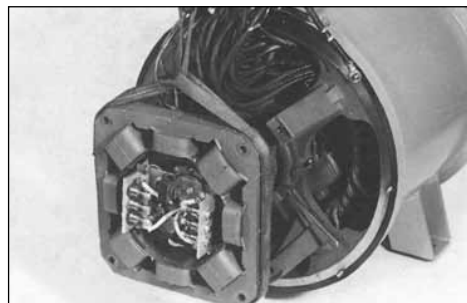


Figure 6-75

## Conduit Box Installation

1. Install the conduit box over the main stator leads (be sure leads are in upper compartment). Secure with bolts and lock washers (figures 6-76 and 6-77).
2. On generators with bus bar assemblies, reassemble main stator leads and insulating blocks to bus bars (figure 6-78).
3. Reconnect exciter leads, PMG leads, and other accessories according to the connection diagrams and markings installed before disassembly.

## Assembly to Prime Mover

1. Attach a suitable hoist to the generator lifting lugs and move the generator until the generator foot mounting holes are aligned with the base and slightly above.
2. a. For single bearing generators, if the screen assembly is mounted on the adapter, remove

the mounting bolts and remove the screen (figure 6-79). (**Note:** Do not remove the drip cover from the screen assembly if so equipped.) Insert two guide pins in the flywheel and two in the flywheel housing. Adjust the generator position until the drive discs are piloted in the flywheel. Remove the guide pins and secure the discs with Grade 8 place bolts and hardened washers or Grade 8 capscrews and heavy series lockwashers. Torque per specifications given in section 12.

**⚠WARNING** Do not apply any force to the generator fan for lifting or rotating the generator rotor. Disregarding these instructions may cause personal injury or equipment damage.

Position the generator so that the SAE adapter mates with the flywheel housing.

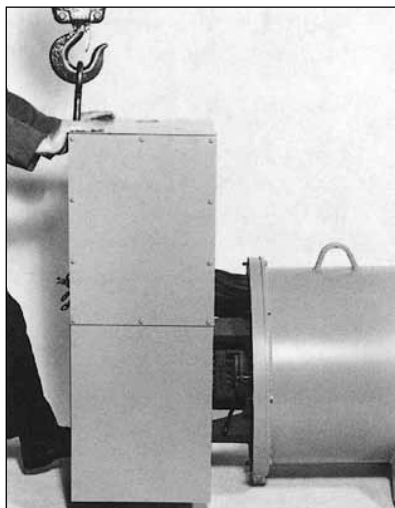


Figure 6-76



Figure 6-77

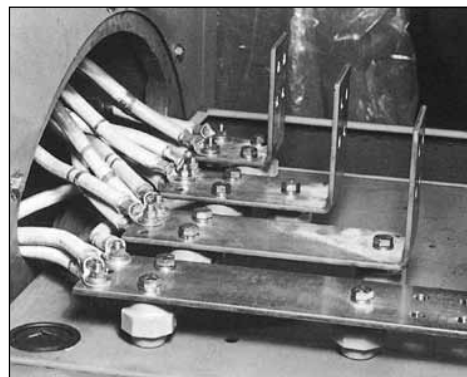


Figure 6-78

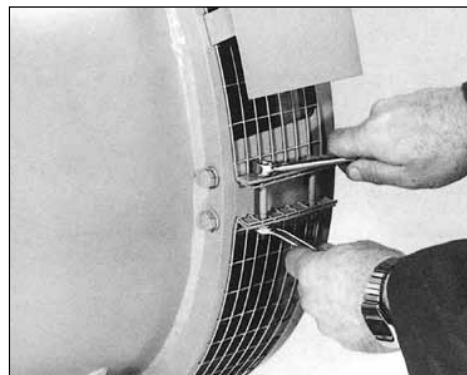


Figure 6-79



# Service

**CAUTION** Do not force the alignment of the units. Shift the generator from side to side or raise or lower with a lifting device as necessary.

It may be necessary to use shims under the mounting feet of either the generator or the prime mover to obtain proper alignment; use the same shims as removed under disassembly or proceed as follows: using the extreme bottom four capscrews, mount the SAE adapter to the flywheel housing. With a .0015 to .002 inch feeler gauge placed at the extreme top of the adapter, between the adapter and flywheel housing, raise the generator or lower the prime mover until the gauge is snug. Relieve just enough to release the feeler gauge and torque the remaining SAE adapter cap-screws to the flywheel housing (torque specifications given in section 12).

Mount the screen assembly and tighten the mounting bolts.

- b. For two-bearing generators, align the coupling halves or sheaves between the generator and the prime mover by adding shims under the feet.
3. Shim under the generator feet for proper support, ensuring that the generator mounting surfaces are level.
4. Install the mounting bolts which secure the generator to the base.
5. For two bearing generators, assemble the coupling halves or sheave belts between the generator and the prime mover (follow the coupling manufacturer's instructions for assembly and alignment).
6. Connect all existing conduit or ducting to the conduit box.
7. Connect all external wiring to the generator inside the conduit box.
8. Check the exciter air gap (gap between the exciter armature and stator) by inserting a .010 inch feeler gauge in the gap and rotating it around the

armature diameter to ensure that a minimum air gap is available (see figure 6-80). If the feeler gauge cannot be rotated on full revolution, then check for a "cocked" exciter stator or loose stator mounting capscrews.

**Note:** On single bearing units, the exciter air gap cannot be checked properly until the generator is mounted to the prime mover.

9. Install the conduit box covers.

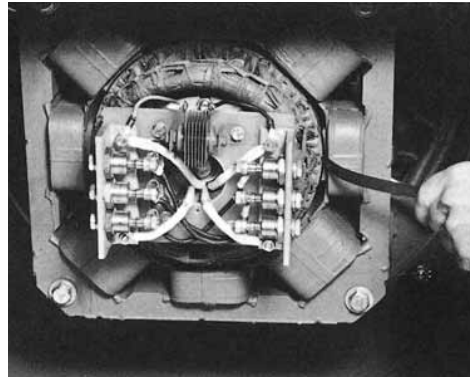


Figure 6-80

# Troubleshooting

## Introduction

This section is intended to suggest a systematic approach to locating and correcting generator or regulator malfunctions. The sections are arranged according to the symptoms of the problem. The steps in each section have been arranged in an attempt to:

- 1) Do the easy checks first.
- 2) Prevent further damage when troubleshooting a disabled machine.

The first and perhaps most important step of troubleshooting should be to gather as much information as possible from personnel who may have been present during the failure. Information on how long the generator had been running, what loads were on the line, weather conditions, what protective equipment operated, etc., can help isolate the problem.

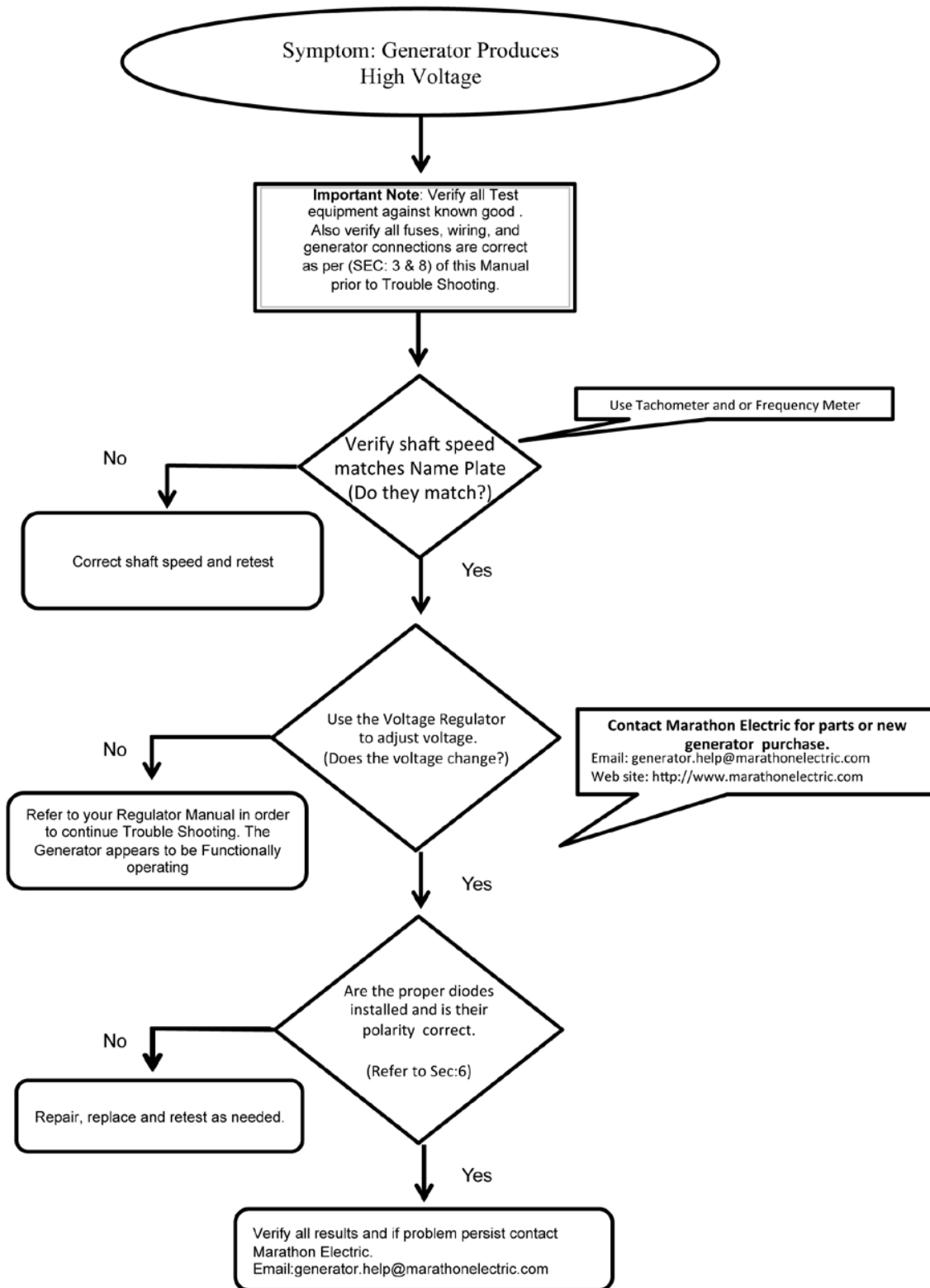
Always make a thorough visual inspection to check for any obvious problems before attempting to run the generator.

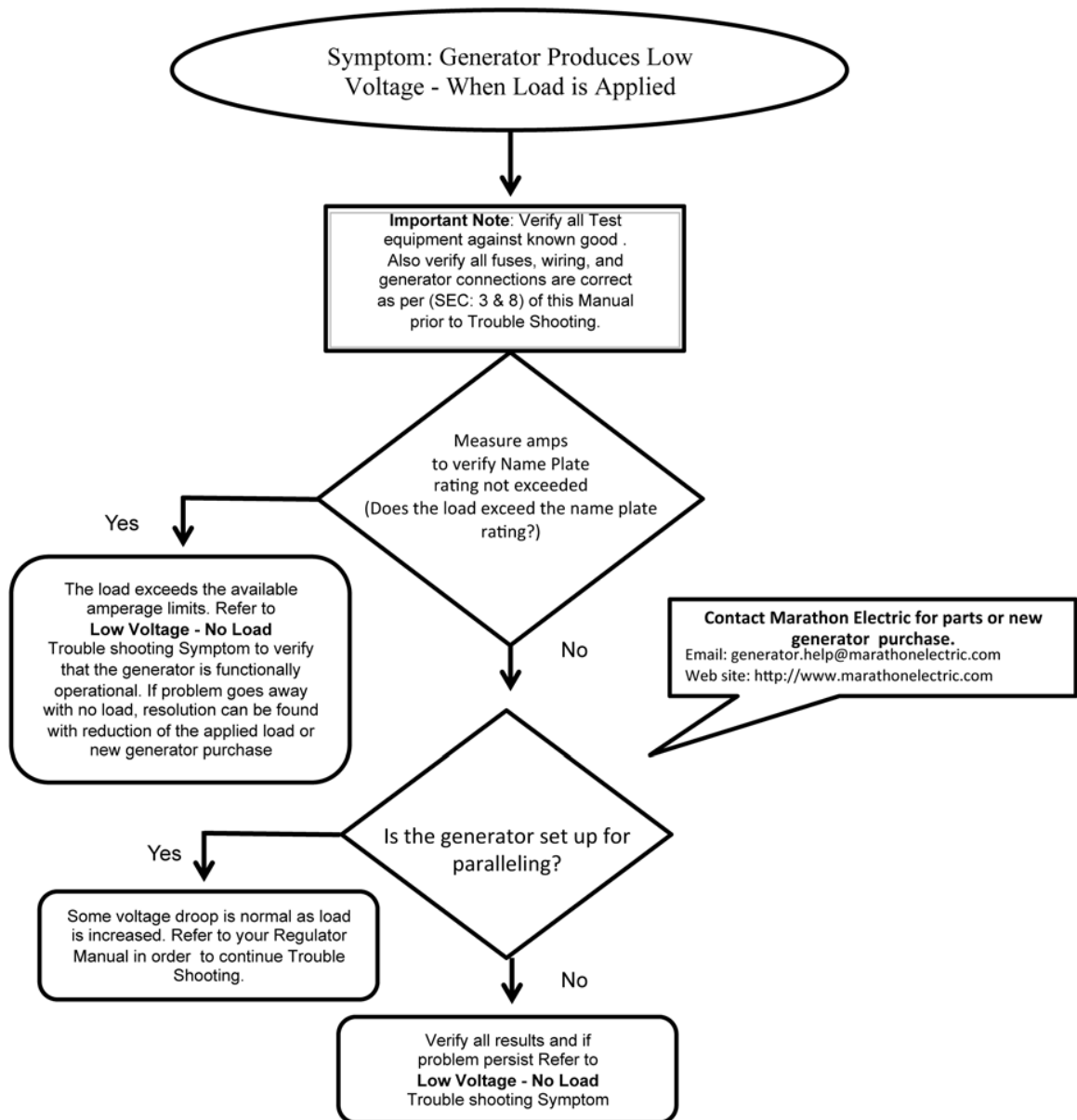
**⚠️ WARNING** High voltages can be present at the generator and regulator terminals. High residual voltages can be present even with the regulator disconnected or its fuses removed. Some equipment (such as space heaters) may be energized when the generator is off. Tools, equipment, clothing, and your body must be kept clear of rotating parts and electrical connections.

**⚠️ WARNING** Special caution must be taken during troubleshooting since protective covers and safety devices may be disabled to gain access and make tests.

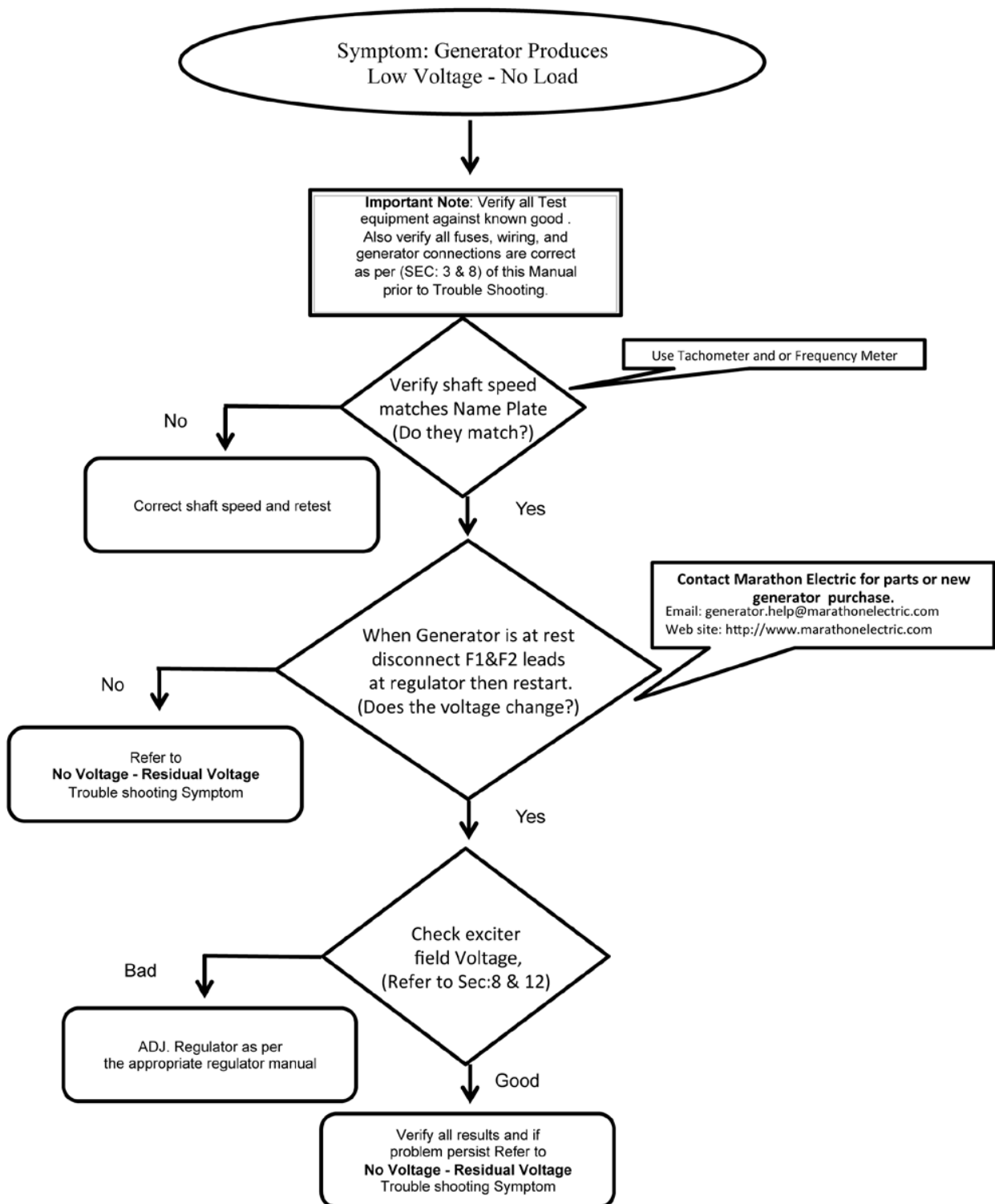
**⚠️ WARNING** Be careful. Serious personal injury or death can result from these hazards. Consult qualified personnel with any questions.

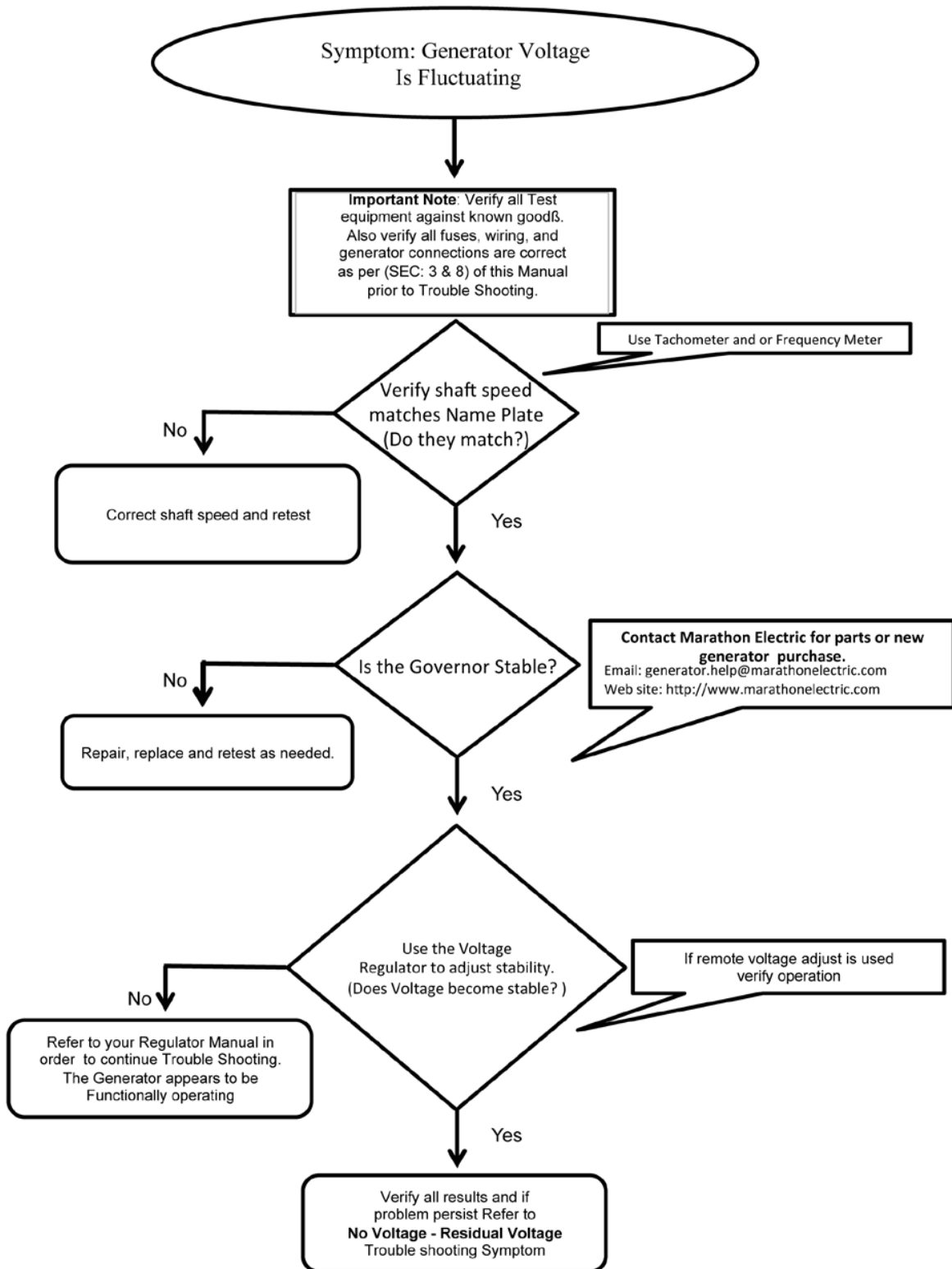
# Troubleshooting



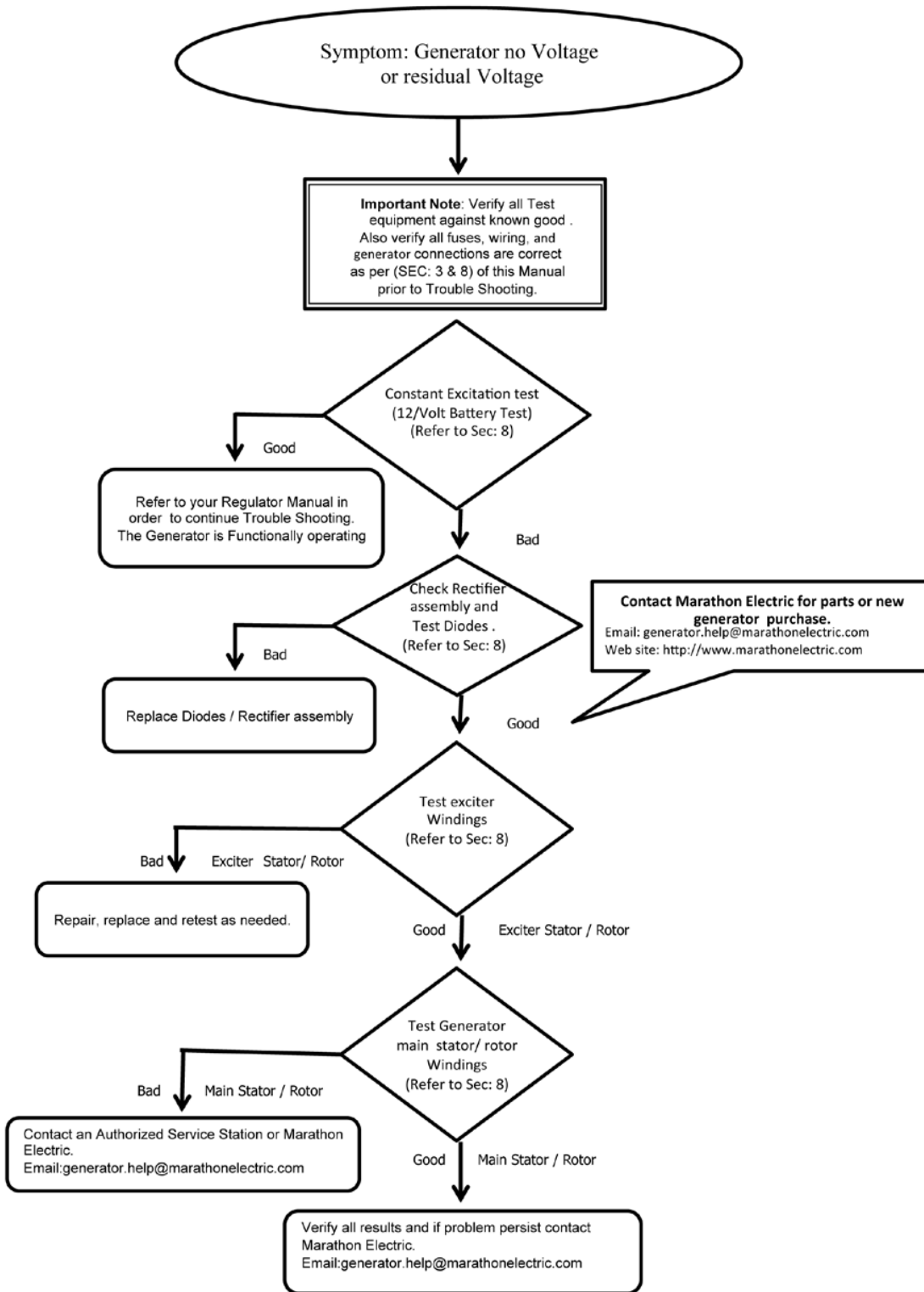


# Troubleshooting

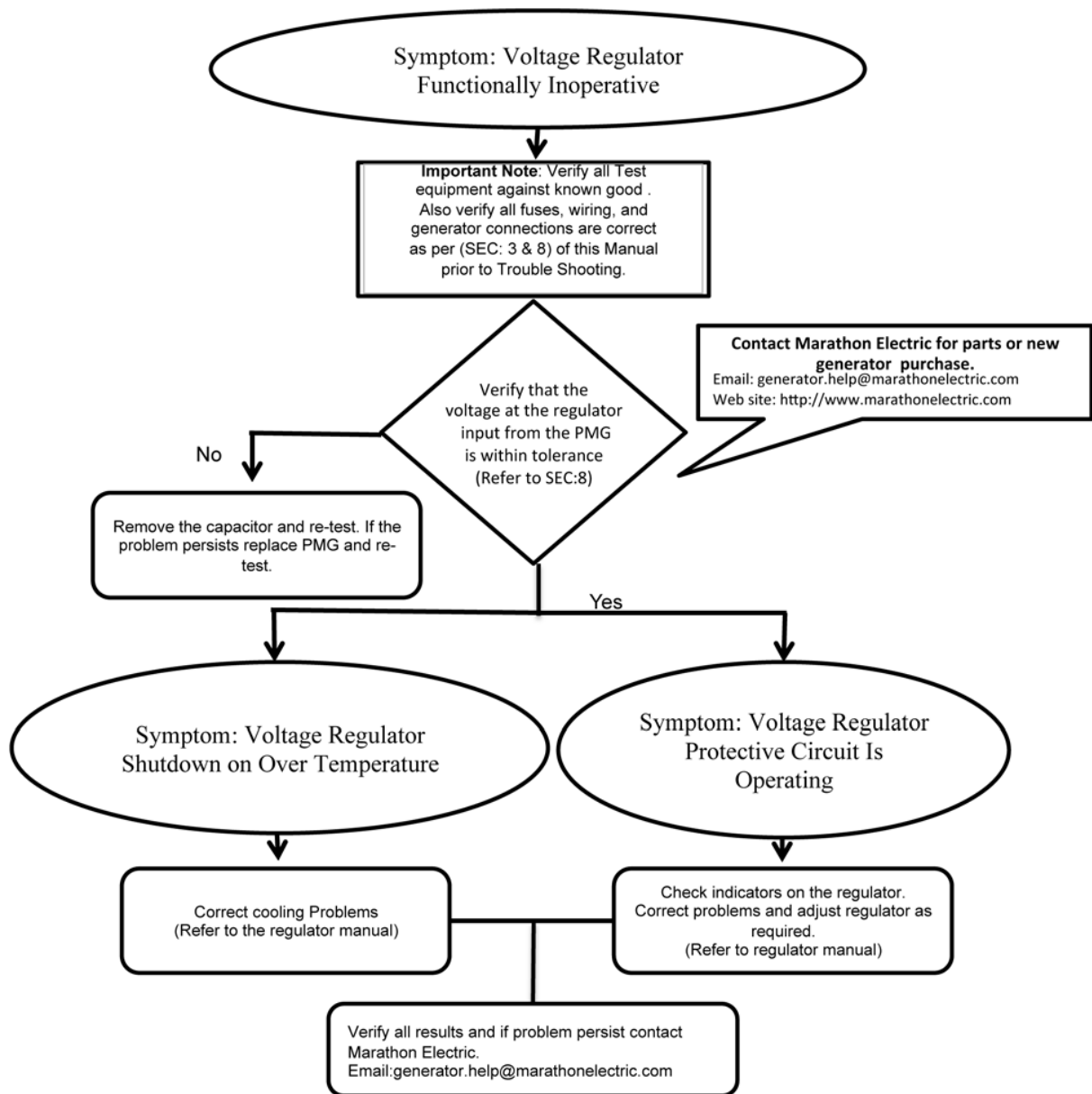




# Troubleshooting



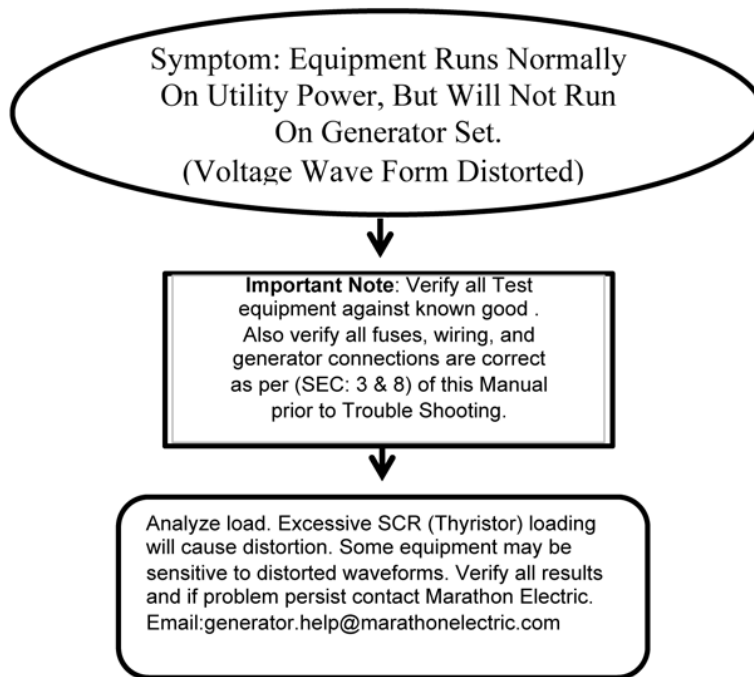
7





# Troubleshooting

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## Visual Inspection

Whenever testing and troubleshooting a generator set, it is always a good practice to make a thorough visual inspection. Remove covers and look for any obvious problems. Burnt windings, broken connectors, leads, mounting brackets, etc., can usually be identified. Look for any loose or frayed insulation, loose or dirty connections, and broken wires. Be sure all wiring is clear of rotating parts.

Verify that the generator is connected for the voltage required. This is especially important on new installations.

Check for any foreign objects, loose nuts, bolts, and electrical connectors. Clear paper, leaves, building materials, etc., that could be sucked into the generator. (Generator is air cooled; air enters the lower portion of the conduit box.) Check the air gap for clearance or obstructions (main generator and exciter)

If possible, rotate the generator rotor by hand to be sure it turns freely.

If serious problems can be identified before attempting to operate the machine, additional damage can be avoided.

## Constant Excitation (12V Battery) Test

**Theory:** The generator output voltage is dependent on generator speed, generator design, load, and exciter input current. If the generator speed and exciter input are known, the output voltage at no load can be measured and compared to the design value. Problems can be isolated to either the generator or regulator system by using this test.

### Test Procedure:

1. Shut the generator set down.
2. Connect a voltmeter to the generator output.
3. Disconnect the F1 and F2 leads at the regulator.
4. Connect a 12 volt battery capable of supplying 1 amp to the F1 and F2 leads. F1 is plus (+), F2 is minus (-).

**CAUTION** Beware of arcing when connecting leads. Stay clear of battery vents. Escaping hydrogen gas can explode. If hazardous conditions exist, use a suitable switch to connect or disconnect the battery.

5. With no load applied to on the generator (main breakers open), run generator at rated speed (1800 rpm – 60 Hz or 1500 rpm – 50 Hz).
6. Measure the generator output voltage.
7. Shut generator down.
8. Disconnect battery (see preceding CAUTION statement).
9. Compare voltage reading with value shown in section 12.

**Conclusion:** If voltage readings are normal, the main generator and exciter are operating properly. Troubleshooting should continue with the regulator. If readings are not normal, the problem is in the generator. Continue testing diodes, surge suppressor, and windings.

## Measuring Voltages

When testing the generator and regulator, the most frequent (and usually easiest) measurement will be a voltage. The generator will need to be running at rated speed and may have some of the protective guards and covers removed. **Be Careful.** Keep yourself and your test leads out of the way. It is best to shut the unit down when connecting meters. When using alligator clips or push-on terminals, be sure the leads are supported so vibration does not shake them loose when running the generator set.

See figure 8-1 for measurement points and expected meter range settings. When in doubt, start with a higher range and work down.

Consult meter instruction manual to verify its operation and limitations.

# Generator Testing

**Figure 8-1: Typical Voltage Measurements**

| Voltage Measurement                      | Test Point   | Meter/Range Selection Requirement   |  |
|--|--|---|--|
| Generator Output Voltage                 | Output "T" leads or bus bars, also main circuit breaker "line" side. | System voltage – volts AC (see generator nameplate and connection diagram).   |  |
| Regulator Output (Excitor Stator Input)  | F1 and F2 terminals at the regulator.                                | 200 volts DC range. F1 is plus (+) and F2 is minus (-).   |  |
| Regulator Sensing Voltage                | E1, E2, and E3 terminals at the regulator.                           | Usually the same as the system voltage (generator output volts); however, in some cases, sensing is taken from winding center taps or instrument potential transformers. Maximum 600 volts AC.<br><b>Example:</b> Center tap of 480 volt system would give 240 volts at E1, E2, or E3.<br><b>Example:</b> A 4160 volt system must use a transformer to step voltage down below 600 volts. See the connection diagram supplied with generator set. |  |
| Regulator Input Volts (PMG Output Volts) | "PMG" leads at the regulator or capacitor.                           | 200-240 VAC<br>180-220 VAC  | 300 Hz @ 1800 rpm<br>250 Hz @ 1500 rpm |

## Current (Amp) Measurements

Current measurements (AC) can be easily taken with a clamp-on type meter.

**Note:** Most clamp-on ammeters will not measure DC.

When measuring generator output current, be sure the clamp is around all cables for each phase. If the physical size of the conductors or the capacity of the meters will not permit all cables to be measured at once, each one can be measured individually. Add the individual readings together to get the total. Compare readings to the generator nameplate (nameplate ratings are always given per phase).

Amperage should never exceed the nameplate rating when running the intended load (amperage may go above nameplate momentarily when starting large motors).

When measuring exciter field amps (F1 and F2 leads), a DC meter is required. The maximum field current under full regulator forcing is 6.5 amps DC. Normal full load reading is approximately 3 amps DC.

## Measuring Resistance

The generator windings can be measured and compared to the values shown in the service specification section 12.

### Main Stator

The main stator winding resistance is very low. A meter capable of readings in the milliohm range would be required; however, a standard VOM (volt ohm meter) can be used to check for continuity, shorts, or grounds.

**Example:** With leads disconnected, a measurement from T1 to T4 should be very low (continuity on most VOMs). Measured from T1 or T4 to any other lead should be infinite. Measure from the "T" lead to the generator frame to check for grounds (reading should be infinite).

### Exciter Stator

The exciter stator resistance is measured by disconnecting the F1 and F2 leads at the regulator. Measure the resistance between the leads (this value is 22–24 ohms on standard generators). Measure from the leads to the frame to check for grounds.

## Main Rotor

Note markings and disconnect the main rotor leads (F1 leads and F2 leads) from the rectifier assembly. Measure the resistance of the main rotor winding. Compare reading to value shown in service specification, section 12. Measure from the leads to the exciter mounting bolt to check for grounds.

## Exciter Rotor

Disconnect the exciter rotor leads at the diodes (leave leads disconnected if proceeding to check diodes). Measure resistance between phases. Compare value to service specifications, section 12. Measure from the leads to the exciter mounting bolt to check for grounds.

## Testing Diodes (Rectifiers)

Diodes perform the function of an “electrical check valve.” They conduct in one direction only and are used to “rectify” AC current into DC current. To test, measure the resistance first in one direction and then reverse the leads and test in the other direction. The reading should be high in the reverse direction and low in the forward direction. A shorted diode will read low in both directions. An open diode will read high in both directions.

## Notes:

1. Two different polarities of diodes are used. The only difference is in the way the device is mechanically placed in the case. When changing diodes, be sure the correct polarity is used (refer to section 6, figure 6-34).
2. Some meters do not have enough voltage output from their internal batteries to turn the diode on (about 0.6 volts is required), and the voltage can change with different range settings. Consult the instruction manual for your meter.
3. Polarities supplied by the meter’s internal battery may or may not correspond to the (+) (-) markings on the meter.

## Insulation Resistance – General

Insulation resistance is a measurement of the integrity of the insulating materials that separate the electrical windings from the generator’s steel core. This resist-

ance can degrade over time or due to contaminants (dust, dirt, oil, grease, and especially moisture). Most winding failures are due to a breakdown in the insulation system. In many cases, low insulation resistance is caused by moisture collected when the generator is shut down. The problem can be corrected simply by drying out the windings (see section 5).

Normally the resistance of the insulation system is on the order of millions of ohms. It is measured with a device called a “megger” which is a megaohm meter (meg is for million) and a power supply. The power supply voltage varies, but the most common is 500 Vdc. A megger voltage over 500 is not recommended, except for measuring medium voltage (2400/4160) stators only.

**⚠ CAUTION** First disconnect any electronic components. Regulators, diodes, surge protectors, protective relays, etc., will be destroyed if subjected to the high megger voltages.

To measure insulation resistance, connect the red or positive megger lead to the leads for the winding to be tested, connect the back or negative megger lead to the generator frame. Be sure the leads of the part being tested are not touching any metal parts of the generator (if the neutral is grounded, it must be disconnected). Take megger reading (refer to the manual for the megger).

## Insulation Resistance – Main Stator

**⚠ CAUTION** Be sure the regulator, and any other electric components, metering, protective relays, etc., are disconnected before meggering. High megger voltages will destroy these parts.

All stator leads must be isolated from ground and connected together (on most systems with grounded neutrals, the neutral can be isolated from ground and used as a test point). Connect the positive megger lead to the main stator leads. Connect the negative megger lead to the generator grounding stud. Take the megohm reading (refer to instructions for the megger).

# Generator Testing

The minimum acceptable value for random wound coils is 5 megohms. For form wound coils, the value is 100 megohms.

If the reading is below the recommended value, the winding must be dried out or repaired.

## Insulation Resistance – Main Rotor

Disconnect the main rotor leads from the diode bridge on the exciter rotor. Connect the leads together with the positive megger lead. Connect the negative megger lead to a good ground on the rotor assembly such as the exciter mounting bolt. Take the megohm reading (refer to instructions for the megger).

The minimum value is 5 megohms.

If the reading is low, the winding must be dried out or repaired.

## Insulation Resistance – Exciter Stator

Disconnect the exciter leads F1 and F2 from the regulator. Never subject the regulator to a megger. Connect F1 and F2 together with the positive megger lead. Connect the negative megger lead to the ground stud. Take the megohm reading (refer to instructions for the megger).

The minimum value is 5 megohms.

If the reading is low, the winding must be dried out or repaired.

## Insulation Resistance – Exciter Rotor

Disconnect the exciter rotor windings (6 leads from the diodes). Connect all leads together with the positive megger lead. Connect the negative megger lead to a good ground on the rotor assembly such as the mounting bolt. Take the megohm reading (refer to the instructions for the megger).

The minimum value is 5 megohms.

If the reading is low, the winding must be dried out or repaired.

## Main Rotor Field AC Impedance Test

**Theory:** The main rotor resistance can be measured with a very accurate meter that is able to measure low (1 ohm) resistance, but it is difficult to determine if there are turn-to-turn shorts in the field pole windings. One shorted turn would only change a resistance reading on the order of one half of one percent.

The AC impedance test measures the impedance (inductance and resistance) of the field pole coils. Shorted turns in the field pole windings change the coil inductance to a much greater degree than the resistance.

### Procedure:

**Step 1:** The rotor must be supported on a non-magnetic surface such as a wooden skid. Do not use a steel table that would create a magnetic "short circuit" between the poles.

**Step 2:** Apply 120 volts AC to disconnected main rotor leads F1 and F2.

**Step 3:** Measure and record voltages across each pole. Between points "A" and "B", "B" and "C", "C" and "D", and "D" and "E" (figure 8-1).

**Step 4:** The voltage readings should balance within one volt.

**Results:** If the AC voltages are not balanced ( $30V \pm 1V$  AC with 120V AC input) across each pole, the winding has shorted turns and should be rewound.

Refer to Marathon Electric for further information.

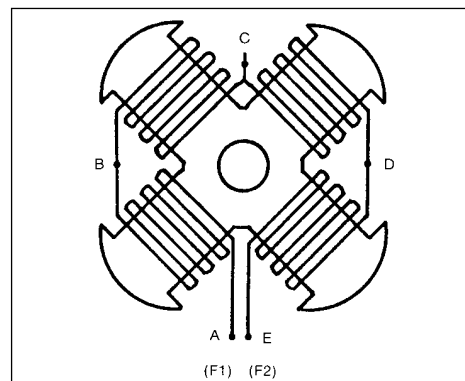
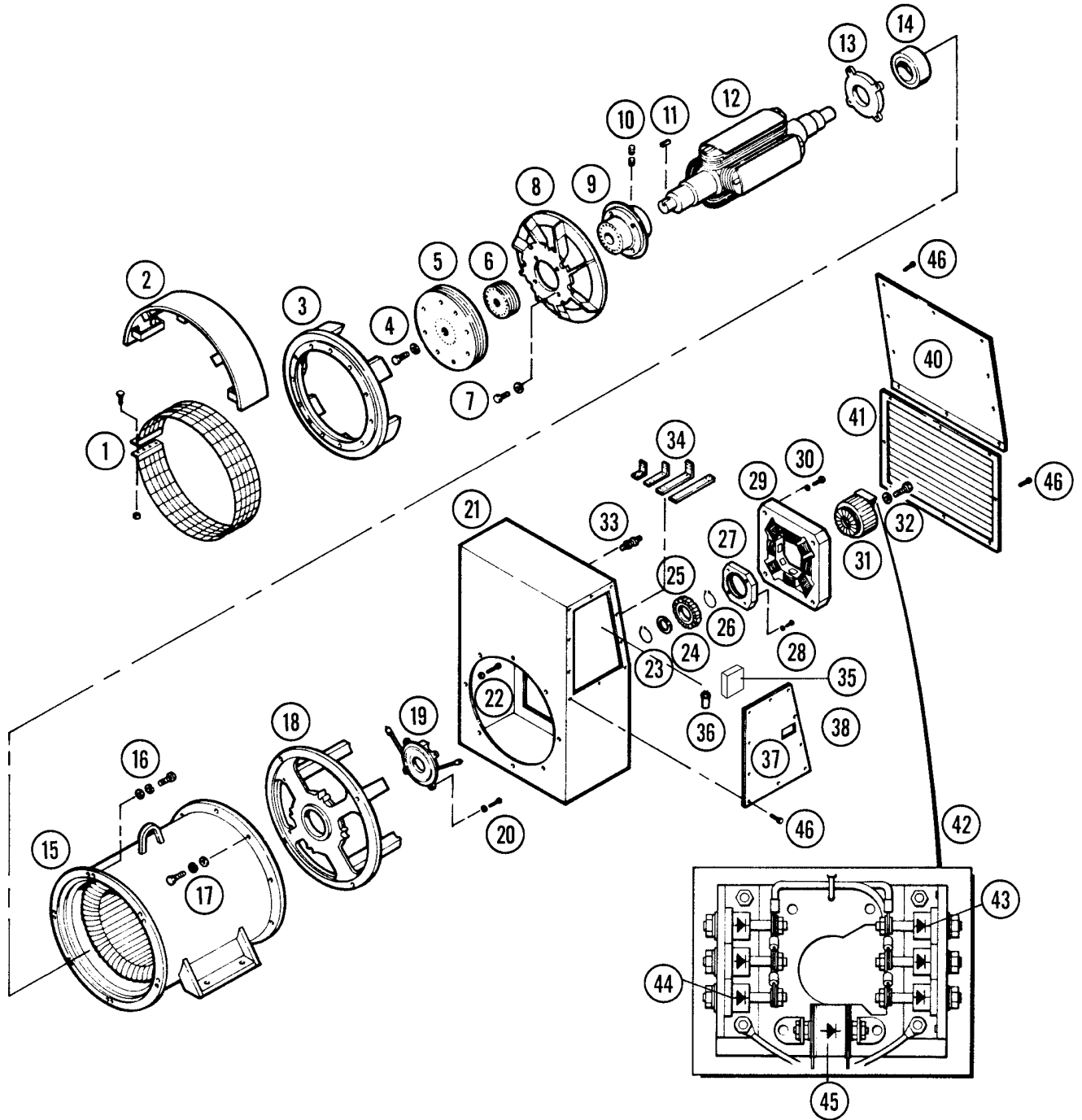


Figure 8-1

## MAGNAMAX<sup>DVR</sup> Exploded View



# Parts

**Table 9-1: Parts List**

| Item | Part Description         | Item | Part Description         | Item | Part Description        |
|------|--------------------------|------|--------------------------|------|-------------------------|
| 1    | Screen Assembly          | 11   | Drive Hub Key            | 32   | Exciter Rotor Fastener  |
|      | Screen                   | 12   | Main Rotor Assembly      |      | Capscrew                |
|      | Screen Mounting Bolt     |      | With Windings            |      | Belleville Washer       |
|      | Screen Mounting Nut      | 13   | Front Bearing Cap        | 33   | Grounding Stud Assembly |
| 2    | Drip Cover Assy (Option) | 14   | Front Ball Bearing       |      | Stud                    |
| 3    | SAE Adapter              | 15   | Main Body Assembly       |      | Washer                  |
|      | #3 Adapter               | 16   | Adapter Mtg Fasteners    |      | Nut                     |
|      | #2 Adapter               |      | Capscrew                 | 34   | Bus Bar Assembly        |
|      | #1 Adapter               |      | Lock Washer              | 35   | Voltage Regulator       |
|      | #1/2 Adapter             |      | Flat Washer              | 36   | Capacitor               |
|      | #0 Adapter               | 17   | Bracket Mtg Fasteners    | 37   | Side Panels             |
|      | #00 Adapter (#18 Disc)   |      | Capscrew                 |      | Blank                   |
|      | #00 Adapter (#21 Disc)   |      | Lock Washer              |      | Machined For Regulator  |
| 4    | Disc Mounting Fasteners  |      | Flat Washer              | 38   | Fuse                    |
|      | Capscrew for #11-1/2     | 18   | Front Bracket            | 40   | Solid Cover             |
|      | Capscrew for #14         | 19   | PMG Bearing Cap          | 41   | Louvered Cover          |
|      | Capscrew for #18         | 20   | Bearing Cap Fasteners    | 42   | Exciter Rect. Assembly  |
|      | Capscrew for #21         |      | Capscrew                 |      | (incl. 43, 44, 45)      |
|      | Capscrew for Delco       |      | Lock Washer              | 43   | Diode Standard Polarity |
|      | Hardened Washer          | 21   | Conduit Box              | 44   | Diode Reverse Polarity  |
| 5    | Drive Discs              | 22   | Conduit Box Mounting     | 45   | Surge Suppressor        |
|      | #11-1/2 Disc             |      | Fasteners                | 46   | Cover Mounting Screws   |
|      | #14 Disc                 |      | Capscrew                 |      |                         |
|      | #18 Disc                 |      | Lock Washer              |      |                         |
|      | #21 Disc                 | 23   | Snap Ring – Inner        |      |                         |
|      | Delco Disc (17.75" OD)   | 24   | Loading Spring           |      |                         |
| 6    | Spacers                  | 25   | PMG Rotor                |      |                         |
|      | For #11-1/2 Disc         | 26   | Snap Ring – Outer        |      |                         |
|      | For #14 Disc             | 27   | PMG Stator               |      |                         |
|      | For #18 Disc             | 28   | PMG Stator Mtg Fasteners |      |                         |
|      | For #21 Disc             |      | Capscrew                 |      |                         |
|      | For Delco Disc           |      | Belleville Washer        |      |                         |
| 7    | Fan Mounting Fasteners   | 29   | Exciter Stator           |      |                         |
|      | Capscrew                 | 30   | Exciter Stator Fasteners |      |                         |
|      | Capscrew (2 brg. only)   |      | Capscrew                 |      |                         |
|      | Belleville Washer        |      | Belleville Washer        |      |                         |
| 8    | Fan                      | 31   | Exciter Rotor Assembly   |      |                         |
| 9    | Hub                      |      | (incl. 42)               |      |                         |
|      | Drive Hub (single        |      | 430 Frame – All          |      |                         |
|      | brg. only)               |      | 570 Frame – Low          |      |                         |
|      | Fan Hub (2 brg. only)    |      | Voltage                  |      |                         |
| 10   | Drive Hub Set Screws     |      | 570 Frame – Medium       |      |                         |
|      |                          |      | Voltage                  |      |                         |

Note: This parts list is for reference only. Always give complete generator model and serial numbers when ordering parts.

## Standard Tools

The MAGNAMAX<sup>DVR</sup>® generator is assembled with American standard SAE hardware. Wrench sizes from 5/16 inch to 7/8 inch are used. A socket head set screw is used in the drive hub. A 1/4 inch allen type wrench is required to remove it.

All fasteners should be properly torqued (see section 12). Torque wrenches ranging from 25 in-lb through 200 ft-lb should be available.

Electrical test equipment should include a voltmeter or multimeter (VOM), clamp on ammeter, accurate frequency meter or tachometer and a megohmmeter. (See section 8—Generator Testing for more information.)

## Special Tools

In addition to the standard tools mentioned above, the following special tools will facilitate removal and installation of large and/or special parts. These tools can be obtained from the Marathon Electric parts department.

**Exciter Stator Lifting Fixture** (figure 10-1) – In cases where the exciter stator is to be serviced without removing the generator conduit box, this fixture can be used with overhead rigging to remove and reinstall the exciter stator.

**Exciter Rotor Puller Bolt** (figure 10-2) – The exciter rotor has a built-in pulling system. With the use of this bolt, the rotor can be easily removed from the shaft without damage to the winding.

**Snap Ring Pliers** (figure 10-3) – The PMG rotor is installed to the generator shaft with a snap ring. The nominal shaft diameter is 2-3/4 inches and the ring must be spread approximately 3/4 inches for removal. To install the snap ring, use a piece of pipe with a 2-3/4 inch ID (figure 10-4). Push the PMG rotor and snap ring onto the shaft until the ring snaps into the groove.

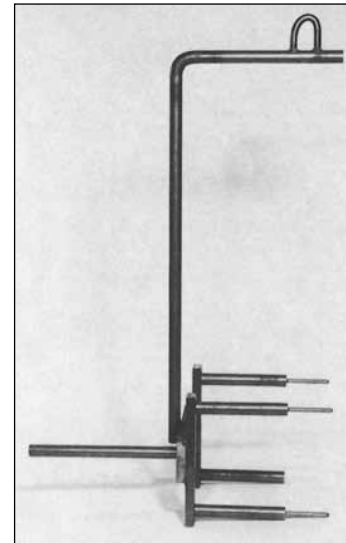


Figure 10-1

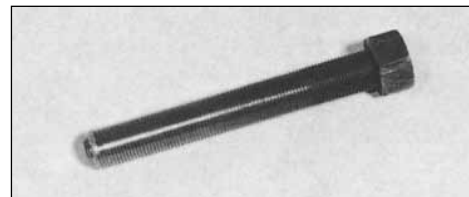


Figure 10-2



Figure 10-3



Figure 10-4



# Special Tools

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**Rotor Lifting Fixture** (figure 10-5) – The main generator rotor is heavy (approx. 1/2 the weight of the generator) and difficult to handle. The proper fixture should be used whenever removing or installing the main rotor into the main stator. Without proper care and equipment, the windings can be easily damaged.

## Miscellaneous

A selection of wiring devices such as electric connectors, tape, cable ties, crimping and stripping tools, etc., should also be a part of the generator service tool kit. The standard regulator uses flat 1/4 inch female insulated terminals for AWG #14 wire.

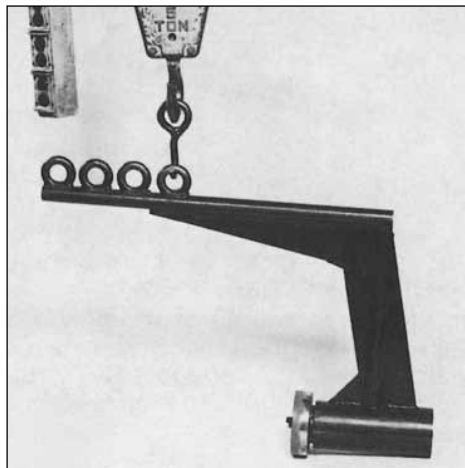


Figure 10-5

# Preparation For Shipment Or Extended Storage

## Shipping Instructions

Shipping and handling will be much easier if the generator is fastened to a suitable shipping skid that will allow handling by a forklift. The skid should extend beyond the generator in all directions. If the original skid is available, it should be used. Marathon Electric will supply shipping skid drawings upon request.

Overseas shipping may require special export crating. Check with your freight carrier.

When installed, single bearing generator rotors are supported on the drive end by the drive discs bolted to the engine flywheel. When the engine is removed, the rotor must be supported by an appropriate fixture to prevent main rotor, main stator, or exciter damage (figure 11-1). Before shipping any single bearing generator, the main rotor must be supported by the adapter using an appropriate fixture.

**CAUTION** Do not attempt to transport any generator without proper rotor support. Extensive equipment damage can occur.

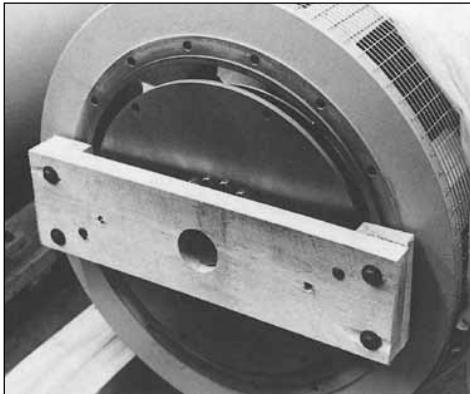


Figure 11-1

## Storage Instructions

If the generator or gen-set is placed into storage, the following precautions should be taken to protect it:

- A. Equipment must be kept clean.
  - 1. Store indoors.
  - 2. Keep covered to eliminate airborne dust and dirt.
  - 3. Cover openings for ventilation, conduit connections, etc., to prevent entry of rodents, snakes, birds, insects, etc.
- B. Equipment must be kept dry.
  - 1. Store in a dry area indoors.
  - 2. Temperature swings should be minimal to prevent condensation.
  - 3. If stored in an unheated or damp building, space heaters will be required to prevent internal condensation.
  - 4. Treat unpainted flanges, shafts, drive discs, and fittings with a rust inhibitor.
  - 5. Check insulation resistance of all windings **before** starting the generator. If readings are low, the windings must be dried (see section
- C. Keep bearings lubricated.
  - 1. Every six months, rotate shaft several turns to distribute grease in bearings.
  - 2. If unit has been stored more than one year, add grease before start-up.
- D. Review and follow instructions in sections 3 and 4 before putting the gen-set into service.

# Specifications




**Table 12-1: MAGNAMAX<sup>DVR</sup>® – Fastener & Torque Specifications**

| Part Description               | Fastener Spec. ③                             | 430-570 Frames        |                   | 740 Frames            |                   |
|--------------------------------|--|-----------------------|-------------------|-----------------------|-------------------|
|                                |  | Size ①<br>Dia.–Thread | Torque ②<br>Ft-Lb | Size ①<br>Dia.–Thread | Torque ②<br>Ft-Lb |
| Front Bracket                  | Grade 5 capscrews with flat and lock washers | 3/8-16                | 25                | 1/2-13                | 60                |
| Bearing Caps                   | Grade 5 capscrews with lock washers          | 3/8-16                | 25                | 3/8-16                | 25                |
| Drive Disc                     | Grade 8 capscrews with hardened washers      | 5/8-18                | 192               | 5/8-18                | 192               |
| Adapter<br>(or Rear Bracket)   | Grade 5 capscrews with flat and lock washers | 3/8-16                | 25                | 1/2-13                | 60                |
| Conduit Box                    | Grade 5 capscrew with star type lock washer  | 3/8-16                | 25                | 1/2-13                | 60                |
| PMG Stator                     | Grade 5 capscrews with belleville washers    | 1/4-20                | 6                 | 1/4-20                | 6                 |
| Exciter Stator                 | Grade 5 capscrews with belleville washers    | 1/2-13                | 60                | 1/2-13                | 60                |
| Exciter Armature<br>(Rotor)    | Grade 8 capscrew with belleville washer      | 1/2-13<br>3/4-10      | 84<br>300         | 1/2-13<br>3/4-10      | 84<br>300         |
| Cooling Fan                    | Grade 5 capscrews with belleville washers    | 1/2-13                | 60                | 1/2-13                | 60                |
| Main Rotor Coil<br>Supports ④  | Grade 8 capscrews with belleville washers    | 5/16-18               | 19                | 3/8-16                | 35                |
| Rectifier Assembly<br>Mounting | Grade 5 capscrews                            | 1/4-20                | 4                 | 1/4-20                | 4                 |
| Drive Hub<br>Set Screw         | Socket head set screw – 1/4 in. hex key      | 1/2-13                | 50                | 1/2-13                | 50                |

**NOTES:**

- ① All fasteners are SAE (American) standard.
- ② All torque values are for plated hardware which is standard on the MAGNAMAX<sup>DVR</sup>®. If hardware is replaced with non-plated, refer to Table 12-2.
- ③ Always use quality hardware of the grade specified.
- ④ 570 and 740 frame only. Not used on 430 frames.

**Table 12-2: Capscrew Torque Values**

| Capscrew Dia. and Ultimate Tensile Strength (PSI) | To 1/2 – 69,000 PSI<br>To 3/4 – 64,000 PSI<br>To 1 – 55,000 PSI                   |           |           | To 3/4 – 120,000 PSI<br>To 1 – 115,000 PSI   |           |           | 150,000 PSI   |            |           |
|---|---|-----------|-----------|--|-----------|-----------|---|------------|-----------|
| SAE Grade Number                                  | 1 or 2  |           |           | 5  |           |           | 8   |            |           |
| Capscrew Head Markings                            |  |           |           |  |           |           |  |            |           |
| Capscrew Body Size (Inches) – (Thread)            | Torque Ft-Lb (N-m)  |           |           | Torque Ft-Lb (N-m)   |           |           | Torque Ft-Lb (N-m)  |            |           |
|   | Dry   | Oiled     | Plated    | Dry  | Oiled     | Plated    | Dry   | Oiled      | Plated    |
| 1/4 - 20  | 5 (7)   | 4.5 (6)   | 4 (5)     | 8 (11)   | 7 (9)     | 6 (8)     | 12 (16)   | 11 (15)    | 10 (14)   |
| - 28  | 6 (8)   | 5.4 (7)   | 4.8 (6)   | 10 (14)  | 9 (12)    | 8 (11)    | 14 (19)   | 13 (18)    | 11 (15)   |
| 5/16 - 18   | 11 (15)   | 10 (14)   | 9 (12)    | 17 (23)  | 15 (20)   | 14 (19)   | 24 (33)   | 22 (30)    | 19 (26)   |
| - 24  | 13 (18)   | 12 (16)   | 10 (14)   | 19 (26)  | 17 (23)   | 15 (20)   | 27 (37)   | 24 (33)    | 22 (30)   |
| 3/8 - 16  | 18 (24)   | 16 (22)   | 14 (19)   | 31 (42)  | 28 (38)   | 25 (34)   | 44 (60)   | 40 (54)    | 35 (47)   |
| - 24  | 20 (27)   | 18 (24)   | 16 (22)   | 35 (47)  | 32 (43)   | 28 (38)   | 49 (66)   | 44 (60)    | 39 (53)   |
| 7/16 - 14   | 28 (38)   | 25 (34)   | 22 (30)   | 49 (66)  | 44 (60)   | 39 (53)   | 70 (95)   | 63 (85)    | 56 (76)   |
| - 20  | 30 (41)   | 27 (37)   | 24 (33)   | 55 (75)  | 50 (68)   | 44 (60)   | 78 (106)  | 70 (95)    | 62 (84)   |
| 1/2 - 13  | 39 (53)   | 35 (47)   | 31 (42)   | 75 (102)   | 68 (92)   | 60 (81)   | 105 (142)   | 95 (129)   | 84 (114)  |
| - 20  | 41 (56)   | 37 (50)   | 33 (45)   | 85 (115)   | 77 (104)  | 68 (92)   | 120 (163)   | 108 (146)  | 96 (130)  |
| 9/16 - 12   | 51 (69)   | 46 (62)   | 41 (56)   | 110 (149)  | 99 (134)  | 88 (119)  | 155 (210)   | 140 (190)  | 124 (168) |
| - 18  | 55 (75)   | 50 (68)   | 44 (60)   | 120 (163)  | 108 (146) | 96 (130)  | 170 (230)   | 153 (207)  | 136 (184) |
| 5/8 - 11  | 83 (113)  | 75 (102)  | 66 (89)   | 150 (203)  | 135 (183) | 120 (163) | 210 (285)   | 189 (256)  | 168 (228) |
| - 18  | 95 (129)  | 86 (117)  | 76 (103)  | 170 (230)  | 153 (207) | 136 (184) | 240 (325)   | 216 (293)  | 192 (260) |
| 3/4 - 10  | 105 (142)   | 95 (130)  | 84 (114)  | 270 (366)  | 243 (329) | 216 (293) | 375 (508)   | 338 (458)  | 300 (407) |
| - 16  | 115 (156)   | 104 (141) | 92 (125)  | 295 (400)  | 266 (361) | 236 (320) | 420 (569)   | 378 (513)  | 336 (456) |
| 7/8 - 9   | 160 (217)   | 144 (195) | 128 (174) | 395 (535)  | 356 (483) | 316 (428) | 605 (820)   | 545 (739)  | 484 (656) |
| - 14  | 175 (237)   | 158 (214) | 140 (190) | 435 (590)  | 392 (531) | 348 (472) | 675 (915)   | 608 (824)  | 540 (732) |
| 1 - 8   | 235 (319)   | 212 (287) | 188 (255) | 590 (800)  | 531 (720) | 472 (640) | 910 (1234)  | 819 (1110) | 728 (987) |
| - 14  | 250 (339)   | 225 (305) | 200 (271) | 660 (895)  | 594 (805) | 528 (716) | 990 (1342)  | 891 (1208) | 792(1074) |

**NOTES:**

① Capscrews threaded into aluminum may require reductions in torque of 30% or more.

# Specifications

Table 12-3: Excitation Data – 60 Hz – 1800 RPM

| Model Number<br>Low Volts | Exciter Field<br>Resistance<br>Ohms @ 25°C | Exciter Field Volts<br>F1 & F2 at Regulator |               | No Load Output Voltage W/Fixed<br>Excitation High Wye Connection <sup>②</sup> |        |
|---------------------------|--|---|---------------|---|--------|
|                           |  | No Load <sup>①</sup>                        | 240/480 Volts | 12V DC  | 24V DC |
| 431RSL4005                | 22.5                                       |   | 13.3          | 460   | 550    |
| 431RSL4007                | 22.5                                       |   | 14.2          | 450   | 545    |
| 432RSL4009                | 22.5                                       |   | 15.3          | 445   | 535    |
| 432RSL4011                | 22.5                                       |   | 13.5          | 460   | 550    |
| 432RSL4013                | 22.5                                       |   | 11.3          | 490   | 580    |
| 432RSL4015                | 22.5                                       |   | 13.1          | 440   | 530    |
| 432RSL4017                | 22.5                                       |   | 14.4          | 450   | 545    |
| 433RSL4019                | 22.5                                       |   | 16.9          | 430   | 525    |
| 433RSL4021                | 22.5                                       |   | 13.7          | 450   | 550    |
| 572RSL4024                | 23.0                                       |   | 16.1          | 440   | 520    |
| 572RSL4027                | 23.0                                       |   | 16.1          | 440   | 520    |
| 572RSL4028                | 23.0                                       |   | 17.5          | 425   | 510    |
| 572RSL4030                | 23.0                                       |   | 15.2          | 440   | 530    |
| 573RSL4032                | 23.0                                       |   | 15.0          | 445   | 530    |
| 573RSL4034                | 23.0                                       |   | 17.0          | 430   | 520    |
| 574RSL4036                | 23.0                                       |   | 18.2          | 420   | 510    |
| 574RSL4038                | 23.0                                       |   | 15.0          | 440   | 540    |
| 575RSL4044                | 23.0                                       |   | 18.8          | 410   | 510    |
| 740RSL4046                | 23.0                                       |   | 18.9          | 410   | 510    |
| 741RSL4045                | 22.0                                       |   | 15.2          | 440   | 540    |
| 742RSL4046                | 22.0                                       |   | 15.6          | 430   | 540    |
| 742RSL4048                | 22.0                                       |   | 17.4          | 410   | 525    |
| 742RSL4050                | 22.0                                       |   | 13.7          | 460   | 565    |
| 743RSL4052                | 22.0                                       |   | 19.4          | 400   | 510    |
| 744RSL4054                | 22.1                                       |   | 18.6          | 400   | 510    |
| 744RSL4056                | 22.1                                       |   | 19.4          | 400   | 515    |
| 744RSL4058                | 22.1                                       |   | 20.3          | 400   | 515    |
| 744FSL4060                | 22.1                                       |   | 15.1          | 420   | 570    |
| 744FSL4062                | 22.1                                       |   | 16.6          | 410   | 535    |

| Model Number<br>Medium Volts | Exciter Field<br>Resistance<br>Ohms @ 25°C | Exciter Field Volts<br>F1 & F2 at Regulator |            | No Load Output Voltage W/Fixed<br>Excitation Wye Connection <sup>③</sup> |        |
|------------------------------|--|---|------------|--|--------|
|                              |  | No Load <sup>①</sup>                        | 4160 Volts | 12V DC   | 24V DC |
| 573FSM4352                   | 23.0                                       |   | 23.5       | 3100   | 4200   |
| 573FSM4354                   | 23.0                                       |   | 20.3       | 3300   | 4400   |
| 574FSM4356                   | 23.0                                       |   | 20.7       | 3200   | 4300   |
| 574FSM4358                   | 23.0                                       |   | 17.3       | 3500   | 4600   |
| 741FSM4360                   | 22.0                                       |   | 16.7       | 3600   | 4600   |
| 742FSM4364                   | 22.0                                       |   | 15.4       | 3700   | 4700   |
| 742FSM4366                   | 22.0                                       |   | 16.3       | 3600   | 4600   |
| 743FSM4368                   | 22.1                                       |   | 17.7       | 3200   | 4600   |
| 743FSM4370                   | 22.1                                       |   | 17.0       | 3500   | 4600   |
| 744FSM4374                   | 22.1                                       |   | 17.5       | 3600   | 4650   |
| 744FSM4376                   | 22.1                                       |   | 17.5       | 3600   | 4650   |

NOTES: ① For rated load exciter field volts – see generator nameplate; ② For low wye connection: divide value shown in table by 2; For high delta connection: divide value shown in table by 1.732; ③ For delta connection: divide value shown in table by 1.732.

# Specifications

Table 12-4: Excitation Data – 50 Hz – 1500 RPM

| Model Number<br>Low Volts | Exciter Field<br>Resistance<br>Ohms @ 25°C | Exciter Field Volts<br>F1 & F2 at Regulator<br>No Load <sup>①</sup> 415 Volts | No Load Output Voltage W/Fixed<br>Excitation High Wye Connection <sup>②</sup> |        |
|---------------------------|--|---|---|--------|
|                           |  |   | 12V DC  | 24V DC |
| 431RSL4005                | 22.5                                       | 15.6  | 380   | 460    |
| 431RSL4007                | 22.5                                       | 17.1  | 370   | 450    |
| 432RSL4009                | 22.5                                       | 18.0  | 360   | 445    |
| 432RSL4011                | 22.5                                       | 16.0  | 380   | 455    |
| 432RSL4013                | 22.5                                       | 13.1  | 400   | 480    |
| 432RSL4015                | 22.5                                       | 18.7  | 360   | 440    |
| 432RSL4017                | 22.5                                       | 17.4  | 370   | 450    |
| 433RSL4019                | 22.5                                       | 20.7  | 340   | 430    |
| 433RSL4021                | 22.5                                       | 16.7  | 360   | 450    |
| 572RSL4024                | 23.0                                       | 19.8  | 360   | 430    |
| 572RSL4027                | 23.0                                       | 20.0  | 355   | 430    |
| 572RSL4028                | 23.0                                       | 21.2  | 370   | 430    |
| 572RSL4030                | 23.0                                       | 18.4  | 360   | 440    |
| 573RSL4032                | 23.0                                       | 18.9  | 360   | 440    |
| 573RSL4034                | 23.0                                       | 20.7  | 350   | 430    |
| 574RSL4036                | 23.0                                       | 21.6  | 345   | 425    |
| 574RSL4038                | 23.0                                       | 17.7  | 365   | 450    |
| 575RSL4044                | 23.0                                       | 21.8  | 340   | 420    |
| 740RSL4046                | 23.0                                       | 21.9  | 340   | 420    |
| 741RSL4045                | 22.0                                       | 18.0  | 360   | 450    |
| 742RSL4046                | 22.0                                       | 18.7  | 350   | 445    |
| 742RSL4048                | 22.0                                       | 20.0  | 340   | 440    |
| 742RSL4050                | 22.0                                       | 16.1  | 370   | 470    |
| 743RSL4052                | 22.0                                       | 22.9  | 330   | 420    |
| 744RSL4054                | 22.1                                       | 22.6  | 320   | 420    |
| 744RSL4056                | 22.1                                       | 23.3  | 330   | 415    |
| 744RSL4058                | 22.1                                       | 24.3  | 330   | 415    |
| 744FSL4060                | 22.1                                       | 17.0  | 350   | 470    |
| 744FSL4062                | 22.1                                       | 19.5  | 330   | 440    |

| Model Number<br>Medium Volts | Exciter Field<br>Resistance<br>Ohms @ 25°C | Exciter Field Volts<br>F1 & F2 at Regulator<br>No Load <sup>①</sup> 3300 Volts | No Load Output Voltage W/Fixed<br>Excitation High Wye Connection <sup>③</sup> |        |
|------------------------------|--|--|---|--------|
|                              |  |  | 12V DC  | 24V DC |
| 573FSM4352                   | 23.0                                       | 21.2   | 2600  | 3400   |
| 573FSM4354                   | 23.0                                       | 18.2   | 2700  | 3600   |
| 574FSM4356                   | 23.0                                       | 18.4   | 2700  | 3600   |
| 574FSM4358                   | 23.0                                       | 15.7   | 2800  | 3800   |
| 741FSM4360                   | 22.0                                       | 15.4   | 3000  | 3800   |
| 742FSM4364                   | 22.0                                       | 14.5   | 3000  | 3900   |
| 742FSM4366                   | 22.0                                       | 15.6   | 2800  | 3800   |
| 743FSM4368                   | 22.1                                       | 15.5   | 2800  | 3900   |
| 743FSM4370                   | 22.1                                       | 15.5   | 2900  | 3800   |
| 744FSM4374                   | 22.1                                       | 16.8   | 2700  | 3800   |
| 744FSM4376                   | 22.1                                       | 16.8   | 2700  | 3800   |

NOTES: ① For rated load exciter field volts – see generator nameplate; ② For low wye connection: divide value shown in table by 2; For high delta connection: divide value shown in table by 1.732; ③ For delta connection: divide value shown in table by 1.732.

# Specifications

**Table 12-5: Resistance Values  
Main Windings  
Nominal Cold (25°C)  
Resistance in Ohms**

| Base Model<br>Low Voltage | Winding<br>H-SG- | Main<br>Stator ① | Main<br>Rotor |
|---------------------------|------------------|------------------|---------------|
| 431RSL4005                | 430049           | .0855            | .153          |
| 431RSL4007                | 430048           | .0648            | .173          |
| 432RSL4009                | 430046           | .0418            | .190          |
| 432RSL4011                | 430018           | .0410            | .186          |
| 432RSL4013                | 430015           | .0370            | .189          |
| 432RSL4015                | 430017           | .0260            | .225          |
| 432RSL4017                | 430016           | .0240            | .226          |
| 433RSL4019                | 430042           | .0140            | .286          |
| 433RSL4021                | 430039           | .0137            | .297          |
| 572RSL4024                | 570078           | .0132            | .376          |
| 572RSL4027                | 570072           | .0126            | .398          |
| 572RSL4028                | 570080           | .0092            | .423          |
| 572RSL4030                | 570074           | .0089            | .426          |
| 573RSL4032                | 570075           | .0074            | .472          |
| 573RSL4034                | 570076           | .0059            | .507          |
| 574RSL4036                | 570077           | .0049            | .584          |
| 574RSL4038                | 570069           | .0048            | .601          |
| 575RSL4044                | 570111           | .0030            | .704          |
| 740RSL4046                | 570111           | .0030            | .704          |
| 741RSL4045                | 740062           | .0045            | .692          |
| 742RSL4046                | 740042           | .0036            | .748          |
| 742RSL4048                | 740043           | .0030            | .776          |
| 742RSL4050                | 740051           | .0023            | .889          |
| 743RSL4052                | 740045           | .0018            | .979          |
| 744RSL4054                | 740046           | .0015            | 1.100         |
| 744RSL4056                | 740066           | .0012            | 1.250         |
| 744RSL4058                | 740066           | .0012            | 1.250         |
| 744FSL4060                | 740306           | .0026            | .892          |
| 744FSL4062                | 740307           | .0018            | 1.044         |

| Base Model<br>Medium Voltage | Winding<br>H-SG- | Main<br>Stator ① | Main<br>Rotor |
|------------------------------|------------------|------------------|---------------|
| 573FSM4352                   | 570213           | 1.030            | .383          |
| 573FSM4354                   | 570214           | .854             | .411          |
| 574FSM4356                   | 570215           | .568             | .508          |
| 741FSM4360                   | 740230           | .277             | .667          |
| 742FSM4364                   | 740204           | .233             | .768          |
| 742FSM4366                   | 740206           | .151             | .888          |
| 743FSM4368                   | 740207           | .127             | .954          |
| 743FSM4370                   | 740208           | .101             | 1.053         |
| 744FSM4374                   | 740240           | .072             | 1.196         |
| 744FSM4376                   | 740260           | .072             | 1.196         |

NOTES: ① Main stator values shown are line to line on the high wye connection.  
For low wye connection, divide value shown in table by 4.

**Table 12-6: Resistance Values  
Exciter Windings  
Nominal Cold (25°C)  
Resistance in Ohms**

| Low<br>Voltage | Exciter<br>Stator<br>(Field) | Exciter<br>Rotor<br>(Armature) | PMG<br>Stator |
|----------------|------------------------------|--------------------------------|---------------|
| 430 Frames     | 22.5                         | 0.022                          | 2.1           |
| 570 Frames     | 23.0                         | 0.045                          | 2.1           |
| 740 Frames     | 23.0                         | 0.045                          | 2.1           |
| 741 Frames     | 22.0                         | 0.043                          | 2.1           |
| 742 Frames     | 22.0                         | 0.043                          | 2.1           |
| 743 Frames     | 22.0                         | 0.043                          | 2.1           |
| 744 Frames     | 22.1                         | 0.048                          | 2.1           |

| Medium<br>Voltage | Exciter<br>Stator<br>(Field) | Exciter<br>Rotor<br>(Armature) | PMG<br>Stator |
|-------------------|------------------------------|--------------------------------|---------------|
| 570 Frames        | 23.0                         | 0.070                          | 2.1           |
| 740 Frames        | 23.0                         | 0.070                          | 2.1           |
| 741 Frames        | 22.0                         | 0.043                          | 2.1           |
| 742 Frames        | 22.0                         | 0.043                          | 2.1           |
| 743 Frames        | 22.1                         | 0.048                          | 2.1           |

# Generator Formulas

## Generator Formulas ①

| To Find                  | Known Values  | Three Phase  |
|--------------------------|---|--|
| kWe                      | Volts, Current, Power Factor  | $\frac{E \times I \times 1.73 \times PF}{1000} = kVA \times PF$  |
| kVA                      | Volts, Current  | $\frac{E \times I \times 1.73}{1000} = \frac{kWe}{PF}$   |
| RkVA                     | Volts, Current, Power Factor  | $\frac{E \times I \times 1.73 \times \sqrt{1 - (PF)^2}}{1000}$   |
| HP – Engine Output       | Generator kWe<br>Generator Efficiency<br>Radiator Cooling Fan HP<br>Battery Charging Generator HP | $\frac{kWe}{Efficiency \times .746} + \frac{Rad. Cooling Fan HP}{.746} + \frac{Bat. Chg. Gen. HP}{.746}$ |
| kWe – Required for Motor | Motor HP, Eff.  | $\frac{HP \times .746}{Efficiency}$  |
| kVA – Required for Motor | Motor HP, Eff., Power Factor  | $\frac{HP \times .746}{Efficiency \times PF}$  |
| Amps                     | HP, Volts   | $\frac{HP \times .746}{1.73 \times E \times Efficiency \times PF}$                                       |
| Amps                     | kWe, Volts, Power Factor  | $\frac{kWe \times 1000}{E \times 1.73 \times PF}$  |
| Amps                     | kVA, Volts  | $\frac{kVA \times 1000}{E \times 1.73}$  |
| Frequency (Hz)           | rpm, Poles  | $\frac{rpm \times Poles}{2 \times 60}$   |
| Poles                    | Hz, rpm   | $\frac{2 \times 60 \times Hz}{rpm}$  |
| rpm                      | Hz, Poles   | $\frac{2 \times 60 \times Hz}{Poles}$  |

① E = Volts  
I = Current (Amps)  
PF = Power Factor



# Warnings & Cautions





## IMPORTANT INFORMATION

Please Read Carefully



This catalog is not intended to provide operational instructions. Appropriate Marathon Electric instructions provided with the motor and precautions attached to the motor should be read carefully prior to installation, operation and/or maintenance of the equipment. Injury to personnel or motor failure may be caused by improper installation, maintenance or operation.

The following  and  information is supplied to you for your protection and to provide you with many years of trouble free and safe operation of your Marathon Electric product:



- Disconnect power and lock out driven equipment before working on a motor.
- Always keep hands and clothing away from moving parts.
- The lifting support on the motor is not to be used to lift the entire machine. Only the motor attached directly to the support may be safely lifted by the support.
- Install and ground per local and national codes.
- Discharge all capacitors before servicing a single phase motor.
- Misapplication of a motor in a hazardous environment can cause fire or an explosion and result in serious injury. Only the end user, local authority having jurisdiction, and/or insurance underwriter are qualified to identify the appropriate class(es), group(s), division and temperature code. Marathon Electric personnel cannot evaluate or recommend what motors may be suitable for use in hazardous environments. If a motor is nameplated for hazardous locations, do not operate the motor without all of the grease and drain plugs installed.
- Never attempt to measure the temperature rise of a motor by touch. Temperature rise must be measured by thermometer, resistance, imbedded detector or thermocouple.
- Motors with automatic reset thermal protectors will automatically restart when the protector temperature drops sufficiently. Do not use motors with automatic reset thermal protectors in applications where automatic restart will be hazardous to personnel or equipment.
- Motors with manual reset thermal protectors may start unexpectedly after the protector trips when the surrounding air is at +20°Fahrenheit or lower. If the manual reset protector trips, disconnect motor from its power supply. After the protector cools (five minutes or more), it can be reset and power may be applied to the motor.
- Connect all protective device leads, marked P1, P2, etc., per instructions supplied with the motor.
- Operation of a motor at other than its nameplate rating may result in fire, damage to equipment or serious injury to personnel.
- For safety, Buyer or User should provide protective guards over all shaft extensions and any moving apparatus mounted thereon. The User is responsible for checking all applicable safety codes in his area and providing suitable guards. Failure to do so may result in bodily injury and/or damage to equipment.



- Consult qualified personnel with questions and all electrical repairs must be performed by trained and qualified personnel only.
- For motors nameplated as "belted duty only", do not operate the motor without belts properly installed.
- Motors and/or driven equipment should not be operated faster than their rated speed.
- For inverter applications, follow the inverter manufacturer's installation guidelines.
- Make sure the motor is properly secured and aligned before operation.

# Resale Of Goods

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## Important Information

### Resale of Goods

In the event of the resale of any of the goods, in whatever form, Resellers/Buyers will include the following language in a conspicuous place and in a conspicuous manner in a written agreement covering such sale:

The manufacturer makes no warranty or representations, express or implied, by operation of law or otherwise, as to the merchantability or fitness for a particular purpose of the goods sold hereunder. Buyer acknowledges that it alone has determined that the goods purchased hereunder will suitably meet the requirements of their intended use. In no event will the manufacturer be liable for consequential, incidental or other damages. Even if the repair or replacement remedy shall be deemed to have failed of its essential purpose under Section 2-719 of the Uniform Commercial Code, the manufacturer shall have no liability to Buyer for consequential damages.

Resellers/Buyers agree to also include this entire document including the warnings and cautions above in a conspicuous place and in a conspicuous manner in writing to instruct users on the safe usage of the product.

This information should be read together with all other printed information supplied by Marathon Electric.

For more information contact: Regal Beloit America, Inc., a subsidiary of Regal-Beloit Corporation, 100 E. Randolph St., Wausau, WI 54401 Phone: 715-675-3311 or Fax: 715-675-8030.

# marathon™

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Generators

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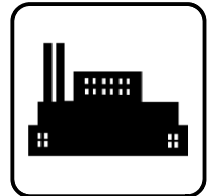


**REGAL**

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# Operation

## Industrial Generator Sets



Models:

**20-3250 kW**

Controllers:

Decision-Maker® 550

Software (Code) Version 3.4.3 or higher

**KOHLER**<sup>®</sup>  
Power Systems \_\_\_\_\_

**ISO 9001**  
**KOHLER**  
POWER SYSTEMS  
NATIONALLY REGISTERED

TP-6200 3/171

**California Proposition 65**

**⚠ WARNING**

Engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

**California Proposition 65**

**⚠ WARNING**

This product contains and/or emits chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

**California Proposition 65**

**⚠ WARNING**

Breathing diesel engine exhaust exposes you to chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

- Always start and operate the engine in a well-ventilated area.
- If in an enclosed area, vent the exhaust to the outside.
- Do not modify or tamper with exhaust system.
- Do not idle the engine except as necessary.

For more information go to [www.P65warnings.ca.gov/diesel](http://www.P65warnings.ca.gov/diesel)

**Product Identification Information**

Product identification numbers determine service parts. Record the product identification numbers in the spaces below immediately after unpacking the products so that the numbers are readily available for future reference. Record field-installed kit numbers after installing the kits.

**Generator Set Identification Numbers**

Record the product identification numbers from the generator set nameplate(s).

Model Designation \_\_\_\_\_

Specification Number \_\_\_\_\_

Serial Number \_\_\_\_\_

| <b>Accessory Number</b> | <b>Accessory Description</b> |
|-------------------------|------------------------------|
| _____                   | _____                        |
| _____                   | _____                        |
| _____                   | _____                        |
| _____                   | _____                        |
| _____                   | _____                        |

**Engine Identification**

Record the product identification information from the engine nameplate.

Manufacturer \_\_\_\_\_

Model Designation \_\_\_\_\_

Serial Number \_\_\_\_\_

**Controller Identification**

Record the controller description from the generator set operation manual, spec sheet, or sales invoice. Record the Controller Serial Number from the controller nameplate.

Controller Description Decision-Maker® 550

Controller Serial Number \_\_\_\_\_

**Firmware/Software Version Numbers**

Record the version and reference numbers as shipped from the manufacturer. Determine the Application Program Version Number as shown in Menu 20. Determine the Personality Profile Reference Number from the disk supplied with the literature packet.

Application Program Version Number \_\_\_\_\_

Personality Profile Reference Number \_\_\_\_\_

User Parameter File Reference Number \_\_\_\_\_

**Version Number Upgrades/Updates**

Record the version number upgrade/updates when installed.

Version No./Date Installed \_\_\_\_\_

**Software Options**

Record the software options.

Number and Description \_\_\_\_\_

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# Notes

# Safety Precautions and Instructions

**IMPORTANT SAFETY INSTRUCTIONS.** Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. **SAVE THESE INSTRUCTIONS.**

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

## DANGER

Danger indicates the presence of a hazard that **will cause severe personal injury, death, or substantial property damage.**

## WARNING

Warning indicates the presence of a hazard that **can cause severe personal injury, death, or substantial property damage.**

## CAUTION


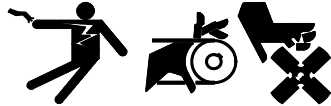
Caution indicates the presence of a hazard that **will or can cause minor personal injury or property damage.**

## NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.



Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.



## Accidental Starting

|   |
|---|
|  <b>WARNING</b>  |
|    |
| <b>Accidental starting.</b><br><b>Can cause severe injury or death.</b>   |
| Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. |

**Disabling the generator set. Accidental starting can cause severe injury or death.** Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

## Battery

|  |
|--|
|  <b>WARNING</b> |
|                 |
| <b>Sulfuric acid in batteries.</b><br><b>Can cause severe injury or death.</b>                     |
| Wear protective goggles and clothing. Battery acid may cause blindness and burn skin.              |

|   |
|---|
|  <b>WARNING</b>                |
|                                |
| <b>Explosion.</b><br><b>Can cause severe injury or death. Relays in the battery charger cause arcs or sparks.</b> |
| Locate the battery in a well-ventilated area. Isolate the battery charger from explosive fumes.                   |

**Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death.** Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.



**Battery acid cleanup. Battery acid can cause severe injury or death.** Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled battery acid and continue to add the neutralizing solution to the spilled battery acid until all evidence of a chemical reaction (foaming) has ceased. Flush the resulting liquid with water and dry the area.

**Battery gases. Explosion can cause severe injury or death.** Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove all jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

**Battery short circuits. Explosion can cause severe injury or death.** Short circuits can cause bodily injury and/or equipment damage. Disconnect the battery before generator set installation or maintenance. Remove all jewelry before servicing the equipment. Use tools with insulated handles. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together.

**Battery gases. Explosion can cause severe injury or death.** Incorrect use of the equalize charge state may lead to hazardous situations. Equalization is ONLY applicable for flooded lead acid (FLA) type batteries and will damage gel, absorbed glass mat (AGM), or nickel-cadmium (NiCad) type batteries. In the controller menu or SiteTech™ settings, verify that the battery topology is set correctly for the battery type used. Do not smoke or permit flames, sparks, or other sources of ignition to occur near a battery at any time.

## Engine Backfire/Flash Fire


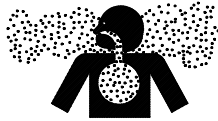
|   |
|---|
|  <b>WARNING</b>  |
|    |
| <p><b>Risk of fire.</b><br/> <b>Can cause severe injury or death.</b></p> <p>Do not smoke or permit flames or sparks near fuels or the fuel system.</p> |

**Servicing the fuel system. A flash fire can cause severe injury or death.** Do not smoke or permit flames or sparks near the carburetor, fuel line, fuel filter, fuel pump, or other potential sources of spilled fuels or fuel vapors. Catch fuels in an approved container when removing the fuel line or carburetor.

**Servicing the air cleaner. A sudden backfire can cause severe injury or death.** Do not operate the generator set with the air cleaner removed.

**Combustible materials. A fire can cause severe injury or death.** Generator set engine fuels and fuel vapors are flammable and explosive. Handle these materials carefully to minimize the risk of fire or explosion. Equip the compartment or nearby area with a fully charged fire extinguisher. Select a fire extinguisher rated ABC or BC for electrical fires or as recommended by the local fire code or an authorized agency. Train all personnel on fire extinguisher operation and fire prevention procedures.

## Exhaust System

|  |
|--|
|  <b>WARNING</b>   |
|   |
| <p><b>Carbon monoxide.</b><br/> <b>Can cause severe nausea, fainting, or death.</b></p> <p>The exhaust system must be leakproof and routinely inspected.</p> |



**Generator set operation. Carbon monoxide can cause severe nausea, fainting, or death.** Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Avoid breathing exhaust fumes when working on or near the generator set. Never operate the generator set inside a building unless the exhaust gas is piped safely outside. Never operate the generator set where exhaust gas could accumulate and seep back inside a potentially occupied building.

**Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death.** Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

## Fuel System

|   |
|---|
|  <b>WARNING</b>  |
|    |
| <p><b>Explosive fuel vapors.<br/>Can cause severe injury or death.</b></p> <p>Use extreme care when handling, storing, and using fuels.</p> |

**The fuel system. Explosive fuel vapors can cause severe injury or death.** Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

**Explosive fuel vapors can cause severe injury or death.** Take additional precautions when using the following fuels:

**Gasoline**—Store gasoline only in approved red containers clearly marked GASOLINE.

**Propane (LPG)**—Adequate ventilation is mandatory. Because propane is heavier than air, install propane gas detectors low in a room. Inspect the detectors per the manufacturer's instructions.

**Natural Gas**—Adequate ventilation is mandatory. Because natural gas rises, install natural gas detectors high in a room. Inspect the detectors per the manufacturer's instructions.



**Fuel tanks. Explosive fuel vapors can cause severe injury or death.** Gasoline and other volatile fuels stored in day tanks or subbase fuel tanks can cause an explosion. Store only diesel fuel in tanks.

**Draining the fuel system. Explosive fuel vapors can cause severe injury or death.** Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

**Gas fuel leaks. Explosive fuel vapors can cause severe injury or death.** Fuel leakage can cause an explosion. Check the LPG vapor or natural gas fuel system for leakage by using a soap and water solution with the fuel system test pressurized to 6–8 ounces per square inch (10–14 inches water column). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.


**LPG liquid withdrawal fuel leaks. Explosive fuel vapors can cause severe injury or death.** Fuel leakage can cause an explosion. Check the LPG liquid withdrawal fuel system for leakage by using a soap and water solution with the fuel system test pressurized to at least 90 psi (621 kPa). Do not use a soap solution containing either ammonia or chlorine because both prevent bubble formation. A successful test depends on the ability of the solution to bubble.


## Hazardous Noise


|  |
|--|
|  <b>CAUTION</b>   |
|   |
| <p><b>Hazardous noise.<br/>Can cause hearing loss.</b></p> <p>Never operate the generator set without a muffler or with a faulty exhaust system.</p> |

**Engine noise. Hazardous noise can cause hearing loss.** Generator sets not equipped with sound enclosures can produce noise levels greater than 105 dBA. Prolonged exposure to noise levels greater than 85 dBA can cause permanent hearing loss. Wear hearing protection when near an operating generator set.

## Hazardous Voltage/ Moving Parts

|   |
|---|
| <b>⚠ DANGER</b>   |
|  |
| <b>Hazardous voltage. Will cause severe injury or death.</b>                      |
| Disconnect all power sources before opening the enclosure.                        |

|  |
|--|
| <b>⚠ WARNING</b>   |
|       |
| <b>Hazardous voltage. Moving parts. Can cause severe injury or death.</b>              |
| Operate the generator set only when all guards and electrical enclosures are in place. |

|  |
|--|
| <b>⚠ WARNING</b>   |
|   |
| <b>Hazardous voltage. Backfeed to the utility system can cause property damage, severe injury, or death.</b>   |
| If the generator set is used for standby power, install an automatic transfer switch to prevent inadvertent interconnection of standby and normal sources of supply. |

**Grounding electrical equipment. Hazardous voltage can cause severe injury or death.** Electrocutation is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

**High voltage test. Hazardous voltage can cause severe injury or death.** Follow the instructions of the test equipment manufacturer when performing high-voltage tests on the rotor or stator. An improper test procedure can damage equipment or lead to generator set failure.

**Installing the battery charger. Hazardous voltage can cause severe injury or death.** An ungrounded battery charger may cause electrical shock. Connect the battery charger enclosure to the ground of a permanent wiring system. As an alternative, install an equipment grounding conductor with circuit conductors and connect it to the equipment grounding terminal or the lead on the battery charger. Install the battery charger as prescribed in the equipment manual. Install the battery charger in compliance with local codes and ordinances.

**Connecting the battery and the battery charger. Hazardous voltage can cause severe injury or death.** Reconnect the battery correctly, positive to positive and negative to negative, to avoid electrical shock and damage to the battery charger and battery(ies). Have a qualified electrician install the battery(ies).

**Short circuits. Hazardous voltage/current can cause severe injury or death.** Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

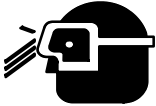
**Engine block heater. Hazardous voltage can cause severe injury or death.** The engine block heater can cause electrical shock. Remove the engine block heater plug from the electrical outlet before working on the block heater electrical connections.

**Handling the capacitor. Hazardous voltage can cause severe injury or death.** Electrical shock results from touching the charged capacitor terminals. Discharge the capacitor by shorting the terminals together. *(Capacitor-excited models only)*

**Electrical backfeed to the utility. Hazardous backfeed voltage can cause severe injury or death.** Install a transfer switch in standby power installations to prevent the connection of standby and other sources of power. Electrical backfeed into a utility electrical system can cause severe injury or death to utility personnel working on power lines.

**Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death.** Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically. *(600 volts and under)*


---

|   |
|---|
| <b>⚠ WARNING</b>  |
|         |
| <b>Airborne particles. Can cause severe injury or blindness.</b>                            |
| Wear protective goggles and clothing when using power tools, hand tools, or compressed air. |


---


**Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death.** Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

## Heavy Equipment

|   |
|---|
| <b>⚠ WARNING</b>  |
|                                      |
| <b>Unbalanced weight. Improper lifting can cause severe injury or death and equipment damage.</b>                     |
| Do not use lifting eyes.<br>Lift the generator set using lifting bars inserted through the lifting holes on the skid. |

## Hot Parts


|  |
|--|
| <b>⚠ WARNING</b>   |
|   |
| <b>Hot coolant and steam. Can cause severe injury or death.</b>  |
| Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure. |

|   |
|---|
| <b>⚠ WARNING</b>  |
|  |
| <b>Hot engine and exhaust system. Can cause severe injury or death.</b>             |
| Do not work on the generator set until it cools.                                    |

**Servicing the alternator. Hot parts can cause severe injury or death.** Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

**Servicing the exhaust system. Hot parts can cause severe injury or death.** Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

## Notice

|   |
|---|
| <b>NOTICE</b>   |
| This generator set has been rewired from its nameplate voltage to                 |
|  |
| <small>246242</small>   |

**NOTICE**

**Voltage reconnection.** Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.

**NOTICE**

**Canadian installations only.** For standby service connect the output of the generator set to a suitably rated transfer switch in accordance with Canadian Electrical Code, Part 1.

# Notes

This manual provides operation instructions for 20 kW and larger generator sets equipped with the following controller:

- Decision® 550, Software (Code) Version 2.10 or higher

Version 2.10 refers to the controller application software. To determine the generator set controller software version, go to Menu 20—Factory Setup and scroll down to *Code Version*. The code version is the controller software version.

Wiring diagram manuals are available separately. Refer to the engine operation manual for generator set engine scheduled maintenance information.

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

The equipment service requirements are very important to safe and efficient operation. Inspect the parts often and perform required service at the prescribed intervals. Maintenance work must be performed by appropriately skilled and suitably trained maintenance personnel familiar with generator set operation and service.

The disk supplied with this generator set is a backup copy of the generator set personality program containing data specific to the engine and alternator. The engine and alternator data was preprogrammed in the controller at the factory and no further use of the disk should be necessary. Typically, your authorized distributor stores this disk for possible future use such as controller replacement or other circumstances requiring a backup.

## Abbreviations

This publication makes use of numerous abbreviations. Typically, the word(s) are spelled out along with the abbreviation in parentheses when shown for the first time in a section. Appendix A, Abbreviations, also includes many abbreviation definitions.

## List of Related Materials

Separate literature contains communication and software information not provided in this manual. Figure 1 lists the available literature part numbers.

| Communication and Software Manual Description             | Literature Part No.   |
|---|---|
| 550 Controller Spec Sheet                                 | G6-46   |
| Generator Set/Controller Wiring Diagram Manual            | Multiple Part Numbers<br>Contact your<br>Distributor/Dealer |
| 550 Communications Spec Sheet                             | G6-50   |
| Monitor III Converters, Connections, and Controller Setup | TT-1405   |
| Monitor III Software Spec Sheet                           | G6-76   |
| Monitor III Converter, Modbus®/Ethernet Spec Sheet        | G6-79   |
| Monitor III Software Operation Manual                     | TP-6347   |
| Modbus® Communications Protocol Operation Manual          | TP-6113   |
| Setup and Application Manual                              | TP-6140   |
| Service Parts Controllers                                 | TP-6780   |
| Program Loader Software Installation                      | TT-1285   |
| SiteTech™ Software Operation Manual                       | TP-6701   |
| Remote Serial Annunciator (RSA)                           | TT-1377   |
| Remote Serial Annunciator (RSA II)                        | TT-1485   |
| Controller Service Replacement                            | TT-1310   |

**Figure 1** Related Literature



# Service Assistance

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For professional advice on generator set power requirements and conscientious service, please contact your nearest Kohler distributor or dealer.

- Consult the Yellow Pages under the heading Generators—Electric.
- Visit the Kohler Power Systems website at KOHLERPower.com.
- Look at the labels and decals on your Kohler product or review the appropriate literature or documents included with the product.
- Call toll free in the US and Canada 1-800-544-2444.
- Outside the US and Canada, call the nearest regional office.

## **Headquarters Europe, Middle East, Africa (EMEA)**

Kohler Power Systems Netherlands B.V.  
Kristallaan 1  
4761 ZC Zevenbergen  
The Netherlands  
Phone: (31) 168 331630  
Fax: (31) 168 331631

## **Asia Pacific**

Power Systems Asia Pacific Regional Office  
Singapore, Republic of Singapore  
Phone: (65) 6264-6422  
Fax: (65) 6264-6455

## **China**

North China Regional Office, Beijing  
Phone: (86) 10 6518 7950  
(86) 10 6518 7951  
(86) 10 6518 7952  
Fax: (86) 10 6518 7955

East China Regional Office, Shanghai  
Phone: (86) 21 6288 0500  
Fax: (86) 21 6288 0550

## **India, Bangladesh, Sri Lanka**

India Regional Office  
Bangalore, India  
Phone: (91) 80 3366208  
(91) 80 3366231  
Fax: (91) 80 3315972

## **Japan, Korea**

North Asia Regional Office  
Tokyo, Japan  
Phone: (813) 3440-4515  
Fax: (813) 3440-2727

# Section 1 Specifications and Features

## 1.1 Introduction

The spec sheets for each generator set provide model-specific generator and engine information. The controller spec sheet provides specifications for this controller. Refer to the respective spec sheet for data not supplied in this manual. Consult the generator set service manual, installation manual, engine operation manual, and engine service manual for additional specifications.

The controller features, accessories, and menu displays depend upon the engine electronic control module (ECM) setup and features. Controller features apply to generator set models with ECM and non-ECM engines unless otherwise noted.

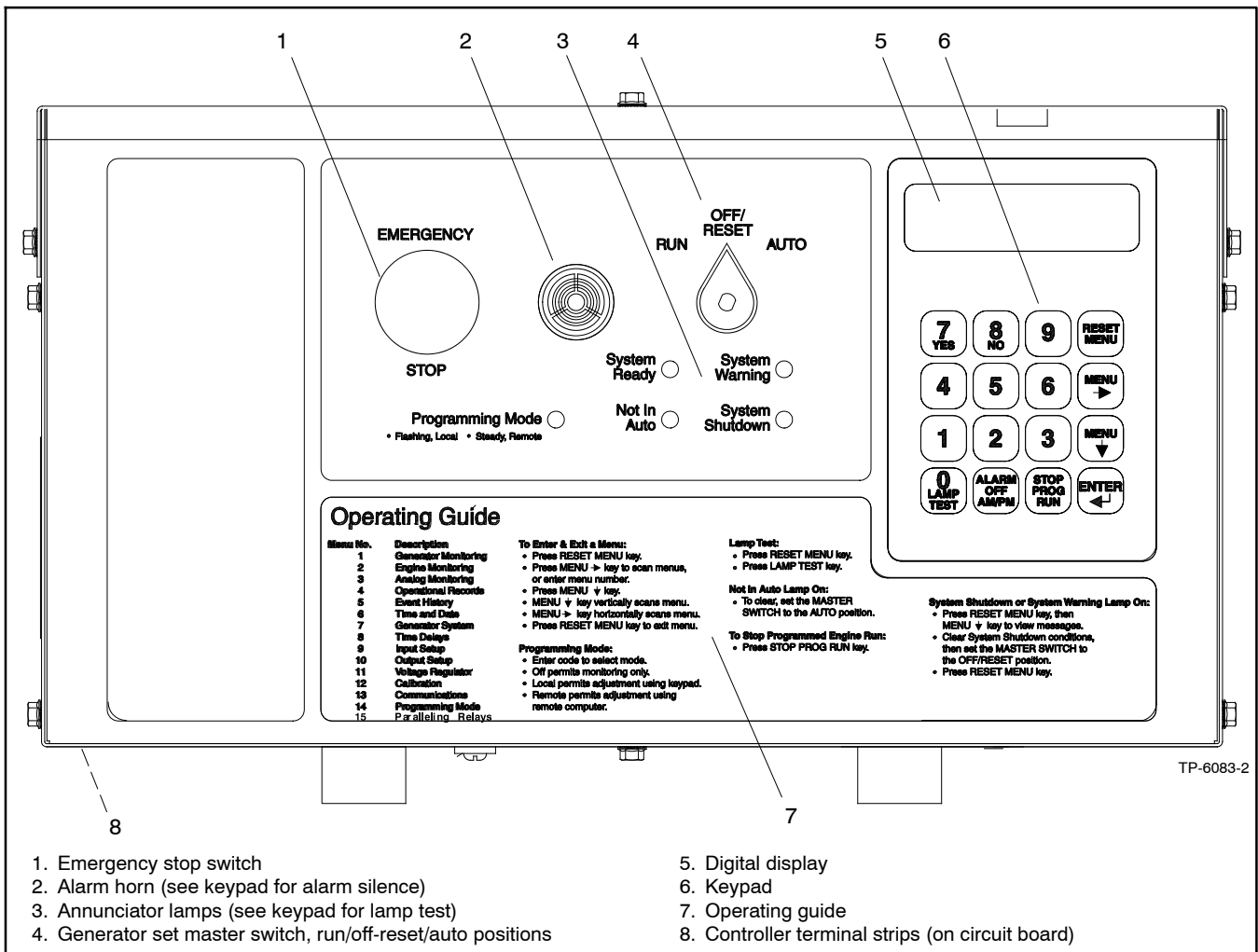
**Note:** Press any key on the keypad to turn on the controller lights and display. The lights and display turn off 5 minutes after the last keypad entry.

## 1.2 Controller Features

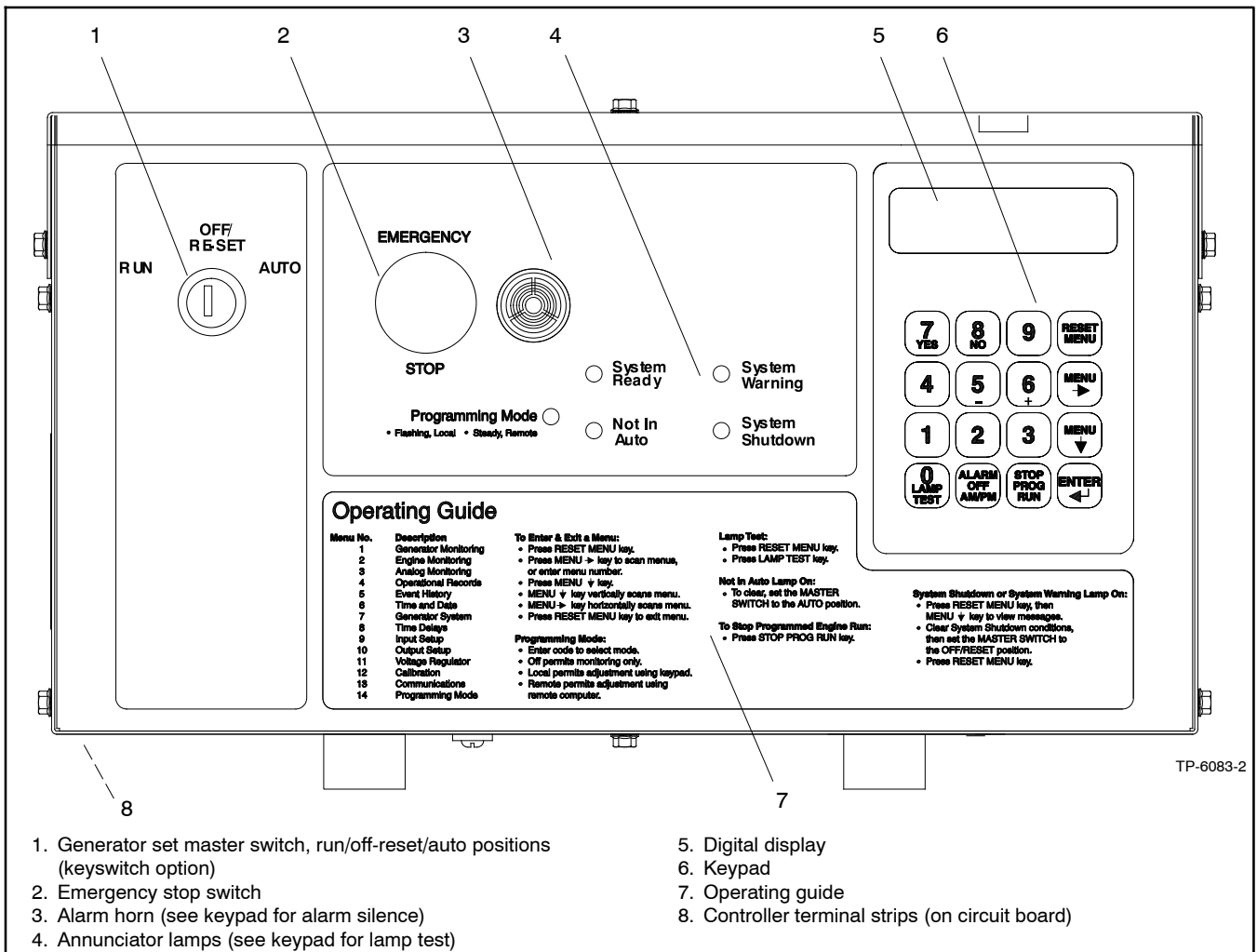
The controller features include the annunciator lamps, digital display and keypad, switches and controls, and fuses and terminal strip. The following paragraphs detail the features by general topics.

**Note:** Measurements display in metric or English. Use Menu 7—Generator System to change the measurement display.

See Figure 1-1 for an illustration of the controller front panel. See Figure 1-2 for an illustration of the controller with the keyswitch option.



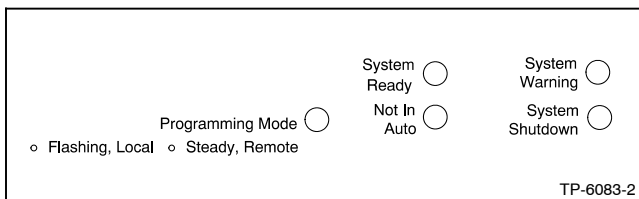
**Figure 1-1** 550 Controller with Three-Position Selector Switch



**Figure 1-2** 550 Controller with Keyswitch Option

### 1.2.1 Annunciator Lamps

Five annunciator lamps provide visual generator set status. See Figure 1-3.



**Figure 1-3** Annunciator Lamps

**System Ready.** Green lamp illuminates when the generator set master switch is in the AUTO (automatic start) position and the system senses no faults. The unit is ready to start.

**Not in Auto (NIA).** Yellow lamp illuminates when the generator set master switch is not in the AUTO (automatic start) position.

**Programming Mode.** Yellow programming lamp indicates the user selected programming mode. See Figure 1-4.

| Programming Lamp | Programming Mode Selection |
|------------------|----------------------------|
| Lamp Flashing    | Local Programming          |
| Lamp Steady On   | Remote Programming         |
| Lamp Off         | Programming Disabled       |

**Figure 1-4** Programming Lamp Mode

**Note:** Find additional information for the programming mode lamp function and access to the local or remote programming modes in Section 2.9, Local Programming Mode On, Menu 14—Programming Mode.

**System Warning.** Yellow lamp identifies an existing fault condition that does not shut down the generator set. A continuing system warning fault condition may cause a system shutdown. Correct all system warnings as soon as practical.

See Section 2.4.5, System Warning Lamp, for definitions of the items listed.

The following conditions cause a system warning:

- Engine functions:
  - ECM yellow alarm (DDC/MTU engine with MDEC/ADEC)
  - High battery voltage
  - High coolant temperature
  - Low battery voltage
  - Low coolant temperature
  - Low fuel (level or pressure)\*
  - Low oil pressure
  - Speed sensor fault
  - Starting aid (system status)
  - Weak battery
- General functions:
  - Auxiliary—Analog up to 7 user-selectable inputs each with a high and low programmable warning level
  - Auxiliary—Digital up to 21 user-selectable warnings
  - Battery charger communication error
  - Battery charger fault\*
    - Note:** Optional input sensors not required with charger GM87448.
  - Battery charger value mismatch error
  - Emergency power system (EPS) supplying load
  - Engine cooldown delay
  - Engine start delay
  - Load shed kW overload
  - Load shed underfrequency
  - Master switch not in AUTO (automatic start) position
  - NFPA 110 fault (National Fire Protection Association)
  - System ready (system status)
- Alternator functions:
  - AC sensing loss
  - Ground fault\*
  - Overcurrent

\* Requires optional input sensors

**Note:** See Figure 2-8 in User Inputs for factory-reserved analog and digital inputs that are not user-selectable.

**System Shutdown.** Red lamp indicates that the generator set has shut down because of a fault condition. The unit will not start without resetting the controller, see Section 2.4.7, Controller Reset Procedure.

See Section 2.4.6, System Shutdown Lamp, for definitions of the items listed.

The following conditions cause a system shutdown:

- Engine functions:
  - Air damper closed (status), if equipped
  - Coolant temperature signal loss
  - ECM red alarm (DDC/MTU engine with MDEC/ADEC)
  - Engine stalled (ECM only)
  - High coolant temperature
  - High oil temperature
  - Low coolant level
  - Low oil pressure
  - Oil pressure signal loss
  - Overcrank
  - Overspeed
- General functions:
  - Auxiliary—Analog up to 7 user-selectable inputs each with a high and low programmable shutdown level
  - Auxiliary—Digital up to 21 user-selectable shutdowns
  - ECM communications loss (ECM models only)
  - Emergency stop
  - Internal fault
  - Master switch in OFF/RESET position
  - Master switch error
  - Master switch open
  - NFPA 110 fault
- Alternator functions:
  - AC output overvoltage
  - AC output undervoltage
  - Alternator protection against overload and short circuits
  - Field overvoltage (M4, M5, M7, or M10 alternator only)
  - Locked rotor (failed to crank)
  - Overfrequency
  - Underfrequency

**Note:** See Figure 2-8 in User Inputs for factory-reserved analog and digital inputs which are not user-selectable.

## 1.2.2 Digital Display and Keypad

Figure 1-5 illustrates the digital display and keypad.

**Note:** Press any key on the keypad to turn on the controller lights and display. The lights and display turn off 5 minutes after the last keypad entry.

The 2-line vacuum fluorescent display provides generator set and engine condition information.

The 16-button keypad gives the user information access and local programming capability.


### Keypad Functions


**Alarm (Horn) Off key** silences the alarm horn at the operator's discretion. Place the generator set master switch in the AUTO position before silencing the alarm horn. See Section 2.4.7, Controller Reset Procedure, and Section 1.2.3, Switches and Controls.

**AM/PM key** provides time of day data entries when programming.

**Enter**  **key** provides confirmation entry when selecting menu or programming.

**Lamp Test key** tests the controller indicator lamps, horn, and digital display. See Section 1.2.3, Switches and Controls.

**Menu down**  **key** provides navigation within menus when necessary.

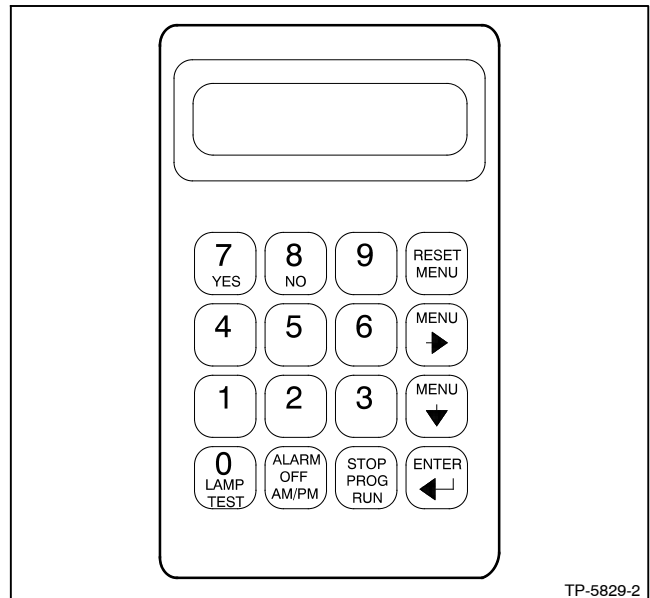
**Menu right**  **key** provides navigation within menus when necessary.

**Numeric 0-9 keys** provide numeric data entries when selecting menus or programming.

**Reset Menu key** exits a menu, clears incorrect entries, and cancels the auto-scroll feature.

**Stop Prog (Program) Run key** allows the user to stop any previously programmed generator set run sequence. See Section 1.2.3, Switches and Controls.

**Yes/No keys** provides data answer entries when programming.



**Figure 1-5** Digital Display and Keypad

### Alternator Output Displays (Menu 1)

**AC Amps** displays the alternator output current. The display shows each line of 3-phase models.

**AC Volts** displays the alternator output voltages. The display shows all line-to-neutral and line-to-line voltage combinations.

**Alternator Duty Level** displays the actual load kW divided by the nameplate kW rating as a percentage.

**Frequency** displays the frequency (Hz) of alternator output voltage.

**Hourmeter** displays the generator set operating hours loaded and unloaded for reference in scheduling maintenance.

**KVA** displays the total and individual L1, L2, and L3 kVA.

**KVAR** displays the total and individual L1, L2, and L3 kVAR.

**Power Factor** displays the kW/kVA and the individual line power factor values.

**Watts** displays the total and individual L1, L2, and L3 kilowatts.

## Engine Displays (Menu 2)

Some engine displays are available with selected generator set engines using engine ECMs only. The controller display shows N/A (not available) for items that are unavailable. See the controller spec sheet for applicable generator set models.

**Ambient Temperature** displays the generator set area ambient temperature.

**Charge Air Pressure** displays the engine turbocharger boost air pressure.

**Charge Air Temperature** displays the engine turbocharger boost air temperature.

**Coolant Level** displays the engine coolant level.

**Coolant Pressure** displays the engine coolant pressure.

**Coolant Temperature** displays the engine coolant temperature.

**Crankcase Pressure** displays the engine crankcase pressure.

**DC Volts** displays the voltage of starting battery(ies).

**Fuel Pressure** displays the fuel supply pressure.

**Fuel Rate** displays the calculated fuel consumption rate based on fuel injector outputs.

**Fuel Temperature** displays the fuel supply temperature.

**Oil Level** displays the engine oil level as a percent of full capacity.

**Oil Pressure** displays the engine oil pressure.

**Oil Temperature** displays the engine oil temperature.

**RPM (Tachometer)** displays the engine speed.

**Used Last Run** displays the accumulated amount of fuel used since last reset by the engine DDEC reader.

## Operational Record Displays (Menus 4 and 5)

The operational record displays events since last reset. See Section 2.9.4, Menu 4—Operational Records, for resetting procedure.

**Engine Start Countdown** displays the time remaining before the next generator set startup.

**Event History** displays up to 100 stored system events including status, warnings, and shutdowns.

**Last Start Date** displays the date when the generator set last operated.

**Number of Starts** displays the total number of generator set startup events.

**Number of Starts (Since) Last Maintenance** displays the total number of generator set startup events since the last maintenance date.

**Operating Days (Since) Last Maintenance** displays the total number of days of operation since the last maintenance date. A counted day of operation can be 1–24 hours.

**Run Time** displays the total loaded hours, total unloaded hours, and total kW hours.

**Run Time Since Maintenance** displays the total loaded hours, total unloaded hours, and total kW hours.

## Time Delay Displays (Menu 8)

The time delays are user adjustable. See Section 2.9.8, Menu 8—Time Delays, for time delay adjustments. See Section 1.3.1, Status Event and Fault Specifications, for range and default settings.

**Crank On/Crank Pause** displays the time allocated for generator set crank on and crank pause in minutes:seconds.

**Engine Cooldown** displays the time delay for engine cooldown while the master switch is in the AUTO or RUN positions and not in the idle mode.

**Engine Start** displays the time delay before the generator set starts while the master switch is in AUTO or RUN positions.

**Overcrank Shutdown (Number of) Crank Cycles** displays the number of unsuccessful crank cycles (crank on/crank pause) before the generator set shuts down on an overcrank fault.

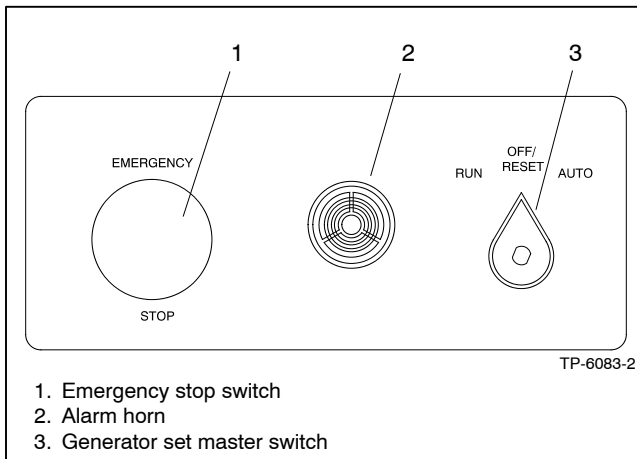
**Overvoltage** displays the time delay before the generator set shuts down because of an overvoltage condition.

**Starting Aid** displays the engine starting aid activation time.

**Undervoltage** displays the time delay before the generator set shuts down because of an undervoltage condition.

### 1.2.3 Switches and Controls

See Figure 1-6 and Figure 1-8 for switches and controls.



**Figure 1-6** Switches and Alarm Horn

**Note:** Find additional switches and controls in Section 2.6.1, Keypad Operation.

**Alarm Horn.** The alarm horn alerts the operator or other attendants that a shutdown or warning condition exists. See Section 1.3, Controller Logic Specifications, for conditions. Place the generator set master switch in the AUTO position before silencing the alarm horn. The alarm horn cannot be silenced unless the generator set master switch is in the AUTO position. See Section 2.4.7, Controller Reset Procedure.

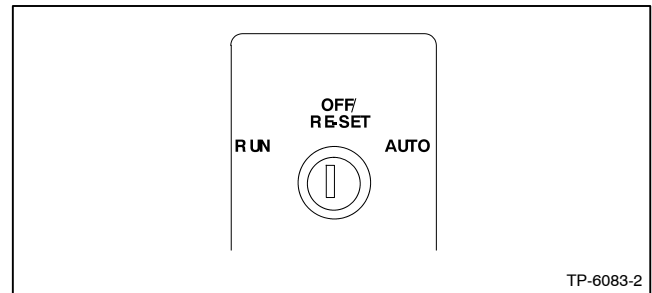
**Alarm (Horn) Off.** The keypad switch silences the alarm horn at the operator's discretion. Place the generator set master switch in the AUTO position before silencing the alarm horn. Restore alarm horn switches at all locations including those on remote annunciator and audiovisual alarm kits to the normal position after correcting the fault shutdown to avoid reactivating the alarm horn. See Section 2.4.7, Controller Reset Procedure.

**AM/PM.** This keypad switch provides time of day data entries when programming.

**Emergency Stop.** The operator-activated pushbutton immediately shuts down the generator set in emergency situations. Reset the emergency stop switch after shutdown by pulling the switch knob outward. *Use the emergency stop switch for emergency shutdowns only. Use the generator set master switch for normal shutdowns.*

**Generator Set Master Switch (Run/Off-Reset/Auto).** This switch resets the controller fault lamps and start/stops the generator set. Refer to Section 2.4.1, Starting, Section 2.4.2, Stopping, and Section 2.4.3, Emergency Stop Switch Reset Procedure.

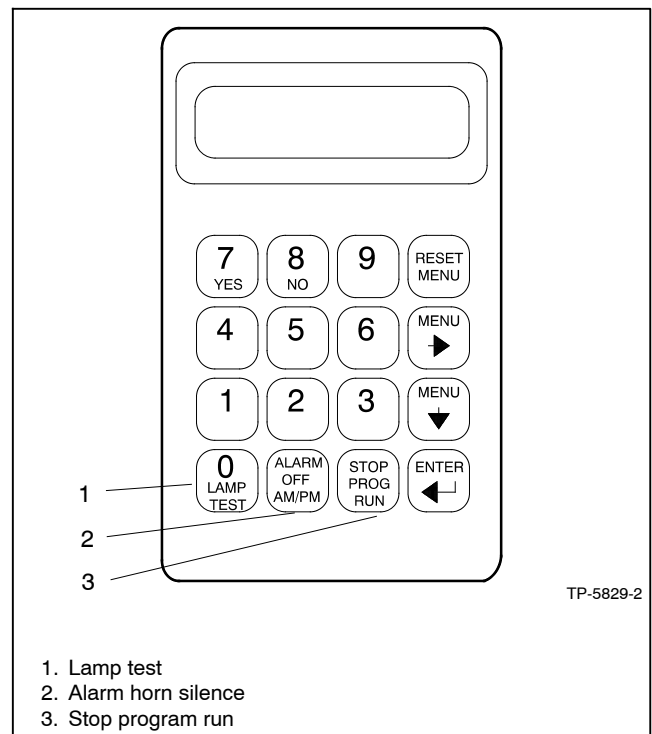
The generator set master switch with the keyswitch option (Figure 1-7) is available to meet appropriate local code requirements. The key is removable in the AUTO position only.



**Figure 1-7** Generator Set Master Switch with Keyswitch Option

**Lamp Test.** The keypad switch tests the controller indicator lamps, horn, and digital display. Press the reset menu key before pressing the lamp test key.

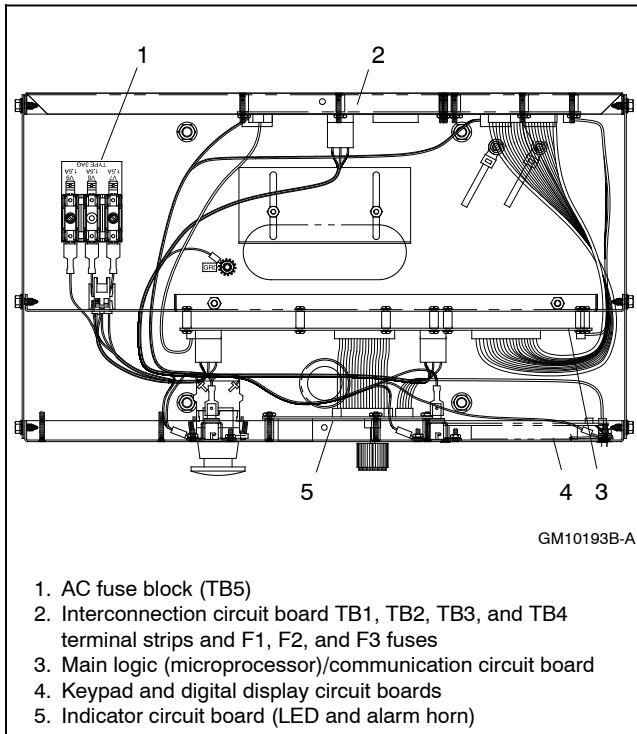
**Stop Prog (Program) Run.** Keypad switch allows the user to stop any previously programmed generator set run sequence.



**Figure 1-8** Keypad Switches

## 1.2.4 Controller Circuit Boards

The controller has five circuit boards—indicator, interconnection, keypad, digital display, and main logic/communication. See Figure 1-9 for circuit board locations.



**Figure 1-9** Controller Circuit Boards and Fuses (Controller Top View)

**Indicator (Status) Circuit Board** includes the LED status lamps, alarm horn, and generator set master switch.

**Interconnection Circuit Board** provides the terminal strips to connect the controller (customer) connection board and/or dry contact kits and three DC fuses (F1, F2, and F3). See 6.1.4 for more information.

**Keypad (Switch Membrane) Circuit Board** provides the keypad to navigate the generator set displays and enter data.

**Digital Display Circuit Board** provides the vacuum fluorescent display (VFD) for monitoring the generator set functions and output values.

**Main Logic (Microprocessor)/Communication Circuit Board** provides the controller operation logic and provides PC communication locally (direct) or remotely (via modem) using RS-232 or RS-485 connectors.

## 1.2.5 Fuses

**AC Circuit Fuses (TB5).** Fuses are located inside the controller. See Figure 1-9.

- **1.5-Amp (V7)** fuse protects L1 sensing input to interconnection circuit board.
- **1.5-Amp (V8)** fuse protects L2 sensing input to interconnection circuit board.
- **1.5-Amp (V9)** fuse protects L3 sensing input to interconnection circuit board.

**DC Circuit Fuses** fuses are located on the controller interconnection circuit board.

- **5-Amp Remote Annunciator (F1)** fuse protects the dry contact kit if equipped and the controller panel lamps.
- **5-Amp Controller (F2)** fuse protects the controller circuitry.
- **15-Amp Engine and Accessories (F3)** fuse protects the engine/starting circuitry and accessories.

## 1.2.6 Terminal Strips and Connectors

Terminal strips and connectors for inputs and outputs are located on the interconnection circuit board. See Section 6, Accessories.

**TB1 Input Connection Terminal Strip** provides input connections for remote start and emergency stop (E-Stop).

**TB2 Analog Input Connection Terminal Strip** provides analog input connections, including non-ECM sensor connections.

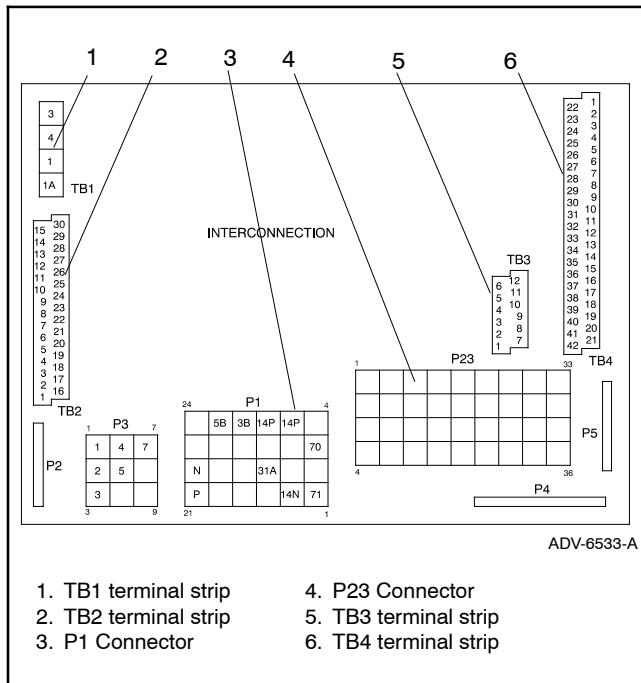
**TB3 Accessory Power Output Connection Terminal Strips** provides a generator set power supply for factory use.

**TB4 Digital Input Connection Terminal Strips** connect external devices (engine ECM and user supplied) to the generator set digital inputs.

**P23 Connector** connects the interconnection circuit board to the controller (customer) connection terminal strip (connector P25) inside the junction box. See 6.1.4 for more information.



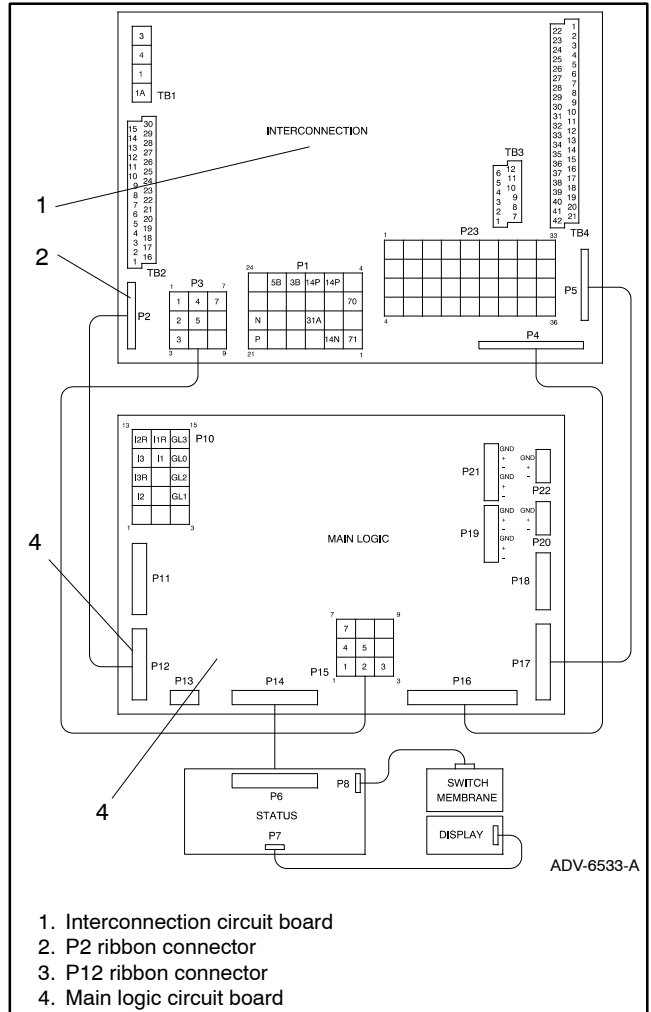
Figure 1-10 shows locations of the terminal strips on the controller interconnection circuit board. See Section 6.2, Accessory and Connections, for specific terminal identification information. Refer to the wiring diagrams for additional information on connecting accessories to the terminal strips.



**Figure 1-10** Interconnection Circuit Board Terminal Strips and Connectors

### 1.2.7 Circuit Board Interconnections for Calibration Procedure

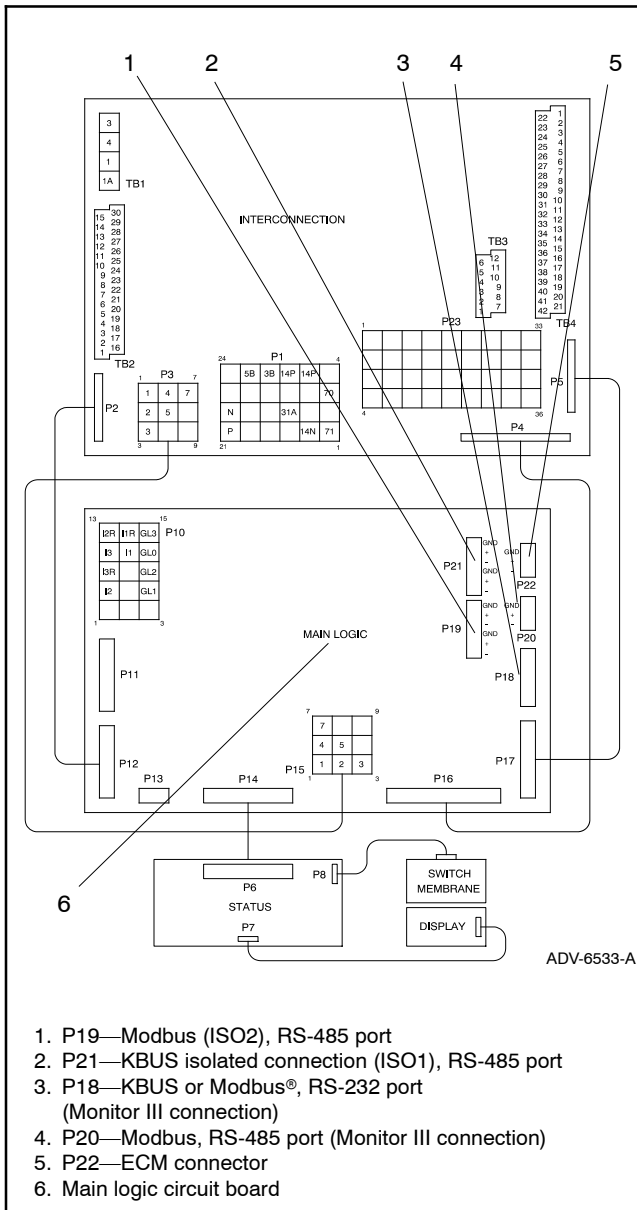
The interconnection circuit board shown in Figure 1-11 contains a ribbon connector that requires disconnection during the calibration procedure in Menu 12—Calibration. Disconnect ribbon connector P2 prior to zeroing out (resetting) the auxiliary analog inputs.



**Figure 1-11** Interconnection Circuit Board Ribbon Connector P2 (Top View of Circuit Board)

## 1.2.8 Communication Ports

The main logic circuit board contains several communication ports for Modbus® and KBUS connections. See Figure 1-12. Refer to the List of Related Materials in the Introduction for corresponding communication installation information.



**Figure 1-12** Main Logic Circuit Board Communication Ports (Top View of Circuit Board)

## 1.3 Controller Logic Specifications

The controller logic specifications section is an overview of the various features and functions of the controller. Certain features function only when optional accessories are connected. See Section 2, Operation, for details.

The default selection time delays and relay driver outputs (RDOs) are factory set and adjustable with the programming mode on (Menu 14). Some data entries require using a PC in the Remote Programming mode. See the monitor software operation manual for details.

**Inhibit Time Delay.** The inhibit time delay is the time period following crank disconnect during which the generator set stabilizes and the controller does not detect a fault or status event. Select the desired inhibit time delay from 0 to 60 seconds.

**Time Delay (Shutdown or Warning).** The time delay follows the inhibit time delay. The time delay is the time period between when the controller first detects a fault or status event and the controller warning or shutdown lamp illuminates. The delay prevents any nuisance alarms. Select the desired time delay from 0 to 60 seconds.

### 1.3.1 Status Event and Fault Specifications

The table starting on the next page contains all status events and faults with ranges and time delays including items that do not have adjustments.

**Note:** The engine ECM may limit the crank cycle even if the controller is set to a longer time period.

## Factory-Defined Settings

| Status Event or Fault                                   | Refer to Menu | Digital Display         | Relay Driver Output (RDO) | Alarm Horn | Lamp                | Range Setting  | Default Selection  | Inhibit Time Delay (sec.) | Time Delay (sec.) |
|---|---------------|-------------------------|---------------------------|------------|---------------------|--|--|---------------------------|-------------------|
| Access Code (password)                                  | 14            |                         |                           |            |                     | User-Selectable  | 0 (zero)   |                           |                   |
| AC Sensing Loss   | 10            | AC SENSING LOSS         | RDO-25 *                  | On         | Warning             |  |  |                           |                   |
| Air Damper Control (if used) **                         | 10            |                         |                           |            |                     |  |  |                           |                   |
| Air Damper Indicator (if used), see D20 **              |               |                         |                           |            |                     |  |  |                           |                   |
| Air/Fuel Module (AFM) Engine Start Delay ‡              | 10            | AFM ENG START DELAY     |                           |            |                     | Fixed  |  |                           |                   |
| Air/Fuel Module (AFM) Remote Start ‡                    | 10            | AFM REMOTE START        | RDO-25 ‡                  | Off        |                     |  |  |                           |                   |
| Air/Fuel Module (AFM) Shutdown (see D11) ‡              |               |                         |                           |            |                     |  |  |                           |                   |
| Alternator Protection Shutdown                          | 10            | ALTERNATOR PROTECTION   |                           | On         | Shutdown            |  |  |                           |                   |
| Analog Aux. Input 0                                     | 9             | LOCAL BATT VDC          |                           |            |                     | Fixed  |  |                           |                   |
| Analog Aux. Inputs A01-A07                              | 9             | USER-DEFINED A01-A07    |                           | On         | Shutdown or Warning | Default Values with Warning Enabled:<br>HI warning 90%<br>LO warning 10%<br>HI shutdown 100%<br>LO shutdown 1%   | 30 sec. inhibit,<br>5 sec. delay                                   | 0-60                      | 0-60              |
| Analog Aux. Input A01 (non-ECM only)                    | 9             | A01 COOLANT TEMP        |                           | On         | Shutdown or Warning | Default Values with Warning Enabled:<br>HI/LO warning and HI/LO shutdown are all engine dependent                | 30 sec. inhibit,<br>0 sec. delay warning,<br>5 sec. delay shutdown |                           |                   |
| Analog Aux. Input A02 (non-ECM only)                    | 9             | A02 OIL PRESSURE        |                           | On         | Shutdown or Warning | Default Values with Warning Enabled:<br>HI/LO warning and HI/LO shutdown are all engine dependent (255 psi max.) | 30 sec. inhibit,<br>0 sec. delay warning,<br>5 sec. delay shutdown |                           |                   |
| Analog Aux. Input A03 ‡                                 | 9             | A03 INTAKE AIR TEMP     |                           |            | Shutdown or Warning | Default Values with Warning Enabled:<br>HI/LO warning and HI/LO shutdown are all engine dependent                | 30 sec. inhibit,<br>0 sec. delay warning                           |                           |                   |
| Analog Aux. Input A04 *                                 | 9             | A04 FUEL LEVEL          |                           |            |                     | Default Values with Warning Enabled:<br>HI/LO warning are engine dependent                                       | 30 sec. inhibit,<br>0 sec. delay warning                           |                           |                   |
| Analog Aux. Input A04 ‡                                 | 9             | A04 OIL TEMP            |                           | On         | Warning             | Default Values with Warning Enabled:<br>HI/LO warning are engine dependent                                       | 30 sec. inhibit,<br>0 sec. delay warning                           |                           |                   |
| Analog Aux. Input A06 VSG (Volvo, GM, Doosan, KDI only) | 9, 12         | A06 ANALOG AUXILIARY IN |                           | Off        |                     |  |  |                           |                   |
| Analog Aux. Input A07                                   | 9             | A07 ANALOG VOLT ADJUST  |                           |            |                     | ±10% of system voltage over the range of 0.5-4.5 VDC   |  |                           |                   |

\* All models, except Waukesha-powered models.

† Non-paralleling applications

‡ Waukesha-powered models

§ Paralleling applications

|| Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual.

\*\* NFPA applications

†† DDC/MTU engine with MDEC/ADEC

‡‡ FAA only

## Factory-Defined Settings

| Status Event or Fault   | Refer to Menu | Digital Display                | Relay Driver Output (RDO) | Alarm Horn | Lamp  | Range Setting                         | Default Selection            | Inhibit Time Delay (sec.) | Time Delay (sec.) |
|---|---------------|--------------------------------|---------------------------|------------|---|---------------------------------------|------------------------------|---------------------------|-------------------|
| Battery Charger Communication Error   |               | CHRG COMM ERROR                |                           | On         | Warning   |                                       |                              |                           |                   |
| Battery Charger Fault (see D01) **<br><b>Note:</b> On charger GM87448, Battery Charger Fault is communicated through CAN communication and D01 is not used.   |               | BATTERY CHRGR FAULT            |                           | On         | Warning   |                                       |                              |                           |                   |
| Battery Charger Value Error   |               | CHGR VAL ERROR                 |                           | On         | Warning   |                                       |                              |                           |                   |
| Battle Switch (Fault Shutdown Override Switch)  | 9             | BATTLE SWITCH                  |                           | Off        | Warning   | Fixed                                 |                              |                           |                   |
| Block Heater Control ††   | 10            | BLOCK HEATER CONTROL           | RDO only                  |            |   |                                       |                              |                           |                   |
| Breaker Trip §  | 10            | BREAKER TRIP                   | RDO-30                    | Off        | Warning   |                                       |                              |                           |                   |
| Charger Absorption Current Termination Target (A)   | 18            | ABSORPTION TERMINATION         |                           |            |   | 1 – 5                                 | 2                            |                           |                   |
| Charger Automatic Equalize Enable<br><b>Note:</b> Equalize is only available with FLA/VRLA topology selected.   | 18            | AUTOMATIC EQUALIZE ENABLED     |                           |            |   | Active<br>Inactive                    | Inactive                     |                           |                   |
| Charger Charge Cycles Between Auto Equalize Cycles<br><b>Note:</b> Equalize is only available with FLA/VRLA topology selected.  | 18            |                                |                           |            |   | 0 – 99                                |                              |                           |                   |
| Charger Custom Profile Enable   | 18            | CUSTOM CHARGING PROFILE ENABLE |                           |            |   | Active<br>Inactive                    | Inactive                     |                           |                   |
| Charger Depleted Battery Current Limit  | 18            |                                |                           |            |   | 1 – 5                                 | 2                            |                           |                   |
| Charger Depleted Battery Voltage Target   | 18            |                                |                           |            |   | 4 – 12<br>(12 V)<br>18 – 24<br>(24 V) | 10<br>(12 V)<br>20<br>(24 V) |                           |                   |
| Charger Equalize Stage Duration (Min)<br><b>Note:</b> Equalize is only available with FLA/VRLA topology selected.   | 18            |                                |                           |            |   | 60 – 480                              |                              |                           |                   |
| * All models, except Waukesha-powered models.<br>† Non-paralleling applications<br>‡ Waukesha-powered models<br>§ Paralleling applications<br>   Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual. |               |                                |                           |            | ** NFPA applications<br>†† DDC/MTU engine with MDEC/ADEC<br>‡‡ FAA only |                                       |                              |                           |                   |

## Factory-Defined Settings

| Status Event or Fault  | Refer to Menu | Digital Display           | Relay Driver Output (RDO)  | Alarm Horn | Lamp | Range Setting  | Default Selection                | Inhibit Time Delay (sec.) | Time Delay (sec.) |
|--|---------------|---------------------------|--|------------|------|--|----------------------------------|---------------------------|-------------------|
| Charger Manual Equalize Cycle Activation<br><b>Note:</b> Equalize is only available with FLA/VRLA topology selected.   | 18            | MANUAL EQUALIZE ACTIVE    |  |            |      | Active<br>Inactive   | Inactive                         |                           |                   |
| Charger Maximum Absorption Time Threshold (Min.)   | 18            | MAX ABSORPTION TIME       |  |            |      | 60 – 360<br>60 – 600 (NiCad only)                                  | 240                              |                           |                   |
| Charger Maximum Bulk Time Threshold (Min)  | 18            | MAX BULK TIME             |  |            |      | 60 – 600   | 480                              |                           |                   |
| Charger Refresh Charge Cycle Time (Hr)   | 18            |                           |  |            |      | 0,<br>23 – 672   | 335                              |                           |                   |
| Charger Return To Bulk State Voltage Threshold (V)   | 18            | BULK STATE RETURN VOLTAGE |  |            |      | 10 – 13<br>(12 V) <sup>  </sup><br>20 – 26<br>(24 V) <sup>  </sup> | 12.8<br>(12 V)<br>25.6<br>(24 V) |                           |                   |
| Charger Starter Battery Topology<br><b>Note:</b> Verify that the battery topology is set correctly for the battery type that is used. Incorrect charger output system voltage may cause irreversible damage to the battery and abnormal out gassing. | 18            | BATTERY TOPOLOGY          |  |            |      | Default<br>FLA/VRLA<br>AGM<br>Gel<br>NiCad                         | Default                          |                           |                   |
| Charger System Battery Voltage<br><b>Note:</b> Verify that the system voltage is set correctly for the battery type that is used. Incorrect charger output system voltage may cause irreversible damage to the battery and abnormal out gassing.     | 18            | CHARGER SYSTEM VOLTAGE    |  |            |      | System 12 VDC<br>System 24 VDC                                     | 12 VDC                           |                           |                   |
| Charger Temperature Compensation Enable  | 18            | TEMP COMPENSATION ENABLED |  |            |      | Active<br>Inactive   | Inactive                         |                           |                   |
| Charger Temperature Compensation Slope (mV/°C)   | 18            | TEMPERATURE COMP SLOPE    |  |            |      | -40 – 0<br>(12 V)<br>-80 – 0<br>(24 V)                             | -30<br>(12 V)<br>-60<br>(24 V)   |                           |                   |
| <p>* All models, except Waukesha-powered models.<br/> † Non-paralleling applications<br/> ‡ Waukesha-powered models<br/> § Paralleling applications</p>  |               |                           | <p>** NFPA applications<br/> †† DDC/MTU engine with MDEC/ADEC<br/> ‡‡ FAA only</p> |            |      |  |                                  |                           |                   |
| <p><sup>  </sup> Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual.</p>  |               |                           |  |            |      |  |                                  |                           |                   |

## Factory-Defined Settings

| Status Event or Fault   | Refer to Menu | Digital Display           | Relay Driver Output (RDO) | Alarm Horn | Lamp                | Range Setting   | Default Selection                 | Inhibit Time Delay (sec.) | Time Delay (sec.) |
|---|---------------|---------------------------|---------------------------|------------|---------------------|---|-----------------------------------|---------------------------|-------------------|
| Charger Voltage Absorption (V)  | 18            | ABSORPTION VOLTAGE        |                           |            |                     | 13 – 15<br>(12 V) <sup>  </sup><br>26 – 30<br>(24 V) <sup>  </sup>  | 14.25<br>(12 V)<br>28.5<br>(24 V) |                           |                   |
| Charger Voltage Bulk (V)  | 18            | BULK VOLTAGE              |                           |            |                     | 13 – 15<br>(12 V) <sup>  </sup><br>26 – 30<br>(24 V) <sup>  </sup>  | 14.25<br>(12 V)<br>28.5<br>(24 V) |                           |                   |
| Charger Voltage Equalize (V)<br><b>Note:</b> Equalize is only available with FLA/VRLA topology selected.  | 18            | EQUALIZE VOLTAGE          |                           |            |                     | 14 – 16<br>(12 V)<br>28 – 32<br>(24 V)  |                                   |                           |                   |
| Charger Voltage Float (V)   | 18            | FLOAT VOLTAGE             |                           |            |                     | 13 – 14<br>(12 V) <sup>  </sup><br>26 – 28<br>(24 V) <sup>  </sup>  | 13.25<br>(12 V)<br>26.5<br>(24 V) |                           |                   |
| Common Protective Relay Output §  | 10            | COMMON PR OUTPUT          | RDO-31 §                  | Off        | Warning             |   |                                   |                           |                   |
| Critical Overvoltage Shutdown   | 10            | CRITICAL OVERVOLTAGE      |                           | On         | Shutdown            | Fixed   | 275 volts (L1-L2)                 |                           |                   |
| Cyclic Cranking   | 8             |                           |                           | Off        |                     | 1-6 crank cycles<br>10-30 sec. crank on<br>1-60 sec. pause  | 3<br>15 sec.<br>15 sec.           |                           |                   |
| Defined Common Faults (each input value is set separately)  | 10            | DEFINED COMMON FAULT      | RDO-18 (lead 32A)         | On         | Shutdown or Warning | Default shutdowns include:<br>Emergency stop<br>High coolant temp<br>Low oil pressure<br>Overcrank<br>Overspeed | 30 sec. inhibit,<br>5 sec. delay  | 0-60                      | 0-60              |
| Detonation Shutdown (see D13) †   |               |                           |                           |            |                     |   |                                   |                           |                   |
| Detonation Warning (see D12) †  |               |                           |                           |            |                     |   |                                   |                           |                   |
| Digital Aux. Input D01-D21  | 9, 10         | USER-DEFINED D01-D21      |                           | On         | Shutdown or Warning |   | 30 sec. inhibit,<br>5 sec. delay  | 0-60                      | 0-60              |
| Digital Aux. Input D01 Battery Charger Fault **<br>(On charger GM87448, Battery Charger Fault is communicated through CAN communication and D01 is not used.)   | 9, 10         | D01 BATTERY CHARGER FAULT | RDO-11 (lead 61)          | On         | Warning             | Fixed   | 0 sec. inhibit,<br>0 sec. delay   |                           |                   |
| Digital Aux. Input D02 Low Fuel Warning **  | 9, 10         | D02 LOW FUEL WARNING      | RDO-08 (lead 63)          | On         | Warning             | Fixed   | 0 sec. inhibit,<br>0 sec. delay   |                           |                   |
| Digital Aux. Input D03 Low Coolant Temperature **   | 9, 10         | D03 LOW COOLANT TEMP      | RDO-05 (lead 35)          | On         | Warning             | Fixed   | 0 sec. inhibit,<br>0 sec. delay   |                           |                   |
| <p>* All models, except Waukesha-powered models.      ** NFPA applications<br/> † Non-paralleling applications      †† DDC/MTU engine with MDEC/ADEC<br/> ‡ Waukesha-powered models      ‡‡ FAA only<br/> § Paralleling applications<br/>    Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual.</p> |               |                           |                           |            |                     |   |                                   |                           |                   |

## Factory-Defined Settings

| Status Event or Fault   | Refer to Menu | Digital Display       | Relay Driver Output (RDO) | Alarm Horn | Lamp     | Range Setting      | Default Selection             | Inhibit Time Delay (sec.) | Time Delay (sec.)          |
|---|---------------|-----------------------|---------------------------|------------|----------|--------------------|-------------------------------|---------------------------|----------------------------|
| Digital Aux. Input D04 Field Overvoltage (M4, M5, M7, or M10 alt. only) | 9, 10         | D04 FIELD OVERVOLTAGE |                           | On         | Shutdown | Fixed              | 1 sec. inhibit, 15 sec. delay |                           |                            |
| Digital Aux. Input D05 Breaker Closed §                                 | 9, 10         | D05 BREAKER CLOSED    |                           | Off        | Warning  | Fixed              | 0 sec. inhibit, 0 sec. delay  |                           |                            |
| Digital Aux. Input D06 §  | 9, 10         | D06 ENABLE SYNCH      |                           |            |          |                    | 20 sec. inhibit, 0 sec. delay |                           |                            |
| Digital Aux. Input D09 Low Fuel Pressure Shutdown (125RZG only)         | 9, 10         | D09 LOW FUEL SHUTDOWN |                           | On         | Shutdown | Fixed              | 5 sec. inhibit, 0 sec. delay  |                           |                            |
| Digital Aux. Input D11 Air/Fuel Module (AFM) Shutdown ‡                 | 9, 10         | D11 AFM SHUTDOWN      |                           | On         | Shutdown | Fixed              | 0 sec. inhibit, 0 sec. delay  |                           |                            |
| Digital Aux. Input D12 Detonation Warning ‡                             | 9, 10         | D12 DETON WARNING     |                           | On         | Warning  | Fixed              | 2 sec. inhibit, 0 sec. delay  |                           |                            |
| Digital Aux. Input D13 Detonation Sensing Module (DSM) Shutdown ‡       | 9, 10         | D13 DETON SHUTDOWN    |                           | On         | Shutdown | Fixed              | 0 sec. inhibit, 0 sec. delay  |                           |                            |
| Digital Aux. Input D13 Knock Detection Module (KDM) Shutdown ‡          | 9, 10         | D13 KNOCK SHUTDOWN    |                           | On         | Shutdown | Fixed              | 0 sec. inhibit, 0 sec. delay  |                           |                            |
| Digital Aux. Input D14 Low Coolant Level, (with LCL switch) **          | 9, 10         | D14 LOW COOLANT LVL   | RDO-19                    | On         | Shutdown | Fixed              | 30 sec. inhibit, 5 sec. delay |                           |                            |
| Digital Aux. Input D15 Remote Shutdown                                  | 9, 10         | D15 REMOTE SHUTDOWN   |                           | On         | Shutdown |                    | 0 sec. inhibit, 0 sec. delay  |                           |                            |
| Digital Aux. Input D16 Remote Reset                                     | 9, 10         |                       |                           |            |          |                    |                               |                           |                            |
| Digital Aux. Input D17 VAR/PF mode                                      | 9, 10         |                       |                           |            |          |                    |                               |                           |                            |
| Digital Aux. Input D18 Voltage Lower                                    | 9, 10         |                       |                           |            |          |                    |                               |                           |                            |
| Digital Aux. Input D19 Voltage Raise                                    | 9, 10         |                       |                           |            |          |                    |                               |                           |                            |
| Digital Aux. Input D20 Air Damper Indicator (if used) **                | 9, 10         | D20 AIR DAMPER        | RDO-23 * (lead 56)        | On         | Shutdown | Fixed              | 0 sec. inhibit, 0 sec. delay  |                           |                            |
| Digital Aux. Input D21 Idle (speed) Mode Function                       | 9, 10         | D21 IDLE MODE ACTIVE  | RDO-21                    | Off        | Warning  | Fixed inhibit time | 0 sec. inhibit, 60 sec. delay |                           | 0-600 or 9:99 for infinity |
| ECM Red Alarm (was MDEC Red Alarm) ††                                   | 10            | ECM RED ALARM         |                           | On         | Shutdown |                    |                               |                           |                            |
| ECM Yellow Alarm (was MDEC Yellow Alarm) ††                             | 10            | ECM YELLOW ALARM      |                           | On         | Warning  |                    |                               |                           |                            |
| EEPROM Write Failure  | 10            | EEPROM WRITE FAILURE  |                           | On         | Shutdown |                    |                               |                           |                            |

\* All models, except Waukesha-powered models.

† Non-paralleling applications

‡ Waukesha-powered models

§ Paralleling applications

\*\* NFPA applications

†† DDC/MTU engine with MDEC/ADEC

‡‡ FAA only

|| Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual.

## Factory-Defined Settings

| Status Event or Fault   | Refer to Menu | Digital Display       | Relay Driver Output (RDO) | Alarm Horn | Lamp  | Range Setting                        | Default Selection          | Inhibit Time Delay (sec.) | Time Delay (sec.) |
|---|---------------|-----------------------|---------------------------|------------|---|--------------------------------------|----------------------------|---------------------------|-------------------|
| Emergency Stop Shutdown   | 10            | EMERGENCY STOP        | RDO-14 (lead 48)          | On         | Shutdown  |                                      |                            |                           |                   |
| Engine Cooldown (see Time Delay-)   |               |                       |                           |            |   |                                      |                            |                           |                   |
| Engine Derate Active  | 10            | ENGINE DERATE ACTIVE  |                           |            |   |                                      |                            |                           |                   |
| (Engine) J1939 CAN Shutdown (ECM only)  | 10            | J1939 CAN SHUTDOWN    |                           | On         | Shutdown  |                                      |                            |                           |                   |
| Engine Stalled (ECM only)   | 10            | ENGINE STALLED        |                           | On         | Shutdown  |                                      |                            |                           |                   |
| Engine Start (see Time Delay-)  |               |                       |                           |            |   |                                      |                            |                           |                   |
| EPS (Emergency Power System) Supplying Load   | 10            | EPS SUPPLYING LOAD    | RDO-22                    | Off        | Warning   | Fixed                                | 1% of rated line current   |                           |                   |
| Equalize Current Limit (A)<br><b>Note:</b> Equalize is only available with FLA/VRLA topology selected.  | 18            |                       |                           |            |   | 1-5                                  |                            |                           |                   |
| Field Overvoltage (see D04)   |               |                       |                           |            |   |                                      |                            |                           |                   |
| Forced Charge Cycle Reset   | 18            |                       |                           |            |   | Active<br>Inactive                   | Inactive                   |                           |                   |
| Fuel Level (see A04)  |               |                       |                           |            |   |                                      |                            |                           |                   |
| Fuel Valve Relay ‡  | 10            | FUEL VALVE RELAY      | RDO-23 ‡                  |            |   |                                      |                            |                           |                   |
| Generator Set Running   | 10            |                       | RDO-15 (lead 70R)         | Off        |   |                                      |                            |                           |                   |
| Ground Fault Detected   | 10            | GROUND FAULT          |                           | On         | Warning   |                                      |                            |                           |                   |
| High Battery Voltage  | 10            | HIGH BATTERY VOLTAGE  | RDO-13                    | Off        | Warning   | 14.5-16.5 V (12 V)<br>29-33 V (24 V) | 16 V (12 V)<br>32 V (24 V) |                           | 10                |
| High Coolant Temperature Shutdown   | 10            | HI COOL TEMP SHUTDOWN | RDO-03 (lead 36)          | On         | Shutdown  |                                      |                            | 30                        | 5                 |
| High Coolant Temperature Warning  | 10            | HI COOL TEMP WARNING  | RDO-06 (lead 40)          | On         | Warning   |                                      |                            | 30                        |                   |
| High Oil Temperature Shutdown   | 10            | HI OIL TEMP SHUTDOWN  |                           | On         | Shutdown  |                                      |                            | 30                        | 5                 |
| High Oil Temperature Warning ‡ ††   | 10            | HI OIL TEMP WARNING   |                           | On         | Warning   |                                      |                            | 30                        |                   |
| Idle (speed) Mode Function (see D21)  |               |                       |                           |            |   |                                      |                            |                           |                   |
| In Synch §  | 10            | IN SYNCH              | RDO-29 *                  |            |   |                                      |                            |                           |                   |
| Intake Air Temperature Shutdown ††  | 10            | INTAKE AIR TEMP SDWN  |                           | On         | Shutdown  |                                      |                            | 30                        |                   |
| * All models, except Waukesha-powered models.<br>† Non-paralleling applications<br>‡ Waukesha-powered models<br>§ Paralleling applications<br>   Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual. |               |                       |                           |            | ** NFPA applications<br>†† DDC/MTU engine with MDEC/ADEC<br>‡‡ FAA only |                                      |                            |                           |                   |



## Factory-Defined Settings

| Status Event or Fault  | Refer to Menu | Digital Display            | Relay Driver Output (RDO) | Alarm Horn | Lamp     | Range Setting                      | Default Selection                   | Inhibit Time Delay (sec.) | Time Delay (sec.) |
|--|---------------|----------------------------|---------------------------|------------|----------|------------------------------------|-------------------------------------|---------------------------|-------------------|
| Intake Air Temperature Warning ††  | 10            | INTAKE AIR TEMP WARN       |                           | On         | Warning  |                                    |                                     | 30                        |                   |
| Intake Air Temp Warning (see A03) ‡  |               |                            |                           |            |          |                                    |                                     |                           |                   |
| Intake Air Temp Shutdown (see A03)‡  |               |                            |                           |            |          |                                    |                                     |                           |                   |
| Internal Fault Shutdown  | 10            | INTERNAL FAULT             |                           | On         | Shutdown |                                    |                                     |                           |                   |
| J1939 CAN Shutdown (see Engine J1939 CAN Shutdown)                         |               |                            |                           |            |          |                                    |                                     |                           |                   |
| Knock Shutdown (see D13) ‡   |               |                            |                           |            |          |                                    |                                     |                           |                   |
| kW Overload (see Load Shed)  |               |                            |                           |            |          |                                    |                                     |                           |                   |
| Load Shed kW Overload ‡‡   | 10            | LOAD SHED KW OVER          | RDO-30 ‡‡                 | Off        | Warning  | 80%-120%                           | 100% of kW rating with 5 sec. delay |                           | 2-10              |
| Load Shed Over Temperature †† (Activated by a High Coolant Temp. shutdown) | 10            | LOAD SHED OVER TEMPERATURE | RDO only                  |            |          |                                    |                                     |                           |                   |
| Load Shed Underfrequency †   | 10            | LOAD SHED UNDER FREQUENCY  | RDO-31 †                  | Off        | Warning  |                                    | 59 Hz (60 Hz)<br>49 Hz (50 Hz)      |                           | 5                 |
| Locked Rotor Shutdown  | 10            | LOCKED ROTOR               |                           | On         | Shutdown |                                    |                                     |                           |                   |
| Loss of ECM Communication (ECM only)                                       | 10            | LOSS OF ECM COMM           | RDO-26 *                  | On         | Shutdown |                                    |                                     |                           | 4                 |
| Loss of Field Shutdown §   | 10            | SD LOSS OF FIELD           |                           | On         | Shutdown |                                    |                                     |                           |                   |
| Low Battery Voltage  | 10            | LOW BATTERY VOLTAGE        | RDO-12 (lead 62)          | Off        | Warning  | 10-12.5 V (12 V)<br>20-25 V (24 V) | 12 V (12 V)<br>24 V (24 V)          | 0                         | 10                |
| Low Coolant Level (see D14) (with LCL switch) **                           |               |                            |                           |            |          |                                    |                                     |                           |                   |
| Low Coolant Temperature (see D03) **                                       |               |                            |                           |            |          |                                    |                                     |                           |                   |
| Low Coolant Temperature Shutdown ††  | 10            | LOW COOLANT TEMP SHUTDOWN  |                           | On         | Shutdown |                                    |                                     |                           |                   |
| Low Fuel (Level or Pressure) Warning (see D02) **                          |               |                            |                           |            |          |                                    |                                     |                           |                   |
| Low Fuel Pressure Shutdown (see D09) (125RZG only)                         |               |                            |                           |            |          |                                    |                                     |                           |                   |
| (Low) Oil Pressure Shutdown  | 10            | OIL PRESSURE SHUTDOWN      | RDO-04 (lead 38)          | On         | Shutdown |                                    |                                     | 30                        | 5                 |

\* All models, except Waukesha-powered models.

† Non-paralleling applications

‡ Waukesha-powered models

§ Paralleling applications

|| Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual.

\*\* NFPA applications

†† DDC/MTU engine with MDEC/ADEC

‡‡ FAA only

## Factory-Defined Settings

| Status Event or Fault                     | Refer to Menu | Digital Display        | Relay Driver Output (RDO) | Alarm Horn | Lamp                     | Range Setting                        | Default Selection                                       | Inhibit Time Delay (sec.) | Time Delay (sec.) |
|---|---------------|------------------------|---------------------------|------------|--------------------------|--------------------------------------|---|---------------------------|-------------------|
| (Low) Oil Pressure Warning                | 10            | OIL PRESSURE WARNING   | RDO-07 (lead 41)          | On         | Warning                  |                                      |   | 30                        |                   |
| Maintenance Due                           | 10            | MAINTENANCE DUE        |                           |            |                          |                                      |   |                           |                   |
| Master Not In Auto (Generator Set Switch) | 10            | MASTER NOT IN AUTO     | RDO-09 (lead 80)          | On         | Warning and Not In Auto  |                                      |   |                           |                   |
| Master Switch Error                       | 10            | MASTER SWITCH ERROR    |                           | On         | Shutdown                 |                                      |   |                           |                   |
| Master Switch to Off                      | 10            | MASTER SWITCH TO OFF   |                           | On         | Shutdown and Not in Auto |                                      |   |                           |                   |
| Master Switch Open                        | 10            | MASTER SWITCH OPEN     |                           | On         | Shutdown                 |                                      |   |                           |                   |
| NFPA 110 Fault **                         | 10            | NFPA 110 FAULT         | RDO-10 (lead 32)          | On         | Shutdown or Warning      |                                      |   |                           |                   |
| No Air Temperature Signal Warning ‡       | 10            | NO AIR TEMP SIGNAL     |                           | On         | Warning                  |                                      |   | 30                        | 4                 |
| No Coolant Temperature Signal             | 10            | NO COOL TEMP SIGNAL    |                           | On         | Shutdown                 |                                      |   | 30                        | 4                 |
| No Oil Pressure Signal                    | 10            | NO OIL PRESSURE SIGNAL |                           | On         | Shutdown                 |                                      |   | 30                        | 4                 |
| No Oil Temperature Signal Warning ‡       | 10            | NO OIL TEMP SIGNAL     |                           | On         | Warning                  |                                      |   | 30                        | 4                 |
| Output Enable                             | 18            |                        |                           |            |                          | Fixed                                | Active  |                           |                   |
| Overcrank Shutdown                        | 8, 10         | OVER CRANK             | RDO-02 (lead 12)          | On         | Shutdown                 | 0-6 Cycles                           | 3 Cycles  |                           |                   |
| Overcurrent                               | 10            | OVER CURRENT           |                           | On         | Warning                  |                                      | 110%  |                           | 10                |
| Over Current PR Shutdown §                | 10            | SD OVER CURRENT PR     |                           | On         | Shutdown                 |                                      |   |                           |                   |
| Overfrequency Shutdown                    | 7, 10         | OVER FREQUENCY         | RDO-28                    | On         | Shutdown                 | 102%-140%                            | 110% Std.<br>103% FAA                                   |                           | 10                |
| Over Power Shutdown §                     | 10            | SD OVER POWER          |                           | On         | Shutdown                 |                                      | 102% Stdby<br>112% Prime                                |                           |                   |
| Overspeed Shutdown                        | 7, 10         | OVER SPEED             | RDO-01 (lead 39)          | On         | Shutdown                 | 65-70 Hz (60 Hz)<br>55-70 Hz (50 Hz) | 70 (60 Hz)<br>70 (50 Hz)                                |                           | 0.25              |
| Overvoltage Shutdown                      | 7, 8, 10      | OVER VOLTAGE           | RDO-20 (lead 26)          | On         | Shutdown                 | 105%-135% of nominal                 | 115%<br>2-sec time delay†<br>135%<br>10-sec time delay§ |                           | 2-10              |
| Password (see Access Code)                |               |                        |                           |            |                          |                                      |   |                           |                   |
| Pre Lube Relay ‡                          | 10            | PRE LUBE RELAY         | RDO-26 ‡                  |            |                          |                                      |   |                           | 4                 |
| Remote Reset (see D16)                    |               |                        |                           |            |                          |                                      |   |                           |                   |
| Remote Shutdown (see D15)                 |               |                        |                           |            |                          |                                      |   |                           |                   |

\* All models, except Waukesha-powered models.

† Non-paralleling applications

‡ Waukesha-powered models

§ Paralleling applications

|| Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual.

\*\* NFPA applications

†† DDC/MTU engine with MDEC/ADEC

‡‡ FAA only

## Factory-Defined Settings

| Status Event or Fault  | Refer to Menu | Digital Display     | Relay Driver Output (RDO) | Alarm Horn | Lamp  | Range Setting       | Default Selection  | Inhibit Time Delay (sec.) | Time Delay (sec.) |
|--|---------------|---------------------|---------------------------|------------|---|---------------------|--|---------------------------|-------------------|
| Reverse Power Shutdown §   | 10            | SD REVERSE POWER    |                           | On         | Shutdown  |                     |  |                           |                   |
| Speed Sensor Fault   | 10            | SPEED SENSOR FAULT  | RDO-24                    | On         | Warning   |                     |  |                           |                   |
| Starting Aid (see Time Delay Starting Aid)   |               |                     |                           |            |   |                     |  |                           |                   |
| System Ready   | 10            |                     | RDO-17 (lead 60)          | Off        | System Ready  |                     |  |                           |                   |
| Time Delay Engine Cooldown (TDEC)  | 8, 10         | DELAY ENG COOLDOWN  | RDO-16 (lead 70C)         | Off        |   | 00:00-10:00 min:sec | 5:00   |                           |                   |
| Time Delay Engine Start (TDES)   | 8, 10         | DELAY ENG START     |                           | Off        |   | 00:00-5:00 min:sec  | 00:01  |                           |                   |
| Time Delay Starting Aid  | 8, 10         |                     |                           | Off        |   | 0-10 sec.           |  |                           |                   |
| Turbocharger Temperature Shutdown (1750/2000REOZMD)  | 10            | TURBO TEMP SHUTDOWN |                           | On         | Shutdown  |                     |  | 30                        |                   |
| Turbocharger Temperature Warning (1750/2000REOZMD)   | 10            | TURBO TEMP WARNING  |                           | On         | Warning   |                     |  | 30                        |                   |
| Underfrequency   | 7, 10         | UNDER FREQUENCY     | RDO-29 ‡                  | On         | Shutdown  | 80%-97%             | 97% FAA<br>90% †<br>80% §                                |                           | 10                |
| Undervoltage Shutdown  | 7, 8, 10      | UNDER VOLTAGE       | RDO-27                    | On         | Shutdown  | 70%-95%             | 85%<br>10-sec time delay †<br>70%<br>30-sec time delay § |                           | 5-30              |
| Variable Speed Governor (VSG) (see A06)  |               |                     |                           |            |   |                     |  |                           |                   |
| VAR/PF Mode (see D17)  |               |                     |                           |            |   |                     |  |                           |                   |
| Voltage Lower (see D18)  |               |                     |                           |            |   |                     |  |                           |                   |
| Voltage Raise (see D19)  |               |                     |                           |            |   |                     |  |                           |                   |
| Weak Battery   | 10            | WEAK BATTERY        |                           | Off        | Warning   |                     | 60% of nominal   |                           | 2                 |
| * All models, except Waukesha-powered models.<br>† Non-paralleling applications<br>‡ Waukesha-powered models<br>§ Paralleling applications                                 |               |                     |                           |            | ** NFPA applications<br>†† DDC/MTU engine with MDEC/ADEC<br>‡‡ FAA only |                     |  |                           |                   |
| Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual. |               |                     |                           |            |   |                     |  |                           |                   |

| Calibration                              | Refer to Menu | Digital Display    | Range Setting  | Default Selection  |
|--|---------------|--------------------|--|--|
| Voltage Adjustment                       | 11            | VOLT ADJ           | ±10% of system voltage—<br>Version 2.10<br>±20% of system voltage—<br>Version 2.11 or higher | System voltage   |
| Underfrequency Unload Frequency Setpoint | 11            | FREQUENCY SETPOINT | 40 to 70 Hz  | 1 Hz below system frequency (ECM)<br>2 Hz below system frequency (non-ECM) |
| Underfrequency Unload Slope              | 11            | SLOPE              | 0–10% of rated voltage<br>volts per cycle  | 3.1% of system voltage   |
| Reactive Droop                           | 11            | VOLTAGE DROOP      | 0–10% of system voltage  | 4% of system voltage   |
| VAR Control                              | 11            | KVAR ADJ           | 0 to rated kVAR generating<br>0 to 35% of rated kVAR absorbing                               | 0  |
| Power Factor (PF) Adjust Control         | 11            | PF ADJ             | 0.7 to 1.0 leading<br>0.6 to 1.0 lagging   | 0.8 lagging  |
| Controller Gain                          | 11            | REGULATOR GAIN     | 1–10000  | 100  |
| VAR/PF Gain or Utility Stability         | 11            | VAR/PF GAIN        | 1–10000  | 100  |

**Figure 1-13** Settings for Controller Internal Voltage Regulation

### 1.3.2 Voltage Regulator and Calibration Specifications

The 550 controller has a voltage regulation function that is internal to the processor. This means that no external voltage regulator is necessary. The voltage regulation of the controller uses root mean square (rms) sensing for fast response to changes in indicated and regulated voltages resulting in excellent regulation accuracy.

RMS voltage regulation is available for both paralleling and utility application to control changes in the reactive loads due to load changes, prime mover speed variation, thermal drift, and other variations. See Figure 1-13 for data on the 550 controller voltage regulation. Refer to Appendix C to customize adjustments for specific applications.

### 1.3.3 Voltage Regulator Adjustments

The descriptions of the voltage regulator adjustments and features follow. See Appendix C, Voltage Regulator Definitions and Adjustments, for additional information.

**Voltage Adjustment.** The voltage adjustment allows the user to *enter the desired generator set output level*. This regulated level setting is the average of the three line-to-line voltages in three-phase configurations or L1-to-L2 in single phase configurations.

Submenus display the individual line-to-line voltages. These voltages are for reference only and are relevant in unbalanced load conditions. The voltage adjust setpoint can be changed to accommodate an important phase in an unbalanced system.

**Underfrequency Unload Frequency Setpoint.** This adjustment affects the voltage droop (volts per Hz) when load is applied and underfrequency occurs. The underfrequency unload setting defines the *setpoint where underfrequency starts*. Any frequency below the setpoint causes the voltage to drop thus reducing the load allowing the engine speed to recover according to the underfrequency unload slope setting.

Engine speed recovery depends upon characteristics such as engine make, fuel type, load types, and operating conditions. The underfrequency unload setting should match the engine speed recovery characteristics for the application.

**Underfrequency Unload Slope.** This setting determines how much the voltage drops during an underfrequency condition. Typically, applying a large electrical load causes a dip in engine speed and frequency. The voltage regulator reduces voltage, allowing engine speed recovery. The volts-per-Hz setting determines the *amount of voltage drop*.

**Reactive Droop.** Reactive droop compensation provides reactive current flow adjustment in the generator set during generator set-to-generator set paralleling applications. Reactive droop reduces excitation levels with increasing reactive current. A reduced excitation level reduces generator set reactive current or generated VARs, improving reactive load sharing.

Enter the gain setting as a *percentage of system voltage* when full-rated load with 0.8 power factor is applied.

Any loads less than full load force the voltage to drop by the ratio of reactive volt-amps (VARs) to rated VARs.

**VAR Control.** VAR control is used in some utility paralleling applications. The excitation is regulated to maintain the reactive load rather than output voltage. The VAR adjust setting determines what reactive load is maintained at the generator set output. The VAR adjust is the total reactive load (sum of three phases).

VAR control allows the user to define the direction of the reactive current out of the generator set (generating) or into the generator set (absorbing).

The utility supply, not the controller, determines terminal voltage. Engine fueling determines real power, measured in watts, using load sharing module control.

**Power Factor (PF) Adjust Control.** Power factor control is used in some utility paralleling applications. The excitation is regulated to maintain PF rather than output voltage. The PF adjustment setting determines what PF is maintained at the generator set output. PF adjustment is the average of three phases.

Power factor is defined as the ratio of real power (watts) over the volt-amps. Power factor can be calculated as the cosine of the electrical angle between current and voltage. The cosine function is positive for angles between  $-90^\circ$  and  $+90^\circ$  including zero; and is negative for angles between  $-90$  and  $+90$  including  $180^\circ$ . This adjustment requires the user to determine whether the current leads or lags the voltage.

**Regulator Gain.** Regulator gain refers to the gain of the control system. Generally, the higher the gain the faster the system responds to changes and the lower the gain, the more stable the system.

If the voltage is slow the recover when loads are applied or removed, increase the regulator gain. If the voltage is unstable, decrease the regulator gain. Regulator gain is active only while not in the VAR/PF mode.

**VAR/PF Gain.** The VAR/PF gain also refers to the gain of the control system. Unlike the regulator gain, the response and stability of the system refers to the reactive current, or more specifically the VARs and/or power factor.

If the system is slow to recover to the desired VAR or PF setting, increase the VAR/PF gain. If the VARs or PF of the system is unstable, decrease the VAR/PF gain. Because VAR/PF stability can be effected by the prime mover (engine), VAR/PF gain adjustments should be coordinated with the load sharing adjustment.

**Analog Voltage Adjust.** Use Menu 11 to enable or disable analog voltage adjust. Analog voltage adjust is commonly used for active control of voltage by some external equipment in certain applications, like synchronizing.

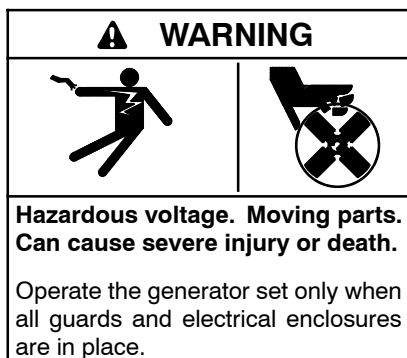
Enabling analog voltage adjust allows slight adjustment to the operating voltage by use of auxiliary analog input #7. This input signal provides a bias to the voltage adjust value. The range of input voltage is 0-5 VDC nominal (0.1-4.9 actual). The corresponding range of bias is approximately  $\pm 10\%$  of nominal or system voltage. If the input voltage is at the midpoint (2.5 volts), the bias is zero and the regulation value will be equal to the voltage adjust value entered by the user in Menu 11 or the system voltage if no value was entered by the user. Likewise, if the input voltage is out of range (below 0.1 volt or above 4.9 volts), the bias will be zero. For every 1 volt of input voltage, the operating voltage will vary approximately 4%; this satisfies the nominal ratio of approximately  $\pm 10\%$  output voltage for 0-5 volts input.

When analog voltage adjust is enabled, the description shown for Auxiliary Analog Input 7 is *Analog Volt Adjust*. Enable analog voltage adjust via KNET or MODBUS by setting the description for Analog Input 7 as *Analog Volt Adjust*.

Analog voltage adjust may be enabled only when the master switch is in the OFF/RESET or AUTO positions and while the generator is not running.

### 2.1 Prestart Checklist

To ensure continued satisfactory operation, perform the following checks or inspections before or at each startup, as designated, and at the intervals specified in the service schedule. In addition, some checks require verification after the unit starts.



**Air Cleaner.** Check for a clean and installed air cleaner element to prevent unfiltered air from entering engine.

**Air Inlets.** Check for clean and unobstructed air inlets.

**Battery.** Check for tight battery connections. Consult the battery manufacturer's instructions regarding battery care and maintenance.

**Controller.** After reconnecting the battery, set the controller time and date. See Section 2, Menu 14—Programming Mode On and Menu 6—Time and Date.

**Coolant Level.** Check the coolant level according to the cooling system maintenance information.

**Note: Block Heater Damage.** The block heater will fail if the energized heater element is not immersed in coolant. Fill the cooling system before turning on the block heater. Run the engine until it is warm, and refill the radiator to purge the air from the system before energizing the block heater.

**Drive Belts.** Check the belt condition and tension of the radiator fan, water pump, and battery charging alternator belt(s) according to the drive belt system maintenance information.

**Exhaust System.** Check for exhaust leaks and blockages. Check the silencer and piping condition and check for tight exhaust system connections.

Inspect the exhaust system components (exhaust manifold, exhaust line, flexible exhaust, clamps, silencer, and outlet pipe) for cracks, leaks, and corrosion.

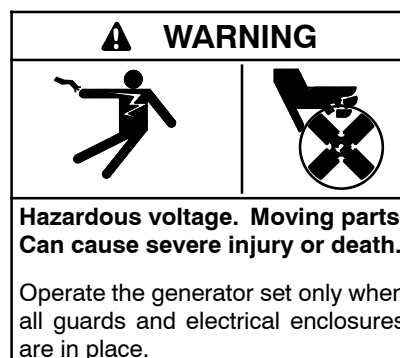
- Check for corroded or broken metal parts and replace them as needed.
- Check for loose, corroded, or missing clamps and hangers. Tighten or replace the exhaust clamps and/or hangers as needed.
- Check that the exhaust outlet is unobstructed.
- Visually inspect for exhaust leaks (*blowby*). Check for carbon or soot residue on exhaust components. Carbon and soot residue indicates an exhaust leak. Seal leaks as needed.

**Fuel Level.** Check the fuel level and keep the tank(s) full to ensure adequate fuel supply.

**Oil Level.** Maintain the oil level at or near, not over, the full mark on the dipstick.

**Operating Area.** Check for obstructions that could block the flow of cooling air. Keep the air intake area clean. Do not leave rags, tools, or debris on or near the generator set.

### 2.2 Exercising Generator Set



Operate the generator set under load once each week for one hour. Perform the exercise in the presence of an operator when the generator set does not have a programmed exercise mode or an automatic transfer switch with an exercise option.

During the exercise period apply a minimum of 35% load based on the nameplate standby rating, unless otherwise instructed in the engine operation manual.

The operator should perform all of the prestart checks before starting the manual exercise procedure. Start the generator set according to the starting procedure in Section 2.4, Controller Operation. While the generator set is operating, listen for a smooth-running engine and visually inspect generator set for fluid or exhaust leaks.

The generator set exercise time can be programmed for a one-time exercise period. See Menu 4—Operational Records. The generator set controller does not provide weekly scheduled exercise periods. For scheduled exercise periods, refer to the automatic transfer switch (if equipped) literature.

## 2.3 Operation in Cold Weather Climates

Cold weather operation is generally considered ambient temperatures below freezing 0°C (32°F). The following items are recommended for cold weather starting and/or operation when the unit is located in an enclosure or unheated structure. Have a licensed electrician install 120 VAC, 15 amp outlets as needed if not already in the immediate area.

Refer to the engine operation manual regarding engine oil viscosity, fuel composition, and coolant mixture recommendations.

- The **engine block heater** is generally recommended for most units when operated below 0°C (32°F) and required as part of NFPA 110. Refer to the respective spec sheet for temperature recommendations in available options.
- A **battery heater** is generally recommended for most units when operated below 0°C (32°F). Refer to the respective spec sheet for model availability.
- An **alternator strip heater** is available for most generator sets providing a heat source to prevent moisture and frost buildup.
- The **crankcase ventilation (CCV) heater kit** provides a controlled heating source to the crankcase ventilation system preventing freezing water buildup during cold weather. The thermostat turns on at 4°C (40°F) and turns off at 16°C (60°F). Refer to Section 3, Scheduled Maintenance for more information. (Applies to 125/150 kW, 8.1 L GM- and 8.8 L PSI- powered generator set models only.)
- **Heater tape** is recommended when the generator set is equipped with a closed crankcase ventilation system and operated at or below 50% of rated load. Wrap the UL/CSA compliant heater tape around the crankcase canister/breather system hose that runs from the crankcase to the air intake and use cable ties as needed to secure the heater tape. If the heater tape is within 152 mm (6 in.) of the exhaust system, use thermal insulation material to protect the heater tape.

**40-60REOZK Models only.** When the ambient temperature drops below -15°C (5°F) a turbocharger pre-lube sequence begins when the crank cycle is

initiated. During the first 10 seconds of cranking, the fuel system is disabled to ensure engine oil is present at the turbocharger. This is necessary for the longevity of the turbocharger on the KDI 3404TM engine. The fuel system is then enabled for the next 5 seconds of cyclic cranking and the engine will start as normal.

## 2.4 Controller Operation

### 2.4.1 Starting

#### Local Manual Starting

Move the generator set master switch to the RUN position to start the generator set at the controller.

**Note:** The alarm horn sounds and the Not-In-Auto lamp lights whenever the generator set master switch is not in the AUTO position.

**Note:** The transient start/stop function of the controller prevents accidental cranking of the rotating engine. The generator set stops and re cranks when the generator set master switch is momentarily placed in OFF/RESET position and then returned to RUN.

#### Auto Starting

Move the generator set master switch to the AUTO position to allow startup by the automatic transfer switch or remote start/stop switch (connected to controller terminals 3 and 4).

Terminals 3 and 4 connect to a circuit that automatically starts the generator set crank cycle when an external source closes the circuit.

**Note:** The controller provides up to 30 seconds of programmable cyclic cranking and up to 60 seconds rest with up to 6 cycles. The default setting is 15 seconds cranking and 15 seconds rest for 3 cycles. Make cyclic cranking adjustments using the keypad. See Section 2.9.14, Menu 14—Programming Mode, and Section 2.9.8, Menu 8—Time Delays.

#### Idle (Speed) Mode Warmup Function

The idle (speed) mode function provides the ability to start and run the engine at reduced speed for a selectable time period (0-10 minutes) during warmup. See Section 6.1.6, Idle (Speed) Mode Feature, for installation information.

To start idle warmup, the master switch must be in the AUTO position. Activate the idle mode input by closing the contacts at the particular auxiliary digital input assigned to Idle Mode (D21 by default). The generator

set will run at idle speed until the engine coolant temperature reaches the pre-programmed warmup temperature, at which point the engine will run at normal speed.

The controller overrides the idle speed function when the generator set is signaled to start via remote start input while in the AUTO position. This override provides emergency generator set power in the event of a utility power failure. When the utility power returns and the generator set is signaled to stop, the generator set continues to run for the duration of the idle mode period when the idle mode is active. When the idle mode is deactivated (by opening contacts), the generator set will shut down in the normal stopping mode including time delays.

See Menu 9—Input Setup to activate the idle speed function as a user-defined digital input. The idle speed feature requires an ECM-equipped engine with the idle speed function.

### Run Time Feature

The run time feature allows the user to set up the generator set to run unassisted and automatically return to the standby mode. The user does not need to wait for the exercise period (run time) to conclude in order to place the unit back in the standby mode. See Menu 4—Operational Records for setup of this feature.

With the run time enabled, the generator set will begin to crank and run based on the run time period and all previously established time delays from Menu 8—Time Delays.

**Generator Set Connected to an Automatic Transfer Switch.** Should a utility power failure occur while the unit is in the run time mode, the controller will bypass the run time mode and function in the standby (backup) mode. When the utility power returns, the generator set continues to run for the duration of the run time period when not timed out.

**Note:** Press the STOP PROG RUN key, when necessary, to stop the generator set when it is in the run time mode.

### Prime Power Switch

The digital controller has an optional prime power mode of operation. The prime power mode requires installation of an optional prime power switch kit. See Section 6, Accessories, for instructions on how to install the optional prime power switch kit. The prime power switch kit prevents engine starting battery drain when the generator set is shut down and no external battery charging is available.

Move the prime power switch located on the back of the controller to the CONTROLLER ON position and set the controller time and date before attempting to start the generator set. When the prime power mode is on, all controller functions including the digital display, LEDs, and alarm horn are operative.

**Note:** After energizing the controller using the prime power switch, set the controller time and date. See Section 2.9.6, Menu 6—Time and Date.

Stop the generator set using the stopping procedures in Section 2.4.2 before placing the generator set in the prime power off mode. Move the prime power switch located on the back of the controller to the CONTROLLER OFF position. When the generator set is in the prime power off mode, all controller functions including the digital display, LEDs, alarm horn, and communications are inoperative.

## 2.4.2 Stopping (User Stopping and Fault Shutdown)

### Manual Stopping (Master Switch in OFF)

Run the generator set without load for 5 minutes prior to shutdown to ensure adequate engine cooldown.

To manually stop the generator set, simply move the master switch to the OFF/RESET position. The generator set will stop immediately with no cooldown time. Manual cooldown without load is required prior to moving to the OFF/RESET position.

### Automatic Stopping (Master Switch in AUTO)

To stop the generator set that was started by activating the remote start input when the master switch is in AUTO, simply deactivate the remote start input by opening the contacts of this input.

The generator set will transition to the Cooldown state. The generator set will run at normal speed until the engine coolant temperature falls below the pre-programmed cooldown threshold or until the programmable cooldown time delay expires, whichever occurs first. If the Cooldown Override parameter is set to TRUE, the coolant temperature will be ignored and the cooldown will continue for the full cooldown delay.

If the remote start input is re-activated during the cooldown cycle, the cooldown will abort and normal generator set operation will resume.



## Emergency Stopping

Use the controller emergency stop switch or optional remote emergency stop for immediate shutdown.

The emergency stop switch bypasses the time delay engine cooldown and immediately shuts down the generator set.

**Note:** Use the emergency stop switch(es) for emergency shutdowns only. Use the generator set master switch for normal shutdowns.

The controller system shutdown lamp lights and the unit shuts down when the local or remote emergency stop switch activates.

## Battle Switch/Emergency Mode/Fault Override Switch

The *battle* switch function forces the system to ignore normal fault shutdowns such as low oil pressure and high engine temperature. The battle switch does not override the emergency stop, overspeed, and overfrequency shutdowns. When the battle switch function is enabled the generator set continues to run regardless of shutdown signals where potential engine/alternator damage can occur.

When this input is enabled the yellow warning lamp illuminates and stored warning/shutdown events that are ignored continue to log in Menu 5—Event History.

See Section 2.9.9, Menu 9—Input Setup, for information on how to enable the battle switch feature.

## Cooldown Temperature Override Function

This feature provides the ability to bypass (override) the generator set's smart cooldown temperature shutdown and force the generator set to run for the full engine cooldown time delay. Set the Override to YES to override temperature based cooldown.

See Section 2.9.8, Menu 8—Time Delays, for information on how to enable the cooldown temperature override feature.

## Idle Cooldown Function

**Idle (Speed) Model Cooldown Function.** To stop the generator set that was started by activating the idle mode input (master switch in AUTO), simply deactivate the idle mode input by opening the contacts at this input.

**Idle Delay Infinite (Idle Delay = 9:99).** The generator set will be running at idle speed until the idle input is

de-activated. When the idle mode contacts open, the generator set will immediately shut down.

## Idle Delay Not Infinite (Idle Delay = 0-10 minutes).

The generator set will transition to the Cooldown state. The generator set will run at idle speed until the engine coolant temperature falls below the pre-programmed cooldown threshold or until the programmable idle time delay expires, whichever occurs first. If the Cooldown Override parameter is set to TRUE, the coolant temperature will be ignored and the cooldown will continue for the full idle delay.

If the remote start input is re-activated during the cooldown cycle, the cooldown will abort and normal generator set operation will resume.

See Section 6.1.6 Idle (Speed) Mode Feature for further information.

## 2.4.3 Emergency Stop Switch Resetting

Use the following procedure to reset the generator set after shutdown by a local or remote emergency stop switch. Refer to Section 2.4.7, Controller Reset Procedure, to restart the generator set following a fault shutdown.

1. Place the generator set master switch in the OFF/RESET position.
2. Investigate and correct the cause of the emergency stop.
3. Reset the optional remote emergency stop switch by replacing the glass piece, when equipped. Additional glass rods are available as a service part. Reset the controller emergency stop switch by pulling the switch knob outward.
4. After resetting all faults using the controller reset procedure in Section 2.4.7, toggle the generator set master switch to RUN or AUTO to restart the generator set. The generator set will not crank until the reset procedure completes.

## 2.4.4 Status Lamps

**System Ready.** The green lamp illuminates when the generator set master switch is in the AUTO position and the system has no fault conditions.

**Not in Auto.** The yellow lamp illuminates when the generator set master switch is not in the AUTO position. See Master (Switch) Not in Auto in 2.4.5 System Warning Lamp.

## 2.4.5 System Warning Lamp

The yellow warning lamp illuminates indicating a fault or status event but does not shut down the generator set under the following conditions. In some cases the alarm horn also sounds. See Section 2.4.7, Controller Reset Procedure, for instructions on resetting a system warning.

When the system warning lamp is on and no message displays, press the Reset Menu and the menu down ↓ key to view messages. When the system warning continues, it may lead to a fault and cause a system shutdown.

Use the Alarm Off keypad switch to silence the alarm horn at the operator's discretion. Place the generator set master switch in the AUTO position before silencing the alarm horn. The alarm horn cannot be silenced unless the master switch is in the AUTO position.

**Note:** Text shown in *italics* in this manual represents digital display messages.

**AC Sensing Loss.** The lamp illuminates when the controller does not detect nominal generator set AC output voltage after crank disconnect. The local display shows *AC sensing loss*.

**Battery Charger Communication Error.** The warning lamp on the controller illuminates yellow and the alarm horn sounds when CAN communication with the battery charger has been lost or there is a CAN address communication error. To correct a CAN address error, verify the address identification in the harness and power cycle the controller. Local display shows *chrg comm error*.

**Battery Charger Fault.** The lamp illuminates and the alarm horn sounds when the battery charger malfunctions or when there is an issue with the battery such as a connection problem or a dead battery. When the temperature compensation sensor is connected, whether active or inactive, and the temperature rises above 60°C (140°F) or below -20°C (-4°F), the battery charger fault will also be displayed indicating that the battery is unable to take charge due to temperature. Absorption timeout will also cause a failure since the battery was unable to accept the expected charge in the time frame given which indicates a potential battery issue. Local display shows *bat chrg fault*.

**Battery Charger Value Error.** The lamp illuminates and the alarm horn sounds when the battery charger metering is not in range of the specified parameters. Local display shows *chrg val error*.

**Battle Switch.** The lamp illuminates when in the battle switch mode. The local display shows *battle switch*.

**Breaker Closed.** The lamp illuminates when the respective circuit breaker is closed. The local display shows *breaker closed*. (Paralleling applications only.)

**Breaker Trip.** The lamp illuminates when the respective circuit breaker is tripped. The local display shows *breaker trip*. (Paralleling applications only.)

**Common Protective Relay Output.** The lamp illuminates when a common protective relay fault occurs. The local display shows *common pr output*. (Paralleling applications only.)

**Customer Auxiliary (Warning).** The lamp illuminates and the alarm horn sounds when an auxiliary digital or analog inputs signals the controller. The user can define inputs as shutdowns or warnings. The local display shows digital input *D01-D21* or analog input *A01-A07*.

Using the remote communications package, the user can label the auxiliary functions. The controller displays the selected name instead of digital input *D01-D21* or analog input *A01-A07*.

**Defined Common Faults.** The lamp illuminates and the alarm horn sounds when one or more of the (user-selected) defined common faults are energized. The local display shows *defined common fault*.

**Detonation Warning.** The lamp illuminates and the alarm horn sounds when the engine detects combustion system detonation. The local display shows *deton warning*. (Waukesha-powered models only.)

**ECM Yellow Alarm.** The lamp illuminates and the alarm horn sounds when ECM yellow alarm signals the controller. The local display shows *ECM yellow alarm*. This fault only relates to the DDC/MTU engine with MDEC/ADEC. The user can navigate the menus to access the fault code. The engine operation manual provides the fault code descriptions.

**Emergency Power System (EPS) Supplying Load.** The lamp illuminates when the generator set supplies more than 1% of the rated standby output current. The local display shows *EPS supplying load*.

**Ground Fault Detected.** The lamp illuminates and the alarm horn sounds when a user-supplied ground fault detector signals the controller. The local display shows *ground fault*.

**High Battery Voltage.** The lamp illuminates when the battery voltage rises above the preset level for more than 10 seconds. The local display shows *high battery voltage*. Figure 2-1 shows high battery voltage specifications. The high battery voltage feature monitors the battery and battery charging system in the generator set operating and off modes.

| Engine Electrical System Voltage | High Battery Voltage Range | High Battery Voltage Default Setting |
|----------------------------------|----------------------------|--------------------------------------|
| 12                               | 14.5-16.5                  | 16                                   |
| 24                               | 29-33                      | 32                                   |

**Figure 2-1** High Battery Voltage Specs

**High Coolant Temperature Warning.** The lamp illuminates and the alarm horn sounds when the engine coolant temperature approaches the shutdown range. The local display shows *hi cool temp warning*.

**High Oil Temperature Warning.** The lamp illuminates and the alarm horn sounds when the engine high oil temperature approaches the shutdown range. The local display shows *hi oil temp warning* (DDC/MTU models with MDEC/ADEC and Waukesha-powered models only).

**Idle (Speed) Mode.** The lamp illuminates when in the idle (speed) mode. The local display shows *idle mode active*. See Section 6.1.6 for idle mode operation.

**Intake Air Temperature Warning.** The lamp illuminates and the alarm horn sounds when the engine intake air temperature approaches the shutdown range. The local display shows *intake air temp warn* (DDC/MTU models with MDEC/ADEC) and *03 intake air temp warn* (Waukesha-powered models).

**Load Shed.** The lamp illuminates when the generator set's total kW load exceeds the programmed level for more than the load shed time. When the load shed alarm sounds and resets more than twice in 1 minute, the load shed warning lamp circuit latches and remains on until the generator set shuts down. The local display shows *load shed kW over*.

When the generator set frequency drops to less than 59 Hz on a 60 Hz system or 49 Hz on a 50 Hz system for more than 5 seconds, the local display shows *load shed under freq*. When the load shed alarm sounds and resets more than twice in 1 minute, the load shed warning lamp latches and remains on until the generator set shuts down.

**Low Battery Voltage.** The lamp illuminates when the battery voltage drops below a preset level for more than 10 seconds. The local display shows *low battery voltage*. See Figure 2-2 for low battery voltage specifications.

| Engine Electrical System Voltage | Low Battery Voltage Range | Low Battery Voltage Default Setting |
|----------------------------------|---------------------------|-------------------------------------|
| 12                               | 10-12.5                   | 12                                  |
| 24                               | 20-25                     | 24                                  |

**Figure 2-2** Low Battery Voltage Specs

The low battery voltage feature monitors the battery and battery charging system in the generator set operating and off modes. The controller logic inhibits the low battery voltage warning during the crank cycle.

**Low Coolant Temperature.** The lamp illuminates and the alarm horn sounds when the engine coolant temperature is low. The local display shows *low coolant temp*.

**Low Fuel (Level or Pressure) Warning.** The lamp illuminates and the alarm horn sounds when the fuel tank level on gasoline or diesel models approaches empty or low fuel pressure on gaseous fueled models occurs. This fault requires an optional low fuel switch for the lamp to function. The local display shows *low fuel warning*.

**(Low) Oil Pressure Warning.** The lamp illuminates and the alarm horn sounds when the engine oil pressure approaches the shutdown range. The local display shows *oil press warning*.

**Master (Switch) Not in Auto.** The lamp illuminates and the alarm horn sounds when the generator set master switch is in the RUN or OFF/RESET position. The local display shows *master not in auto*. The Not in Auto lamp will also illuminate.

**NFPA 110 Fault.** The lamp illuminates and the alarm horn sounds when NFPA 110 faults signal the controller. The local display shows the respective fault message. The NFPA 110 faults (Warning/Shutdown) include:

- Air damper indicator (Factory-Reserved D20) (S)
- Battery charger fault (Factory-Reserved D01) (W)
- EPS supplying load (W)
- High battery voltage (W)
- High coolant temperature (W)
- High coolant temperature (S)
- Low battery voltage (W)
- Low coolant level (Factory-Reserved D14) (S)
- Low coolant temperature (Factory-Reserved D03) (W)
- Low fuel (level or pressure) (Factory-Reserved D02) (W)
- Low oil pressure (W)
- Low oil pressure (S)
- Master switch not in auto (W)
- Overcrank (S)
- Overspeed (S)

**No Air Temperature Signal.** The lamp illuminates and the alarm horn sounds when the air temperature sender circuit is open. The local display shows *no air temp signal*. (Waukesha-powered models only.)

**No Oil Temperature Signal.** The lamp illuminates and the alarm horn sounds when the oil temperature sender circuit is open. The local display shows *no oil temp signal*. (Waukesha-powered models only.)

**Oil Temperature.** The lamp illuminates and the alarm horn sounds when oil temperature approaches the shutdown range. The local display shows *oil temp*. (Waukesha-powered models only.)

**Overcurrent.** The lamp illuminates and the alarm horn sounds when the generator set supplies more than 110% of the rated standby output current for more than 10 seconds. The local display shows *overcurrent*.

**Speed Sensor Fault.** The lamp illuminates and the alarm horn sounds when the speed signal is absent for one second while the generator set runs. The local display shows *speed sensor fault*. This warning lamp remains on until the operator places the master switch in the OFF/RESET position.

**Turbocharger Temperature Warning.** The lamp illuminates and the alarm horn sounds when the ambient air temperature approaches the shutdown range. The local display shows *turbo temp warning* (1750/2000REOZMD models).

**Weak Battery.** The lamp illuminates when the battery voltage falls below 60% of the nominal voltage (12 VDC or 24 VDC) for more than 2 seconds during the crank cycle. The local display shows *weak battery*.

## 2.4.6 System Shutdown Lamp

The red lamp illuminates, the alarm horn sounds, and the unit shuts down to indicate a fault shutdown under the following conditions. See Section 2.4.7, Controller Reset Procedure, for information on resetting a system shutdown.

Use the Alarm Off keypad switch to silence the alarm horn at the operator's discretion. Place the generator set master switch in the AUTO position before silencing the alarm horn. The alarm horn will not stop sounding unless the master switch is in the AUTO position.

**Note:** The text shown in *italics* represents digital display messages.

**Air Damper Indicator.** The lamp illuminates and the unit shuts down when signaled by a closed air damper circuit. The local display shows *air damper indicator*.

**Air/Fuel Module.** The lamp illuminates and the unit shuts down when the controller detects a fault with the air/fuel module. The local display shows *afm shutdown*. (Waukesha-powered models only.)

**Alternator Protection.** The lamp illuminates and the unit shuts down because of an alternator overload or short circuit. The local display shows *altrntr protect sdwn*. See Appendix D, Alternator Protection for more information.

**Critical Overvoltage.** The lamp illuminates and the unit shuts down when the voltage exceeds 275 volts. The local display shows *critical overvoltage*.

For voltages configurations of **240 volts and less**, the critical voltage shutdown monitors nominal voltage line-to-line. For voltage configurations **greater than 240 volts and less than 600 volts**, the critical voltage shutdown monitors nominal voltage line-to-line with a center tap connection. For voltage configurations of **600 volts and above**, the critical voltage shutdown monitors nominal voltage with a stepdown transformer in the 208–240 voltage range.

**Customer Auxiliary (Shutdown).** The lamp illuminates and the unit shuts down when an auxiliary digital or analog input signals the controller. The user can define inputs as shutdowns or warnings. The local display shows digital input *D01-D21* or analog input *A01-A07* when activated.

Using the remote communications package, the user can label the auxiliary functions. The controller displays the selected name instead of digital input *D01-D21* or analog input *A01-A07*.

**Defined Common Faults.** The lamp illuminates and the unit shuts down when one or more of the (user-selected) defined common faults are energized. The local display shows *defined common fault*.

**Detonation Shutdown.** The lamp illuminates and the unit shuts down when the controller detects combustion system detonation. The local display shows *deton shutdown*. (Waukesha-powered models only.)

**ECM Red Alarm.** The lamp illuminates and the unit shuts down when the controller receives a signal from the engine. The local display shows *ECM red alarm*. This fault only relates to the DDC/MTU engine with MDEC/ADEC. The user can navigate the menus to access the fault code. The engine operation manual provides the fault code descriptions.

**EEPROM Write Failure.** The lamp illuminates and the unit shuts down when the control logic detects a data save error. The local display shows *EEPROM write failure*.

**(Engine) J1939 CAN Shutdown.** The lamp illuminates and the unit shuts down when the control logic detects an engine ECM communication signal interruption. The local display shows *J1939 CAN shutdown*.

**Engine Stalled.** The lamp illuminates and the unit shuts down when the control logic detects an engine ECM signal that the engine has stalled. The local display shows *engine stalled* and no attempts to restart the engine will occur.

**Emergency Stop.** The lamp illuminates and the unit shuts down when the local or optional remote emergency stop switch activates. The local display shows *emergency stop*.

**Field Overvoltage.** The lamp illuminates and the unit shuts down when the controller detects field overvoltage. The local display shows *field over volts*. (350–2000 kW generator sets only)

**High Coolant Temperature Shutdown.** The lamp illuminates and the unit shuts down because of high engine coolant temperature. The shutdown occurs 5 seconds after the engine reaches the temperature shutdown range. The high engine temperature shutdown does not function during the first 30 seconds after startup. The local display shows *hi cool temp shutdown*.

**Note:** The high engine temperature shutdown function and the low coolant level shutdown function are independent. A low coolant level condition may not activate the high engine temperature switch.

**High Oil Temperature.** The lamp illuminates and the unit shuts down because of high engine oil temperature. The shutdown occurs 5 seconds after the engine oil reaches the temperature shutdown range. The high engine oil temperature shutdown does not function during the first 30 seconds after startup. The local display shows *high oil temp sdwn*.

**Intake Air Temperature.** The lamp illuminates and the unit shuts down because of high intake air temperature. The shutdown occurs 5 seconds after the engine intake air reaches the temperature shutdown range. The engine intake air temperature shutdown does not function during the first 30 seconds after startup. The local display shows *intake air temp shutdown* (DDC/MTU models with MDEC/ADEC) and *03 intake air temp shutdown* (Waukesha-powered models).

**Internal Fault.** The lamp illuminates and the unit shuts down when the internal diagnostics detect a controller malfunction. The local display shows *internal fault*.

**Knock Shutdown.** The lamp illuminates and the unit shuts down when the controller detects a detonation fault. The local display shows *knock shutdown*. (Waukesha-powered models only.)

**Locked Rotor.** If none of the speed sensing inputs show engine rotation within 5 seconds of initiating engine cranking, the ignition and crank circuits turn off for 5 seconds and the cycle repeats. The unit shuts down after the second cycle of 5 seconds of cranking. The local display shows *locked rotor*.

**Loss of ECM Communications.** The lamp illuminates and the unit shuts down when the ECM communication link is disrupted. The local display shows *loss of ECM comm*.

**Loss of Field (Reverse VARs).** The lamp illuminates and the unit shuts down when the reactive current into the alternator (absorbing) exceeds the shutdown level. This could be caused by a disruption of the field signal. The local display shows *sd loss of field*. (Paralleling applications only.)

**Low Coolant Level.** The lamp illuminates and the unit shuts down because of low coolant level. Shutdown occurs 5 seconds after low coolant level is detected. Low coolant level shutdown is inhibited during the first 30 seconds after startup. Local display shows *low coolant lvl*.

**Low Coolant Temperature.** The lamp illuminates and the unit shuts down because of low coolant temperature. Shutdown occurs 5 seconds after low coolant temperature is detected. Low coolant temperature shutdown is inhibited during the first 30 seconds after startup. Local display shows *low coolant temp shutdown*. (DDC/MTU models with MDEC/ADEC only.)

**Low Fuel (Pressure) Shutdown.** The lamp illuminates and the unit shuts down when the controller detects a low fuel condition. The low fuel (pressure) shutdown does not function during the first 5 seconds after startup. The local display shows *low fuel shdown*. (125RZG only.)

**(Low) Oil Pressure Shutdown.** The lamp illuminates when the unit shuts down because of low oil pressure. The shutdown occurs 5 seconds after the low pressure condition is detected. The low oil pressure shutdown does not function during first the 30 seconds after startup. The local display shows *(low) oil press shutdown*.

**Master Switch Error.** The lamp illuminates and the unit shuts down when the controller detects a fault in the master switch position or circuit. The local display shows *master switch error*.

**Master Switch Open.** The lamp illuminates and the unit shuts down when the controller detects an open circuit in the master switch circuit. The local display shows *master switch open*.

**Master Switch to Off.** The lamp illuminates and the unit shuts down when the master switch is moved to the off position. The local display shows *master switch to off*.

**NFPA 110 Fault.** The lamp illuminates and the unit shuts down when NFPA 110 faults signal the controller. The local display shows the respective fault message. See Section 2.5, Menu List Summary, Menu 10—Output Setup, for the NFPA 110 list.

**No Coolant Temperature Signal.** The lamp illuminates and the unit shuts down when the engine coolant temperature sender circuit is open. The local display shows *no cool temp signal*.

**No Oil Pressure Signal.** The lamp illuminates and the unit shuts down when the engine oil pressure sender circuit is open. The local display shows *no oil press signal*.

**Overcrank.** The lamp illuminates and cranking stops when the unit does not start within the defined cranking period. The local display shows *overcrank*. See Section 2.4.1, Auto Starting, and Section 1, Specifications and Features, for cyclic crank specifications.

**Note:** The controller is equipped with an automatic restart function. When speed drops below 13 Hz (390 rpm) while the engine is running, the unit attempts to recrank. The unit then follows the cyclic cranking cycle and, when the engine fails to start, will shut down on an overcrank fault condition.

**Over Current VR Shutdown.** The lamp illuminates and the unit shuts down when the controller detects an overcurrent fault with voltage restraint. The local display shows *sd over current pr*. (Paralleling applications only.)

**Overfrequency.** The lamp illuminates and the unit shuts down when the frequency is above the overfrequency setting. The local display shows *overfrequency*. See Figure 2-3.

| Overfrequency Setting Range | Time Delay | Overfrequency Default Setting |
|-----------------------------|------------|-------------------------------|
| 102%-140% of nominal        | 10 sec.    | 110% of nominal               |

**Figure 2-3** Overfrequency Specs

**Overpower.** The lamp illuminates and the unit shuts down when the controller detects a fault in the paralleling system. The shutdown is set at 102% for standby and 112% for prime power applications. The local display shows *over power*. (Paralleling applications only.)

**Overspeed.** The lamp illuminates and the unit shuts down immediately when the governed frequency on 50 and 60 Hz models exceeds the overspeed setting for 0.25 seconds. The local display shows *overspeed*. See Figure 2-4 for overspeed specs.

| Generator Set Frequency Hz | Time Delay | Overspeed Range Hz | Overspeed Default Setting Hz |
|----------------------------|------------|--------------------|------------------------------|
| 60                         | 0.25 sec.  | 65-70              | 70                           |
| 50                         | 0.25 sec.  | 55-70              | 70                           |

**Figure 2-4** Overspeed Specs

**Overvoltage.** The lamp illuminates and the unit shuts down when the voltage exceeds the overvoltage setting for the time delay period. The local display shows *overvoltage*. Overvoltage specifications follow. See Figure 2-5.

**Note:** Overvoltage can damage sensitive equipment in less than one second. Install separate overvoltage protection on online equipment requiring faster than 2-second shutdown.

| Overvoltage Setting Range | Time Delay Range | Overvoltage Default Setting without Paralleling | Overvoltage Default Setting with Paralleling |
|---------------------------|------------------|---|--|
| 105%–135% of nominal      | 2–10 sec.        | 115% at 2 sec.                                  | 135% at 10 sec.                              |

**Figure 2-5** Overvoltage Specs

**Reverse Power.** The lamp illuminates and the unit shuts down when the controller detects a reverse power condition. The reverse power relay senses AC power flow into the generator set. If the generator set is being feed power or being "motored" by another generator set or the utility, the reverse power relay senses this AC power flow and opens the generator set circuit breaker. The local display shows *sd reverse power*. (Paralleling applications only.)

**Turbocharger Temperature Shutdown.** The lamp illuminates and the alarm horn sounds when the ambient air temperature reaches the shutdown range. The local display shows *turbo temp shutdown* (1750/2000REOZMD models).

**Underfrequency.** The lamp illuminates and the unit shuts down when the frequency falls below the underfrequency setting. The local display shows *underfrequency*. See Figure 2-6.

| Underfreq. Setting Ranges | Time Delay | Underfrequency Default Setting without Paralleling | Underfrequency Default Setting with Paralleling |
|---------------------------|------------|--|---|
| 80%–95% of nominal        | 10 sec.    | 90% of nominal                                     | 80% of nominal                                  |

**Figure 2-6** Underfrequency Specs

**Undervoltage.** The lamp illuminates and the unit shuts down when the voltage falls below the undervoltage setting for the time delay period. The local display shows *undervoltage*. Undervoltage specifications follow. See Figure 2-7.

| Undervoltage Setting Range | Time Delay Range | Undervoltage Default Setting w-o/Paralleling | Undervoltage Default Setting w/Paralleling |
|----------------------------|------------------|--|--|
| 70%–95% of nominal         | 5–30 sec.        | 85% of nominal at 10 sec.                    | 70% of nominal at 30 sec.                  |

**Figure 2-7** Undervoltage Specs

## 2.4.7 Controller Resetting (Following System Shutdown or Warning)

Use the following procedure to restart the generator set after a system shutdown or to clear a warning lamp condition. This procedure includes the resetting of the optional remote annunciator and the audiovisual alarm.

Refer to Section 2.4.3, Emergency Stop Switch Reset Procedure, to reset the generator set after an emergency stop.

1. Move the generator set master switch to the AUTO position, if not already done.
2. Silence the controller alarm horn by pressing the *alarm off* key.

When equipped, the optional remote annunciator and/or audiovisual alarm horn and lamp activate. Move the alarm switch to the SILENCE position to stop the alarm horn. The lamp stays lit.

3. Disconnect the generator set load using the line circuit breaker or automatic transfer switch.
4. Correct the cause of the fault shutdown or warning. See the Safety Precautions and Instructions section of this manual before proceeding.
5. Start the generator set by moving the generator set master switch to the OFF/RESET position and then to the RUN position.

When equipped, the remote annunciator and/or audiovisual alarm horn sounds when the alarm switch is in the NORMAL position. When necessary, move the alarm switch to the SILENCE position to stop the alarm horn. The lamp turns off.

6. Test operate the generator set to verify correction of the shutdown cause.
7. Move the generator set master switch to the OFF/RESET position to stop the generator set.
8. Move the generator set master switch to the AUTO position.
9. Silence the controller alarm horn by pressing the *alarm off* key.
10. Reconnect the generator set load via the line circuit breaker or automatic transfer switch.
11. Move the generator set master switch to the AUTO position for startup by the remote transfer switch or the remote start/stop switch.

When equipped, move the remote annunciator and/or audiovisual alarm switch to the NORMAL position.

## 2.5 Menu List Summary

Use the Menu List Summary section on the following pages after reading and understanding the features of the keypad. See Section 1.2.2, Digital Display and Keypad.

The Menu List Summary provides a quick reference to the digital display data. Some digital display data may not be identical to your display due to generator set application differences. The closed bullet items represent main level data and the open bullet items are sub-level data.

Section 2.8, Reviewing the Menu Displays, provides a digital display menu overview and explains the navigation using the down and right arrow keys.

Section 2.9, Local Programming Mode On, contains the keystroke details of each menu when programming.

**User Inputs.** Available user inputs are dependent on factory-reserved inputs for specific engine types, engine controls, and paralleling applications. See Figure 2-8 for analog and digital inputs that are not user-selectable.



| Input Type   | Specific Applications |                       |                                       |                           |  |                               |                               |
|--|-----------------------|-----------------------|---------------------------------------|---------------------------|--|-------------------------------|-------------------------------|
|  | ECM Engine            | Non-ECM Engine        | NFPA 110                              | Waukesha-Powered Engine   | with Menu 15 (Paralleling Application) | DDC/MTU Engine with MDEC/ADEC | Other Specialized Application |
| <b>Analog Inputs</b>   |                       |                       |                                       |                           |  |                               |                               |
| A1   | X                     | Coolant Temperature * | X                                     | Coolant Temperature *     | X                                      | X                             | X                             |
| A2   | X                     | Oil Pressure *        | X                                     | Oil Pressure *            | X                                      | X                             | X                             |
| A3   | X                     | X                     | X                                     | Intake Air Temperature *  | X                                      | X                             | X                             |
| A4   | Fuel Level *          | Fuel Level *          | Fuel Level *                          | Oil Temperature Warning * | Fuel Level *                           | Fuel Level *                  | Fuel Level *                  |
| A5   | X                     | X                     | X                                     | X                         | X                                      | X                             | X                             |
| A6   | X                     | X                     | X                                     | X                         | X                                      | X                             | X (8) *                       |
| A7 (9)   | Voltage Adjust        | Voltage Adjust        | Voltage Adjust                        | Voltage Adjust            | Voltage Adjust                         | Voltage Adjust                | Voltage Adjust                |
| <b>Digital Inputs</b>  |                       |                       |                                       |                           |  |                               |                               |
| D1   | X                     | X                     | Battery Charger Fault *               | X                         | X                                      | X                             | X                             |
| D2   | X                     | X                     | Low Fuel Warning *                    | X                         | X                                      | X                             | X                             |
| D3   | Low Coolant Temp.     | X                     | Low Coolant Temp.*                    | X                         | X                                      | X                             | X                             |
| D4   | X                     | X                     | X                                     | X                         | X                                      | X                             | X (1) *                       |
| D5   | X                     | X                     | X                                     | X                         | Breaker Closed *                       | X                             | X                             |
| D6   | X                     | X                     | X                                     | X                         | Enable Synch *                         | X                             | X                             |
| D7   | X                     | X                     | X                                     | X                         | X                                      | X                             | X                             |
| D8   | X                     | X                     | X                                     | X                         | X                                      | X                             | X                             |
| D9   | X                     | X                     | X                                     | X                         | X                                      | X                             | X (2) *                       |
| D10  | X                     | X                     | X                                     | X                         | X                                      | X                             | X                             |
| D11  | X                     | X                     | X                                     | AFM Shutdown *            | X                                      | X                             | X                             |
| D12  | X                     | X                     | X                                     | Deton Warning *           | X                                      | X                             | X                             |
| D13  | X                     | X                     | X                                     | Deton/Knock Shutdown *    | X                                      | X                             | X                             |
| D14  | X                     | X                     | Low Coolant Level (with LCL Switch) * | X                         | X                                      | X                             | X                             |
| D15  | X                     | X                     | X                                     | X                         | X                                      | X                             | X (3) *                       |
| D16  | X                     | X                     | X                                     | X                         | X                                      | X                             | X (4) *                       |
| D17  | X                     | X                     | X                                     | X                         | X                                      | X                             | X (5) *                       |
| D18  | X                     | X                     | X                                     | X                         | X                                      | X                             | X (6) *                       |
| D19  | X                     | X                     | X                                     | X                         | X                                      | X                             | X (7) *                       |
| D20  | X                     | X                     | Air Damper *                          | X                         | X                                      | X                             | X                             |
| D21  | Idle Mode Active      | X                     | X                                     | X                         | X                                      | X                             | X                             |
| <p>(1) D4 is preassigned as Field Overvolts when using a Marathon M4/M5/M7/M10 alternator.</p> <p>(2) D9 is preassigned as Low Fuel Shutdown when using 125RZG (GM powered).</p> <p>(3) D15 is preassigned as Remote Shutdown.</p> <p>(4) D16 is preassigned as Remote Reset.</p> <p>(5) D17 is preassigned as VAR/PF mode.</p> <p>(6) D18 is preassigned as Voltage Lower.</p> <p>(7) D19 is preassigned as Voltage Raise.</p> <p>(8) A6 is available for assignment as Variable Speed Governor (VSG) (Volvo, GM, Doosan, and KDI engines only)</p> <p>(9) A7 is default location, however the default function is not Analog Voltage Adjust; the function must be enabled. See Section 1.3.3.</p> <p>* Factory-reserved inputs that are fixed and not user-changeable.</p> |                       |                       |                                       |                           |  |                               |                               |

**Figure 2-8** User Inputs (X) and Factory-Reserved Inputs (as shown)

**Menu List Summary (Legend: ● First level submenu, ○ second level submenu)**

| Menu 1<br>Generator Monitoring  | Menu 2<br>Engine Monitoring  | Menu 2<br>Engine Monitoring, cont.  | Menu 4<br>Operational Records  |
|---|--|---|--|
| <p><b>Volts &amp; Amps</b></p> <ul style="list-style-type: none"> <li>● L1-L2 Volts<br/>L1 Amps</li> <li>● L2-L3 Volts<br/>L2 Amps (3 phase)</li> <li>● L3-L1 Volts<br/>L3 Amps (3 phase)</li> <li>● L1-L2 Volts<br/>L2 Amps (1 phase)</li> <li>● L1-L0 Volts<br/>L1 Amps</li> <li>● L2-L0 Volts<br/>L2 Amps</li> <li>● L3-L0 Volts<br/>L3 Amps (3 phase)</li> <li>● Frequency</li> </ul> <p><b>V &amp; A Summary</b></p> <ul style="list-style-type: none"> <li>● V L1-L2, L2-L3, L3-L1 (3 phase)</li> <li>● V L1-L0, L2-L0, L3-L0 (3 phase)</li> <li>● A L1, L2, L3 (3 phase)</li> <li>● V L1-L2, L1-L0, L2-L0 (1 phase)</li> <li>● A L1, L2 (1 phase)</li> </ul> <p><b>Power kW</b></p> <ul style="list-style-type: none"> <li>● Total kW<br/>Power Factor</li> <li>● L1 kW<br/>Power Factor</li> <li>● L2 kW<br/>Power Factor</li> <li>● L3 kW<br/>Power Factor (3 phase)</li> <li>● Total kW<br/>% of Rated kW</li> </ul> <p><b>Power kVAR</b></p> <ul style="list-style-type: none"> <li>● Total kVAR<br/>Absorbing/Generating</li> <li>● L1 kVAR<br/>Absorbing/Generating</li> <li>● L2 kVAR<br/>Absorbing/Generating</li> <li>● L3 kVAR<br/>Absorbing/Generating (3 phase)</li> </ul> <p><b>Power kVA</b></p> <ul style="list-style-type: none"> <li>● Total kVA</li> <li>● L1 kVA</li> <li>● L2 kVA</li> <li>● L3 kVA (3 phase)</li> </ul> | <p><b>Engine Monitoring Basic</b></p> <ul style="list-style-type: none"> <li>● Oil Pressure<br/>Coolant Temperature</li> <li>● Intake Air Temperature<br/>Oil Temperature (DDC/MTU engine with MDEC/ADEC and Waukesha engine only)</li> <li>● Engine RPM<br/>Local Battery VDC</li> <li>● High Coolant<br/>Temperature Shutdown and Warning Setpoints</li> <li>● Low Oil Pressure<br/>Shutdown and Warning Setpoints</li> <li>● Engine Warmup<br/>Temperature Setpoint</li> <li>● Engine Cooldown<br/>Temperature Setpoint</li> </ul> <p><b>Engine Monitoring Detailed (DDEC/JDEC/EMS2/EDC3 equipped engines only)</b></p> <p><b>Engine Fuel</b></p> <ul style="list-style-type: none"> <li>● Fuel Pressure<br/>Fuel Temperature</li> <li>● Charge Air Pressure<br/>Charge Air Temperature</li> <li>● Fuel Rate</li> <li>● Used Last Run</li> </ul> <p><b>Engine Coolant</b></p> <ul style="list-style-type: none"> <li>● Coolant Pressure<br/>Coolant Temperature</li> <li>● Coolant Level</li> </ul> <p><b>Engine Oil</b></p> <ul style="list-style-type: none"> <li>● Oil Pressure<br/>Oil Temperature</li> <li>● Oil Level<br/>Crankcase Pressure</li> </ul> <p><b>Engine Misc</b></p> <ul style="list-style-type: none"> <li>● ECM Battery VDC<br/>Ambient Temperature</li> <li>● Engine Model No.</li> <li>● Engine Serial No.</li> <li>● Unit No.<br/>ECM S/N</li> <li>● ECM Fault Codes</li> </ul> | <p><b>Engine Monitoring Detailed (MDEC/ADEC equipped engines only)</b></p> <p><b>Engine Fuel</b></p> <ul style="list-style-type: none"> <li>● Fuel Pressure<br/>Fuel Temperature</li> <li>● Charge Air Pressure<br/>Charge Air Temperature</li> <li>● Fuel Rate</li> <li>● Daily Fuel Used</li> <li>● Total Fuel Used</li> </ul> <p><b>Engine Oil</b></p> <ul style="list-style-type: none"> <li>● Oil Pressure<br/>Oil Temperature</li> </ul> <p><b>Engine Misc</b></p> <ul style="list-style-type: none"> <li>● ECU Supply VDC<br/>Ambient Temperature</li> <li>● ECU Hours</li> <li>● ECU Fault Codes</li> </ul> <hr/> <p><b>Menu 3<br/>Analog Monitoring</b></p> <ul style="list-style-type: none"> <li>● Local Batt VDC</li> <li>● Analog 01 to 07 (user-defined descriptions) (Scroll through 7 user-defined descriptions. See <b>Figure 2-8</b> in User Inputs for factory-reserved inputs that are not user-selectable.)</li> </ul> <p><b>Non-ECM Engines</b></p> <ul style="list-style-type: none"> <li>● A03–A07 User-Defined</li> </ul> <p><b>ECM Engines</b></p> <ul style="list-style-type: none"> <li>● A01 Coolant Temperature</li> <li>● A02 Oil Pressure</li> <li>● A03–A07 User-Defined</li> <li>● A06 VSG (User has option to set to VSG for Doosan, GM, Volvo, and KDI only)</li> </ul> <p><b>Waukesha Engines</b></p> <ul style="list-style-type: none"> <li>● A05–A07 User-Defined</li> </ul> | <ul style="list-style-type: none"> <li>● Factory Test Date</li> <li>● Total Run Time</li> <li>● Total Run Time<br/>Loaded Hours</li> <li>● Total Run Time<br/>Unloaded Hours</li> <li>● Total Run Time<br/>kW Hours</li> <li>● No. of Starts</li> <li>● Engine Start Countdown <ul style="list-style-type: none"> <li>○ Run Time</li> </ul> </li> <li>● Records-Maintenance <ul style="list-style-type: none"> <li>○ Reset Records</li> </ul> </li> <li>● Run Time Since Maintenance<br/>Total Hours</li> <li>● Run Time Since Maintenance<br/>Loaded Hours</li> <li>● Run Time Since Maintenance<br/>Unloaded Hours</li> <li>● Run Time Since Maintenance<br/>kW Hours</li> <li>● Operating Days<br/>Last Maintenance</li> <li>● No. of Starts<br/>Last Maintenance</li> <li>● Last Start<br/>Date</li> <li>● Length of Run<br/>(Un)loaded Hours</li> </ul> <hr/> <p><b>Menu 5<br/>Event History</b></p> <ul style="list-style-type: none"> <li>● (Message Text)</li> <li>● (Scroll through up to 100 stored events)</li> </ul> <hr/> <p><b>Menu 6<br/>Time and Date</b></p> <ul style="list-style-type: none"> <li>● Time 00:00 AM/PM</li> <li>● Date</li> </ul> |

**Menu List Summary, continued (Legend: ● First level submenu, ○ second level submenu)**

| Menu 7<br>Generator System  | Menu 9<br>Input Setup   | Menu 9<br>Input Setup, cont.   | Menu 10<br>Output Setup, cont.   |
|---|---|--|--|
| <ul style="list-style-type: none"> <li>● Operating Mode               <ul style="list-style-type: none"> <li>○ Standby Y/N</li> <li>○ Prime Power N/Y</li> </ul> </li> <li>● System Voltage Line-Line</li> <li>● System Frequency</li> <li>● Phase               <ul style="list-style-type: none"> <li>○ 3-Phase Delta Y/N</li> <li>○ 3-Phase WYE N/Y</li> <li>○ 1-Phase N/Y</li> </ul> </li> <li>● kW Rating</li> <li>● Rated Current</li> <li>● Load Shed Output               <ul style="list-style-type: none"> <li>○ Time Delay</li> </ul> </li> <li>● Overvoltage               <ul style="list-style-type: none"> <li>○ Time Delay</li> </ul> </li> <li>● Undervoltage               <ul style="list-style-type: none"> <li>○ Time Delay</li> </ul> </li> <li>● Overfrequency</li> <li>● Underfrequency</li> <li>● Overspeed</li> <li>● Battery Voltage               <ul style="list-style-type: none"> <li>○ 12 VDC Y/N</li> <li>○ 24 VDC N/Y</li> </ul> </li> <li>● Low Battery Voltage</li> <li>● High Battery Voltage</li> <li>● Block Heater ON †</li> <li>● Block Heater OFF †</li> <li>● Enable VSG Y/N †</li> <li>● Enable DSC †</li> <li>● Adjust System Speed**</li> <li>● Speed Adjust Select**</li> <li>● Metric Units Y/N</li> <li>● Set NFPA110 Defaults Y/N</li> </ul> <p>† DDC/MTU engine w/MDEC/ADEC only<br/>**Doosan, GM, Volvo, KDI only</p> | <p><b>Setup Digital Auxiliary Inputs</b></p> <ul style="list-style-type: none"> <li>● Digital Input (Scroll through up to 21 user-defined descriptions. See <b>Figure 2-8</b> in User Inputs for factory-reserved inputs that are not user-selectable.)</li> <li>● Digital Input Message Text Y/N, see Group A</li> </ul> <p><b>Group A Preprogrammed selections include the following:</b></p> <p>Warning</p> <p>Shutdown Type A</p> <p>Shutdown Type B</p> <p>Voltage Raise</p> <p>Voltage Lower</p> <p>VAR PF Mode</p> <p>Remote Shutdown</p> <p>Remote Reset</p> <p>Air Damper</p> <p>Low Fuel</p> <p>Field Overvoltage</p> <p>Idle Mode Active (ECM engines only)</p> <p>Battle Switch</p> <p>Ground Fault</p> <p>Bat Chgr Fault</p> <p>High Oil Temperature (non-ECM only)</p> <p>Low Coolant Level</p> <p>Low Coolant Temperature (Not user-selectable)</p> <p>Breaker Closed, (Paralleling non-selectable)</p> <p>Enable Synchronizer, (Paralleling non-selectable)</p> <p>Air/Fuel Module Shutdown*</p> <p>Knock Shutdown*</p> <p>Detonation Warning*</p> <p>Detonation Shutdown*</p> <p>Low Fuel Shutdown</p> <ul style="list-style-type: none"> <li>● Digital Input Enable Y/N</li> <li>● Digital Input Inhibit Time</li> <li>● Digital Input Delay Time</li> </ul> <p>*Waukesha engine only</p> | <p><b>Setup Analog Auxiliary Inputs</b></p> <ul style="list-style-type: none"> <li>● Analog Input (Scroll through up to 7 user-defined descriptions. See <b>Figure 2-8</b> in User Inputs for factory-reserved inputs that are not user-selectable.)</li> <li>● Analog Input Warning Enabled Y/N</li> <li>● Analog Input Shutdown Enabled Y/N</li> <li>● Analog Input Inhibit Time 0–60 Sec.</li> <li>● Analog Input Warning Delay Time 0–60 Sec.</li> <li>● Analog Input Shutdown Delay Time 0–60 Sec.</li> <li>● Analog Input Low Shutdown Value</li> <li>● Analog Input Low Warning Value</li> <li>● Analog Input High Warning Value</li> <li>● Analog Input High Shutdown Value</li> </ul> | <p><b>Relay Driver Outputs (RDOs)</b></p> <ul style="list-style-type: none"> <li>● RDOs (Y/N) (Scroll through up to 31 status and fault choices from:               <ul style="list-style-type: none"> <li>○ System events, see Group B</li> <li>○ 21 digital inputs D01-D21</li> <li>○ 7 analog inputs A01-A07</li> </ul> </li> </ul> <p><b>Group B System events include the following:</b></p> <p>Emergency Stop</p> <p>Over Speed</p> <p>Overcrank</p> <p>High Cool Temp Shutdown</p> <p>Oil Pressure Shutdown</p> <p>Low Coolant Temperature (<b>non-ECM engines</b>)</p> <p>Low Fuel Warning</p> <p>Hi Cool Temp Warning</p> <p>Oil Pressure Warning</p> <p>Master Not in Auto</p> <p>NFPA 110 Fault†</p> <p>†<b>The 15 NFPA 110 Common Fault Alarms include the following:</b></p> <p>Over Speed</p> <p>Overcrank</p> <p>High Coolant Temperature Shutdown</p> <p>Oil Pressure Shutdown</p> <p>Low Coolant Temperature</p> <p>High Coolant Temperature Warning</p> <p>Oil Pressure Warning</p> <p>Low Fuel</p> <p>Master Not In Auto</p> <p>Battery Charger Fault</p> <p>Low Battery Voltage</p> <p>High Battery Voltage</p> <p>Low Coolant Level</p> <p>EPS Supplying Load</p> <p>Air Damper Indicator</p> |
| <p><b>Menu 8 Time Delays</b></p> <ul style="list-style-type: none"> <li>● Time Delay Engine Start</li> <li>● Time Delay Starting Aid</li> <li>● Time Delay Crank On</li> <li>● Time Delay Crank Pause</li> <li>● Time Delay Eng. Cooldown</li> <li>● Cooldown Temperature Override Y/N</li> <li>● Overcrank Shutdown Crank Cycles</li> <li>● Time Delay Overvoltage</li> <li>● Time Delay Undervoltage</li> <li>● Time Delay Load Shed kW</li> </ul>  | <p><b>Menu 10 Output Setup</b></p> <p><b>Defined Common Fault</b></p> <ul style="list-style-type: none"> <li>● Defined Common Fault (Y/N for a <i>single</i> defined common fault) Scroll through status and fault choices from:               <ul style="list-style-type: none"> <li>○ System events, see Group B (except Defined Common Fault)</li> <li>○ 21 digital inputs D01-D21</li> <li>○ 7 analog inputs A01-A07</li> </ul> </li> </ul>   |  |  |

**Menu List Summary, continued (Legend: ● First level submenu, ○ second level submenu)**

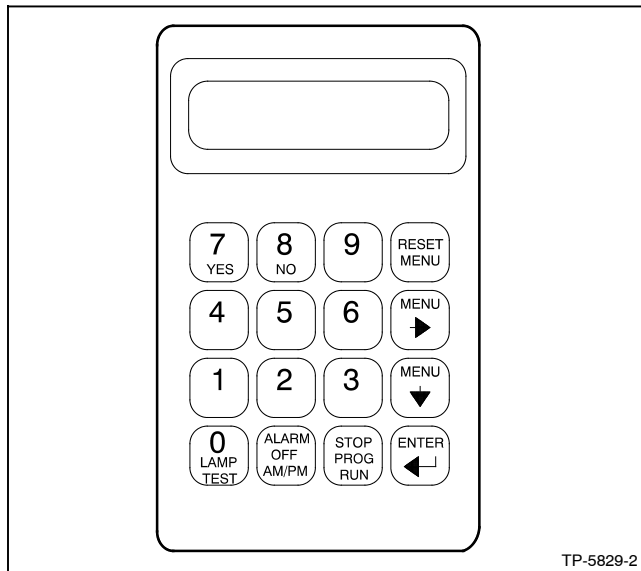
| Menu 10<br>Output Setup, cont.  | Menu 10<br>Output Setup, cont.  | Menu 11<br>Voltage Regulator   | Menu 12<br>Calibration   |
|---|---|--|--|
| <p><b>Group B, continued</b><br/>                     Low Battery Voltage<br/>                     High Battery Voltage<br/>                     Battery Charger Fault<br/>                     System Ready<br/>                     Loss of ECM Comm<br/> <b>(ECM engines)</b><br/>                     No Oil Pressure Signal<br/>                     High Oil Temperature Shutdown<br/>                     No Temperature Signal<br/>                     Low Coolant Level<br/>                     Speed Sensor Fault<br/>                     Locked Rotor<br/>                     Master Switch Error<br/>                     Master Switch Open<br/>                     Master Switch to Off<br/>                     AC Sensing Loss<br/>                     Over Voltage<br/>                     Under Voltage<br/>                     Weak Battery<br/>                     Over Frequency<br/>                     Under Frequency<br/>                     Load Shed kW Over<br/>                     Load Shed Under Freq<br/>                     Over Current<br/>                     EPS Supplying Load<br/>                     Internal Fault<br/>                     Delay Engine Cooldown<br/>                     Delay Engine Start<br/>                     Starting Aid<br/>                     Generator Set Running<br/>                     Air Damper Control<br/>                     Ground Fault<br/>                     EEPROM Write Failure<br/>                     Critical Overvoltage<br/>                     Alternator Protection<br/>                     Air Damper Indicator<br/>                     Defined Common Fault (RDO only)<br/>                     SCRDOs 1-4 (Software-Controlled RDOs)</p> | <p><b>Group B, continued</b><br/>                     Reverse Power Shutdown†<br/>                     Over Power Shutdown†<br/>                     Loss of Field Shutdown†<br/>                     Overcurrent VR Shutdown†<br/>                     Common Protective Relay Output†<br/>                     In Synchronization†<br/>                     Breaker Trip†<br/>                     Fuel Valve Relay*<br/>                     Prelube Relay*<br/>                     Air/Fuel Module Remote Start*<br/>                     No Oil Temperature Signal*<br/>                     High Oil Temperature Warning*‡<br/>                     No Air Temperature Signal*<br/>                     Intake Air Temperature Warning*‡<br/>                     Intake Air Temperature Shutdown*‡<br/>                     Air/Fuel Module Engine Start Delay*<br/>                     ECM Yellow Alarm‡<br/>                     ECM Red Alarm‡<br/>                     Block Heater Control‡<br/>                     Low Coolant Temperature Shutdown‡<br/>                     Load Shed Overtemperature‡<br/>                     Maintenance Due<br/>                     Engine Derate Active<br/>                     Turbo Temperature Warning§<br/>                     Turbo Temperature Shutdown§<br/>                     Engine Stalled<br/> <b>(ECM engines)</b><br/>                     J1939 CAN Shutdown<br/> <b>(ECM engines)</b><br/>                     *Waukesha engine<br/>                     †Paralleling applications<br/>                     ‡DDC/MTU engine with MDEC/ADEC<br/>                     §1750/2000REOZMD</p> | <p><b>AVG L-L V Volt ADJ</b><br/>                     ● L1-L2 Volts<br/>                     ● L2-L3 Volts (3 phase)<br/>                     ● L3-L1 Volts (3 phase)<br/> <b>Under Freq. Unload Enabled N/Y</b><br/>                     ● Frequency Setpoint (Cut-In Point)<br/>                     ● Slope Volts-Per-Cycle<br/> <b>Reactive Droop Enabled N/Y</b><br/>                     ● Voltage Droop at 0.8 PF Rated Load<br/> <b>VAR Control Enabled N/Y</b><br/>                     ● Total kVAR (Running) kVAR Adj<br/>                     ● Generating/Absorbing Y/N<br/> <b>PF Control Enabled N/Y</b><br/>                     ● Average PF PF Adjustment<br/>                     ● Lagging/Leading Y/N<br/> <b>Regulator Gain Adj.</b><br/>                     ● Gain<br/> <b>Utility Gain Adj.</b><br/>                     ● Gain<br/> <b>Analog Voltage Adjust Enabled N/Y</b><br/> <b>Reset Regulator Defaults?</b></p> | <p><b>Scale AC Analog Inputs</b><br/>                     Generator Set Voltage LN<br/>                     ● Gen L1-L0 V Calibration Reference<br/>                     ● Gen L2-L0 V Calibration Reference<br/>                     ● Gen L3-L0 V (3 phase) Calibration Reference<br/>                     Generator Set Voltage LL<br/>                     ● Gen L1-L2 V Calibration Reference<br/>                     ● Gen L2-L3 V (3 phase) Calibration Reference<br/>                     ● Gen L3-L1 V (3 phase) Calibration Reference<br/>                     ● Calibrate Regulator Y/N<br/>                     Generator Set Amps<br/>                     ● Gen L1 Amps Calibration Reference<br/>                     ● Gen L2 Amps Calibration Reference<br/>                     ● Gen L3 Amps (3 phase) Calibration Reference<br/>                     Load Voltage LN (Paralleling Applications only)<br/>                     ● Load L1-L0 V Calibration Reference<br/>                     ● Load L3-L0 V Calibration Reference<br/>                     Restore Defaults? Y/N<br/> <b>Scale Aux. Analog Inputs</b><br/>                     ● Zero Aux. Analog Inputs? (Scroll through up to 7 user-defined descriptions. See <b>Figure 2-8</b> in User Inputs for factory-reserved inputs that are not user-selectable.)<br/>                     ● Analog 01 Scale Value 1<br/>                     ○ Scale 1 V<br/>                     Scale 2 V<br/>                     ● Analog 01 Scale Value 2<br/>                     ○ Scale 1 V<br/>                     Scale 2 V</p> |

**Menu List Summary, continued (Legend: ● First level submenu, ○ second level submenu)**

| Menu 13<br>Communications  | Menu 14<br>Programming Mode  | Menu 18 (v. 3.4.3)<br>Battery Chargers   | Menu 18 (v. 3.4.3)<br>Battery Chargers Cont.   |
|--|--|--|--|
| <p><b>Protocol KBUS</b></p> <ul style="list-style-type: none"> <li>● KBUS Online Y/N</li> <li>● Connection Type (User-defined) <ul style="list-style-type: none"> <li>○ Local Single Y/N</li> <li>○ Local LAN Y/N</li> <li>○ Local LAN Conv Y/N</li> <li>○ Remote Single Y/N</li> <li>○ Remote LAN Y/N</li> <li>○ Remote LAN Conv Y/N</li> </ul> </li> <li>● Primary Port (User-defined) <ul style="list-style-type: none"> <li>○ RS-232 Y/N</li> <li>○ RS-485 ISO1 Y/N</li> </ul> </li> <li>● Address (LAN Connections)</li> <li>● System ID (Remote Connections)</li> <li>● BAUD Rate (User-defined) <ul style="list-style-type: none"> <li>○ BAUD Rate 1200</li> <li>○ BAUD Rate 2400</li> <li>○ BAUD Rate 9600</li> </ul> </li> </ul> <p><b>Protocol Modbus 0</b></p> <ul style="list-style-type: none"> <li>● Modbus Online N/Y</li> <li>● Connection Type (User-defined) <ul style="list-style-type: none"> <li>○ Single Y/N</li> <li>○ Convertor Y/N</li> </ul> </li> <li>● Primary Port <ul style="list-style-type: none"> <li>○ RS-485</li> <li>○ RS-232</li> </ul> </li> <li>● Address</li> <li>● BAUD Rate (User-defined) <ul style="list-style-type: none"> <li>○ 9600</li> <li>○ 19200</li> </ul> </li> </ul> <p><b>Modbus 1</b></p> <ul style="list-style-type: none"> <li>● Modbus Online N/Y</li> <li>● Connection Type (User-defined) <ul style="list-style-type: none"> <li>○ Single Y/N</li> <li>○ Convertor Y/N</li> </ul> </li> <li>● Primary Port <ul style="list-style-type: none"> <li>○ RS-485 ISO</li> </ul> </li> <li>● Address</li> <li>● BAUD Rate (User-defined) <ul style="list-style-type: none"> <li>○ 9600</li> <li>○ 19200</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>● Programming Mode <ul style="list-style-type: none"> <li>○ Local? Y/N</li> <li>○ Remote? Y/N</li> <li>○ Off? Y/N</li> </ul> </li> <li>● Programming Mode Change, Access Code <ul style="list-style-type: none"> <li>○ Enter Old Code</li> <li>○ Enter New Code</li> </ul> </li> </ul> <hr/> <p><b>Menu 15 Paralleling Relays (PR)</b></p> <p><b>Purchased Option</b></p> <ul style="list-style-type: none"> <li>● PR Overvoltage VAC <ul style="list-style-type: none"> <li>○ Time Delay Seconds</li> </ul> </li> <li>● PR Undervoltage VAC <ul style="list-style-type: none"> <li>○ Time Delay Seconds</li> </ul> </li> <li>● PR Overfrequency Hz <ul style="list-style-type: none"> <li>○ Time Delay Seconds</li> </ul> </li> <li>● PR Underfrequency Hz <ul style="list-style-type: none"> <li>○ Time Delay Seconds</li> </ul> </li> <li>● PR Reverse Power kW <ul style="list-style-type: none"> <li>○ Time Delay Seconds</li> </ul> </li> <li>● SD Reverse Power kW <ul style="list-style-type: none"> <li>○ Time Delay Seconds</li> </ul> </li> <li>● PR Over Power kW <ul style="list-style-type: none"> <li>○ Time Delay Seconds</li> </ul> </li> <li>● SD Over Power kW <ul style="list-style-type: none"> <li>○ Time Delay Seconds</li> </ul> </li> <li>● PR Loss of Field kVAR <ul style="list-style-type: none"> <li>○ Time Delay Seconds</li> </ul> </li> <li>● SD Loss of Field kVAR <ul style="list-style-type: none"> <li>○ Time Delay Seconds</li> </ul> </li> <li>● PR Overcurrent Amps <ul style="list-style-type: none"> <li>○ Time Delay Seconds</li> </ul> </li> <li>● SD Overcurrent Amps <ul style="list-style-type: none"> <li>○ Time Delay Seconds</li> </ul> </li> <li>● Synchronization <ul style="list-style-type: none"> <li>○ Synch Voltage Match VAC</li> <li>○ Synch Freq. Match Hz</li> <li>○ Synch Phase Match Degrees</li> <li>○ Time Delay Seconds</li> </ul> </li> </ul> | <p><b>Battery Charger 1</b></p> <ul style="list-style-type: none"> <li>● Battery Charger Metering <ul style="list-style-type: none"> <li>○ Output Voltage</li> <li>○ Output Current</li> <li>○ Charger State</li> <li>○ SFWR Ver (software version)</li> <li>○ Reduced Output</li> <li>○ Temp Comp Active</li> </ul> </li> <li>● Battery Charger Basic Config <ul style="list-style-type: none"> <li>○ Battery Topology</li> <li>○ Charger System Voltage</li> <li>○ Automatic Equalize Enabled</li> <li>○ Temp Compensation Enabled</li> <li>○ Absorption Termination</li> </ul> </li> <li>● Battery Charger Advanced Config <ul style="list-style-type: none"> <li>○ Custom Charging Profile Enable</li> <li>○ Bulk Voltage</li> <li>○ Absorption Voltage</li> <li>○ Float Voltage</li> <li>○ Manual Equalize Active</li> <li>○ Temperature Comp Slope</li> <li>○ Equalize Voltage</li> <li>○ Max Absorption Time</li> <li>○ Max Bulk Time</li> <li>○ Bulk State Return Voltage</li> </ul> </li> </ul> <p><b>Battery Charger 2</b></p> <ul style="list-style-type: none"> <li>● Battery Charger Metering <ul style="list-style-type: none"> <li>○ Output Voltage</li> <li>○ Output Current</li> <li>○ Charger State</li> <li>○ SFWR Ver (software version)</li> <li>○ Reduced Output</li> <li>○ Temp Comp Active</li> </ul> </li> <li>● Battery Charger Basic Config <ul style="list-style-type: none"> <li>○ Battery Topology</li> <li>○ Charger System Voltage</li> <li>○ Automatic Equalize Enabled</li> <li>○ Temp Compensation Enabled</li> <li>○ Absorption Termination</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>● Battery Charger Advanced Config <ul style="list-style-type: none"> <li>○ Custom Charging Profile Enable</li> <li>○ Bulk Voltage</li> <li>○ Absorption Voltage</li> <li>○ Float Voltage</li> <li>○ Manual Equalize Active</li> <li>○ Temperature Comp Slope</li> <li>○ Equalize Voltage</li> <li>○ Max Absorption Time</li> <li>○ Max Bulk Time</li> <li>○ Bulk State Return Voltage</li> </ul> </li> </ul> <hr/> <p><b>Menu 20 Factory Setup Menu</b></p> <ul style="list-style-type: none"> <li>● Final Assembly Date DD/MM/YY</li> <li>● Final Assembly Clock No.</li> <li>● Operating Days</li> <li>● Model No.</li> <li>● Spec No.</li> <li>● Generator Set Serial No.</li> <li>● Alternator Part No.</li> <li>● Engine Part No.</li> <li>● Temp Sensor <ul style="list-style-type: none"> <li>○ GM31045-X</li> <li>○ GM16787</li> <li>○ GM17362</li> </ul> </li> <li>● Disable Low Coolant Temp Warning (ECM Engines Only)</li> <li>● Serial No. Confirm <ul style="list-style-type: none"> <li>○ Confirm Serial?</li> </ul> </li> <li>● Controller Serial No.</li> <li>● Code Version</li> <li>● Setup Locked</li> <li>● Engine Type (Non-ECM Engines Only)</li> </ul> <hr/> <p><b>Menu 55 Load Factor</b></p> <ul style="list-style-type: none"> <li>● 100%–125% Load Factor Hours</li> <li>● 126%–150% Load Factor Hours</li> <li>● 151%–200% Load Factor Hours</li> <li>● 201%+ Load Factor Hours</li> </ul> |

## 2.6 Reviewing Digital Display

The user interacts with the controller with a keypad and digital display. Use the keypad to access the generator set informational data and preset settings. This review section shows how to access the data. See Section 2.9, Local Programming Mode On, for instructions on how to change the information. See Figure 2-9 for an illustration of the digital display and keypad.



**Figure 2-9** Digital Display and Keypad

**Note:** After energizing the controller by reconnecting the battery, set the controller time and date. See Section 2.9.6, Local Programming Mode On, Menu 6—Time and Date.

Pressing any key on the keypad activates the controller panel display. The panel lamps and display turn off 5 minutes after the last keypad entry.

### 2.6.1 Keypad Operation

Use the keypad to enter information into the controller. Some of the keys have two functions. The following gives keypad definitions and functions.

**Alarm (Horn) Off Key.** Press the *alarm off* key to silence the horn at the user's discretion. Place the generator set master switch in the AUTO position before silencing the alarm horn. The alarm horn cannot be silenced unless the master switch is in the AUTO position. See Section 2.4.7, Controller Reset Procedure, for more information on turning the alarm horn off.

**AM/PM Key.** When the controller displays a question during programming requiring a nonnumeric answer (am or pm), the controller accepts the secondary key function and ignores the *alarm off* function of the key.

**Enter ↵ Key.** Press the enter ↵ key to confirm the entered information on the display when selecting menus or programming.

**Lamp Test Key.** Press the lamp test key to check that the status and fault lamps illuminate, the horn sounds, and the digital display clears. Press the reset menu key before pressing the lamp test key.

**Menu Down ↓ Key.** The controller displays consist of menus with various data levels or programming steps. Use the menu down ↓ key to navigate through the menu levels.

**Note:** Pressing the menu down ↓ key in some menus locks the user into that level structure of the menu where the display will not change. Press the reset menu key to access other main menus.

**Menu Right → Key.** Press the menu right → key to scroll through sub-levels of each main menu. The display contains an arrow in the right-hand corner when there is a sub-level. Pressing the menu right → key when no arrow is present moves to the next submenu header. Press the menu right → key prior to entering decimal values when required.

**Note:** Pressing the menu right → key in some menus locks the user into that level structure of the menu where the display will not change. Press the reset menu key to access other main menus.

**Numeric 0-9 Keys.** Press the numeric keys when selecting menus or entering numeric values during programming. The controller ignores the secondary function of the key (yes, no, etc.) when only numeric values are valid.

**Reset Menu Key.** The reset menu key exits a menu, clears incorrect entries, and cancels the auto-scroll function. Press the reset menu key to exit a menu or any layer within that menu.

**Stop Prog Run Key.** Press the stop prog run key to end the generator set programmed exercise run created in Menu 4—Operational Records. The generator set shuts down after the time delay for engine cooldown expires. The stop prog run key does not affect the programmed transfer switch exercise function.

**Yes/No Keys.** When the controller displays a question during programming requiring a nonnumeric answer (yes or no), the controller accepts the secondary key function and ignores the numeric value of the key. Press the ENTER key to confirm the response.

## 2.6.2 Auto-Scroll Function

The auto-scroll function continuously shows voltage and current data from Menu 1—Generator Monitoring, V & A Summary without the need to press the down arrow for each display.

For auto-scroll function press ENTER at the V & A Summary menu. Press the Reset Menu key or Menu Right → key to stop the auto-scroll function.

## 2.6.3 Request and Error Messages

**Note:** When EEPROM errors occur or initializing the EEPROM is required, contact an authorized distributor/dealer.

### Request and Status Messages

Display messages require the user to enter additional data, confirm the previous entry or require time to process as described below.

**Entry Accepted** appears for several seconds after pressing the Enter key during the programming mode. The display then shows the new data.

**Initialize EEPROM?** Prompt to confirm EEPROM initialization.

**Reset Complete** indicates the user has successfully:

- Reset the maintenance records or
- Restored the AC analog inputs to the default settings.
- Restored voltage regulator settings to the defaults.

**Right Arrow** → directs the user to the next menu. The menus loop; press the right arrow key to move to the next menu.

**Setup Complete** indicates the completion of the analog input setup.

**Setup Locked** appears when user attempts to change a value or perform a function available only when the system is unlocked.

**Setup Unlocked** appears when user has unlocked the system for maintenance or troubleshooting.

**(Question) ?** asked by the control firmware; answer the question by pressing the yes/no, numeric digit, or am/pm key.

**Wait for System Reset (6 Sec)** appears while the EEPROM initializes.

## Error Messages

When an error message appears, the entered information is not within the allowable parameters set by the control firmware or is not permitted as described below. In cases where the data was outside the parameters, press the Reset Menu key and enter the corrected information.

**Access Denied** appears when the user attempts to:

- Enter data prohibited by the master switch position,
- Enter data prohibited by the generator set state, or
- Enable the LDD (load disturbance detection).

**Access Denied Idle Mode Active** appears when the user attempts to modify the voltage regulator setup while the idle mode is active.

**Alarm Active** appears when the user attempts to modify an analog or a digital input that is active. See Menu 9—Input Setup.

**Cannot Change (because the) NFPA is Enabled** appears when the user attempts to modify an RDO setting that is a NFPA 110 default requirement.

**Cannot Change Preset** appears when the user attempts to change the factory preset analog input, digital input, or input parameter.

**EEPROM Write Error** appears when a component failure occurs. Contact an authorized distributor/dealer.

**Entry Unacceptable** appears when the user attempts an invalid input to the voltage regulator setup.

Some alternators are intended to operate within a specific, limited range of conditions (voltage, frequency, and phase or connection). The following error messages can appear when attempts are made to enter system values that do not match acceptable conditions for the particular alternator.

- **Fixed Frequency** when entry is beyond the range of limited entries for the respective alternator. Occurs when the alternator is not rated for the value entered. Updated parameter files may be available by contacting an authorized service dealer/distributor.
- **Fixed Phase** when entry is beyond the range of limited entries for the respective alternator. Occurs when the alternator is not rated for the value entered. Updated parameter files may be available by contacting an authorized service dealer/distributor.

- **Fixed Voltage** when entry is beyond the range of limited entries for the respective alternator. Occurs when the alternator is not rated for the value entered. Updated parameter files may be available by contacting an authorized service dealer/distributor.

**Func (Function) Used by (RDO) XX Reassign?** appears when the user attempts to assign an RDO to a function already assigned.

**Internal Error** appears when controller logic detects a functional sequence error.

**Invalid Code** appears when the user attempts to enter:

- An invalid access code for programming mode setup, or
- An invalid access code for setup unlock.

**Invalid Menu ID** appears when the user attempts to enter a menu number that is unavailable or non-functional.

**N/A** appears when data to be displayed is not available.

**No Input Assigned** appears when the user attempts to assign any of the following system faults to an RDO where the digital input is not defined. See digital input scale requirements in Menu 12—Calibration.

- Air damper indicator
- Battery charger fault
- Ground fault
- High oil temperature shutdown
- Low coolant level
- Low fuel

**Not in Local Program Mode** appears when the user attempts to program using the keypad when the programming mode is set for remote or off.

**Not User-Selectable** appears when the user attempts to change an analog or digital input that is factory-reserved. Items identified as *not user-selectable* are included for specific applications. (Example: AFM SHUTDOWN is enabled with a Waukesha-powered model.) The user cannot disable an analog or digital input when identified as not user-selectable. See **Figure 2-8** in User Inputs for factory-reserved digital and analog inputs that are not user-selectable.

**Output in Use** appears when the user attempts to modify or reassign an active RDO.

**Port in Use** appears when the user attempts to use an already assigned communications port.

**Range Error** appears when the user attempts to enter:

- A numeric input that is not within the acceptable range of the system settings, time delays, addresses, etc.
- An invalid analog or digital input number.
- An invalid date/time.

**Remove Load** appears when trying to calibrate the voltage regulator in menu 12 with load connection. The voltage regulation calibration must be performed during a no load condition.

**Setpoint Values Cannot be Equal** appears when the user attempts to enter the same value for both setpoints during the analog input calibration.

## 2.7 Monitoring and Programming Setup

The user can access the controller data with the controller keypad and display or a personal computer (PC) with optional software to monitor and/or program. Access the controller system with a PC using local (direct) or remote (modem) systems. Refer to the Introduction, List of Related Materials for related software literature. See Menu 13—Communications.

The user can access the controller data while in the programming mode off or programming mode on. See Menu 14—Programming Mode.

While this manual focuses on data access and programming through the controller keypad and display, some data entries require input using a PC for initial setup. The PC entries typically include alpha characters such as digital input descriptions. The individual menus in Section 2.9, Local Programming Mode On, indicate where data requires entry using a PC.

There are six basic configurations for data monitoring and programming using access source options. See Figure 2-13.

Other combinations of data monitoring and programming are possible but require programming from a single location. Figure 2-13, Monitoring and Programming Configurations, briefly describes the settings of Menu 13—Communications and Menu 14—Programming Mode based on user-selected operating mode.

Use the keypad and digital display to setup the access configurations the first time. Go to Section 2.9, Local Programming Mode On, and set the desired selection in Menu 13—Communication and Menu 14—Programming Mode before accessing data.

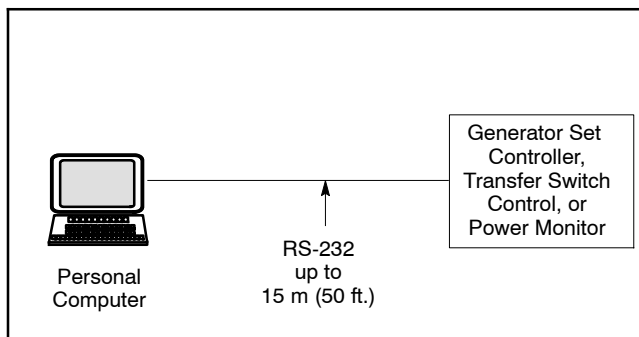


## 2.7.1 PC Communications

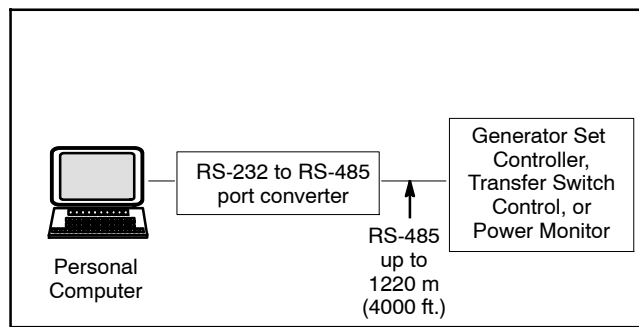
There are four ways to communicate between a PC and the generator set and/or transfer switch devices using KBUS communication protocol. The PC connections require optional software and possibly other hardware, communication modules in the generator set controller and/or transfer switch. See the monitor software operation manual for details. Contact your authorized distributor/dealer for availability.

### Local Single Connection

A PC connects to the COM port of the controller module using an RS-232 cable when the PC is within 15 m (50 ft.) of the device or an RS-485 cable when the PC is within 1220 m (4000 ft.) of the device. See Figure 2-10 or Figure 2-11.



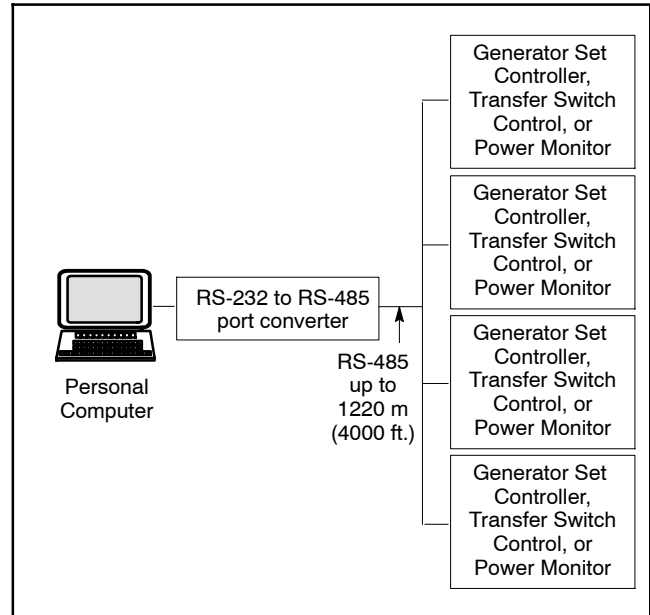
**Figure 2-10** Local Single Connection, up to 15 m (50 ft.)



**Figure 2-11** Local Single Connection, up to 1220 m (4000 ft.)

## Local Area Network (LAN)

A PC connects to the device's LAN. A LAN is a system that connects more than one device to a single PC. Acceptable devices include the Decision-Maker® 550 controller, Decision-Maker® 340 controller, M340 transfer switch control, M340+ transfer switch control, and PM340 power monitor. See Figure 2-12.



**Figure 2-12** Local Area Network

The 550 controller can be used as an RS-232 to RS-485 port converter in a LAN network if the 550 controller is located within 15 m (50 ft.) of the PC. This configuration is the Local LAN Conv option.

| User Operating Mode Selection |                        | Menu 13—Communications Settings |            |                       | Menu 14—Programming Mode |                         |                          |
|-------------------------------|------------------------|---------------------------------|------------|-----------------------|--------------------------|-------------------------|--------------------------|
| User Activity                 | Access Source          | On Line?                        | Local LAN? | Remote Single or LAN? | Programming Mode Off?    | Local Programming Mode? | Remote Programming Mode? |
| Monitor only                  | Controller             | No                              | No         | No                    | Yes                      | No                      | No                       |
|                               | Direct PC              | Yes                             | Yes        | No                    | Yes                      | No                      | No                       |
|                               | PC via Telephone Lines | Yes                             | No         | Yes                   | Yes                      | No                      | No                       |
| Monitor and Program           | Controller             | No                              | No         | No                    | No                       | Yes                     | No                       |
|                               | Direct PC              | Yes                             | Yes        | No                    | No                       | No                      | Yes                      |
|                               | PC via Telephone Lines | Yes                             | No         | Yes                   | No                       | No                      | Yes                      |

**Figure 2-13** Monitoring and Programming Configurations

## Remote Single Connection

A modem connects a PC to a single device. The PC communicates with the device via a telephone network. Locate the PC anywhere a telephone line is available. See Figure 2-14.

## Remote Area Network

A PC connects to a modem. The devices connect to a LAN network. The PC communicates to the devices via a telephone network that is interfaced to the LAN

network. Acceptable devices include the Decision-Maker® 550 controller, Decision-Maker® 340 controller, M340 transfer switch control, M340+ transfer switch control, and PM340 power monitor. Locate the PC anywhere a telephone line is available. See Figure 2-15.

The 550 controller can be used as an RS-232 to RS-485 port converter in a LAN network if the 550 controller is located within 15 m (50 ft.) of the device modem. This configuration is the Remote LAN Conv option.

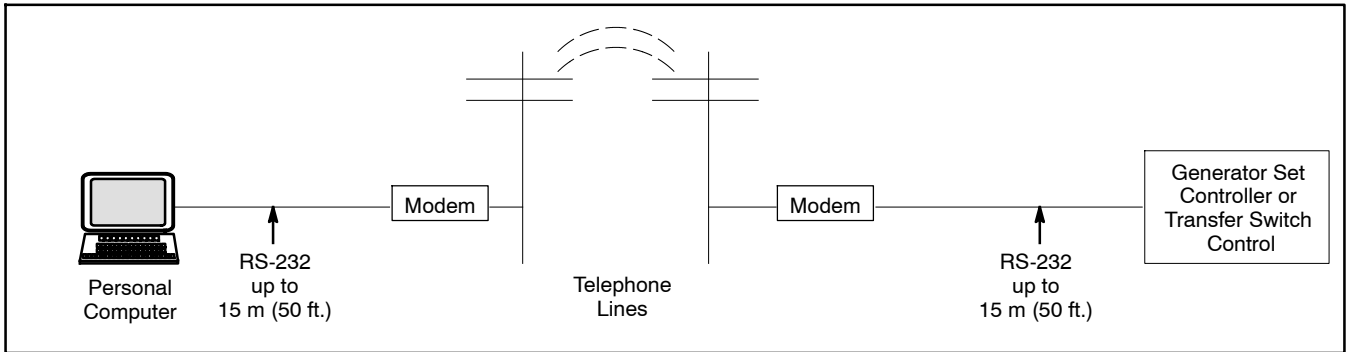


Figure 2-14 Remote Single Connection

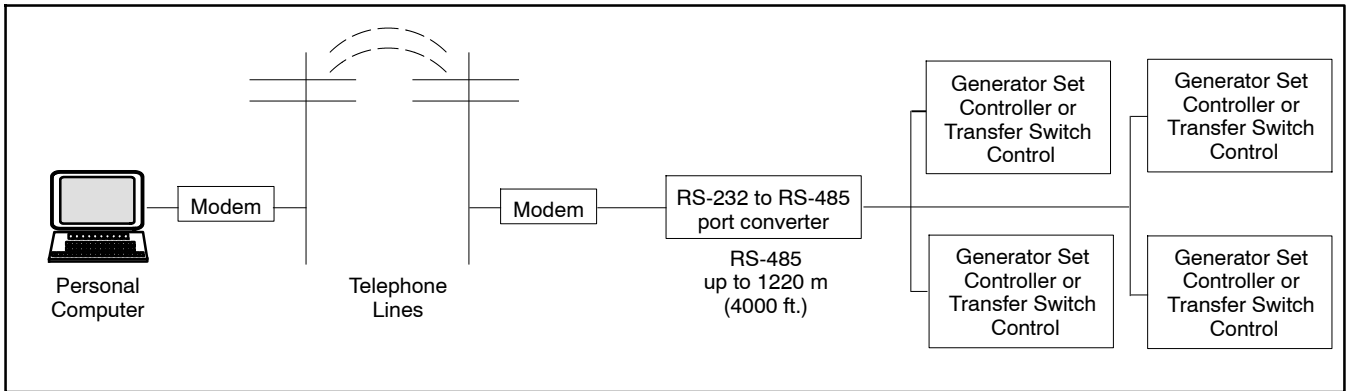


Figure 2-15 Remote Area Network

## 2.7.2 Modbus Communications

The controller communicates using Modbus® as a slave connection with the Modbus® master initiating the communication. The controller seeks the system and alternator parameters and diagnostic information then responds back to the Modbus® master. In addition, the controller accepts information to alter controller parameters including generator set starting and stopping. See Figure 2-16. Refer to the List of Related Materials for available Modbus® literature.

**Note:** Only one Modbus® master can be connected to each Modbus port on the 550 controller. Examples include the remote serial annunciator, Monitor III, and switchgear applications.

Modbus® is a registered trademark of Schneider Electric.

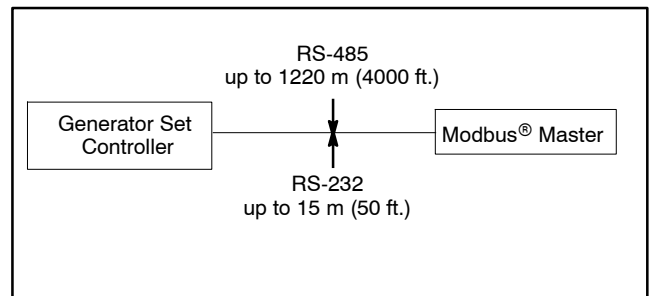


Figure 2-16 Modbus® Connections

## 2.8 Reviewing Menu Displays

Use this section to review a summary of the generator set controller data. See Figure 2-17 for which menus provide data monitoring and adjusting data.

Press the Reset key, enter the desired menu number key(s), and then press the Enter key. Use the down arrow and right arrow keys for navigation.

See Section 1, Specifications and Features, to review set point ranges and default settings for comparison to the actual setup.

The user must enable the programming mode to edit the display. See Menu 14—Programming Mode and Section 2.9, Local Programming Mode On, for more information.

**Note:** Press any key on the keypad to activate the controller panel display. The panel display turns off 5 minutes after the last keypad entry.

**Note:** Press the Reset Menu key to clear error messages.

**Note:** Press the Menu Right → key prior to entering decimal values where necessary.

Menus displaying the # symbol represent one of the following data types:

- System-calculated data
- System-measured data
- User-entered data

Menus displaying the ? symbol require the user to enter data.

Menus displaying the \* symbol represent access code or password type entries. The actual key entry does not display.

See Section 2.6.3, Request and Error Messages, for error display messages and explanations while navigating the menus.

### Legend:

▼ Menu Down Key

➤ Menu Right Key

| Menu Number | Menu Name            | View Only Data | View and Adjust Data |
|-------------|----------------------|----------------|----------------------|
| 1           | Generator Monitoring | X              |                      |
| 2           | Engine Monitoring    | X              |                      |
| 3           | Analog Monitoring    | X              |                      |
| 4           | Operational Records  |                | X                    |
| 5           | Event History        | X              |                      |
| 6           | Time and Date        |                | X                    |
| 7           | Generator System     |                | X                    |
| 8           | Time Delays          |                | X                    |
| 9           | Input Setup          |                | X                    |
| 10          | Output Setup         |                | X                    |
| 11          | Voltage Regulator    |                | X                    |
| 12          | Calibration          |                | X                    |
| 13          | Communications       |                | X                    |
| 14          | Programming Mode     |                | X                    |
| 15          | Protective Relays    |                | X                    |
| 18          | Battery Chargers     |                | X                    |
| 20          | Factory Setup        |                | X                    |

**Figure 2-17** Menu Displays for Viewing and Adjusting

## 2.8.1 Menu 1—Generator Monitoring

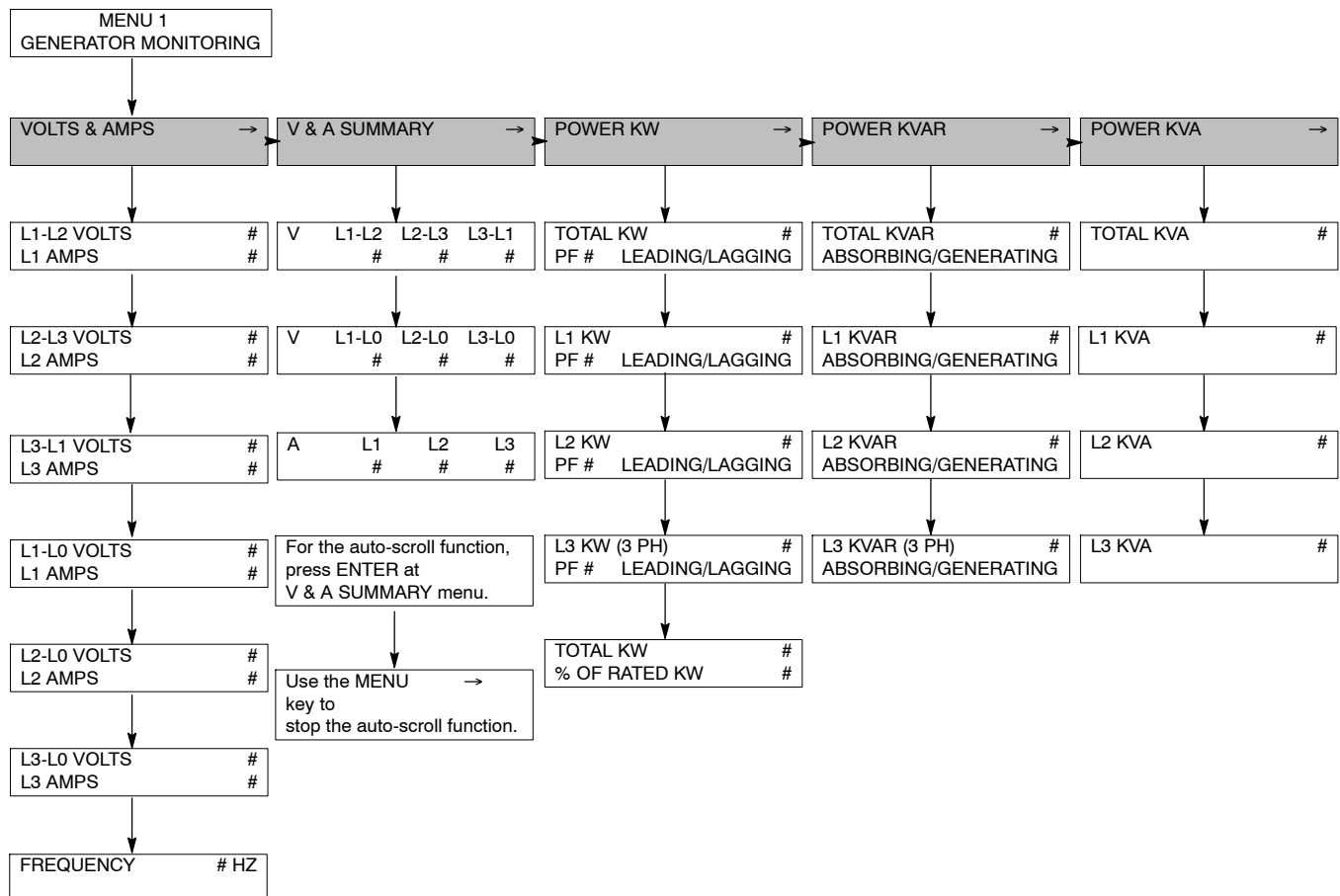
Menu 1 displays generator output data including line-to-line and line-to-neutral voltages, current, frequency, power factor, total kilowatts, percent of maximum kW, total kVA, and total kVAR. Menu 1 displays three-phase voltage and current readings when applicable.

All menu displays apply to both single-phase and three-phase voltages unless otherwise noted as (1 PH) or (3 PH) on the menu overview. The phase designation does not appear in the controller menu displays.

**Note:** For the auto-scroll function, press ENTER at V & A Summary menu. Press the Reset Menu key or Menu Right → key to stop the auto-scroll function.

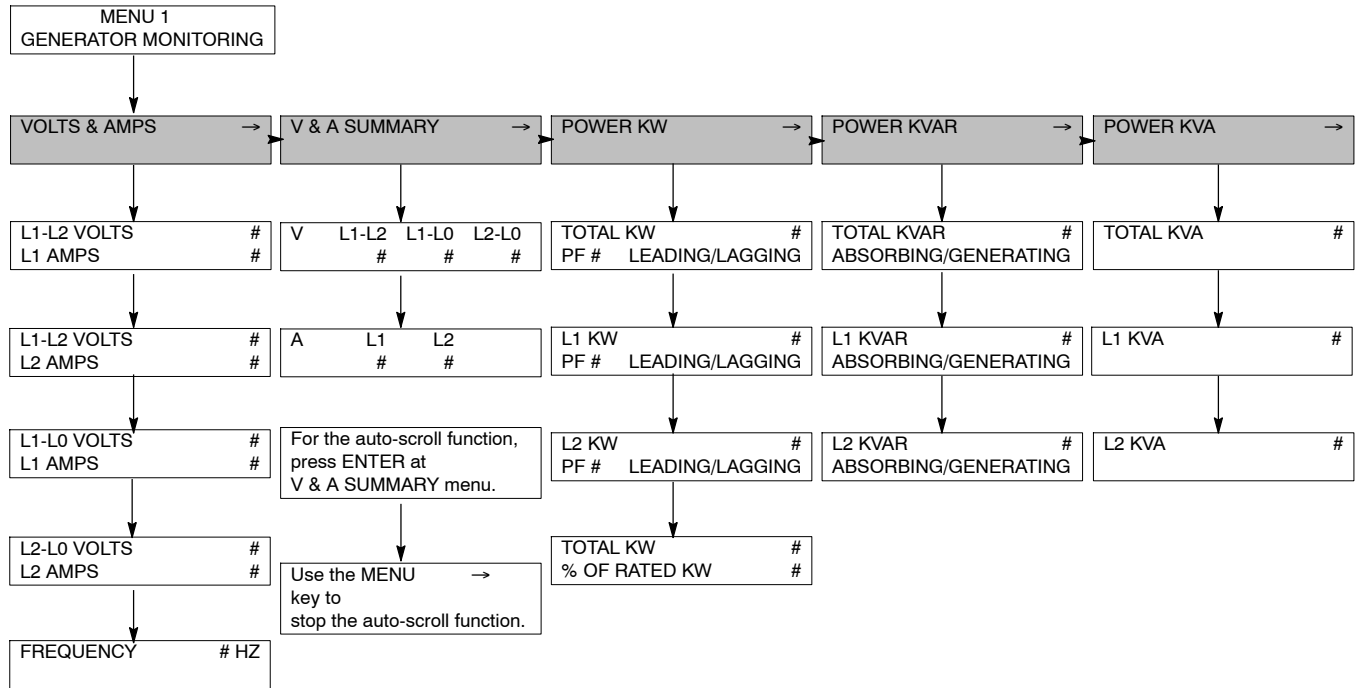
**Note:** Pressing a right arrow key from any submenu moves to the next submenu header.

### Menu 1 Overview (Three-Phase Connections)



# Menu 1—Generator Monitoring, continued

## Menu 1 Overview (Single-Phase Connections)

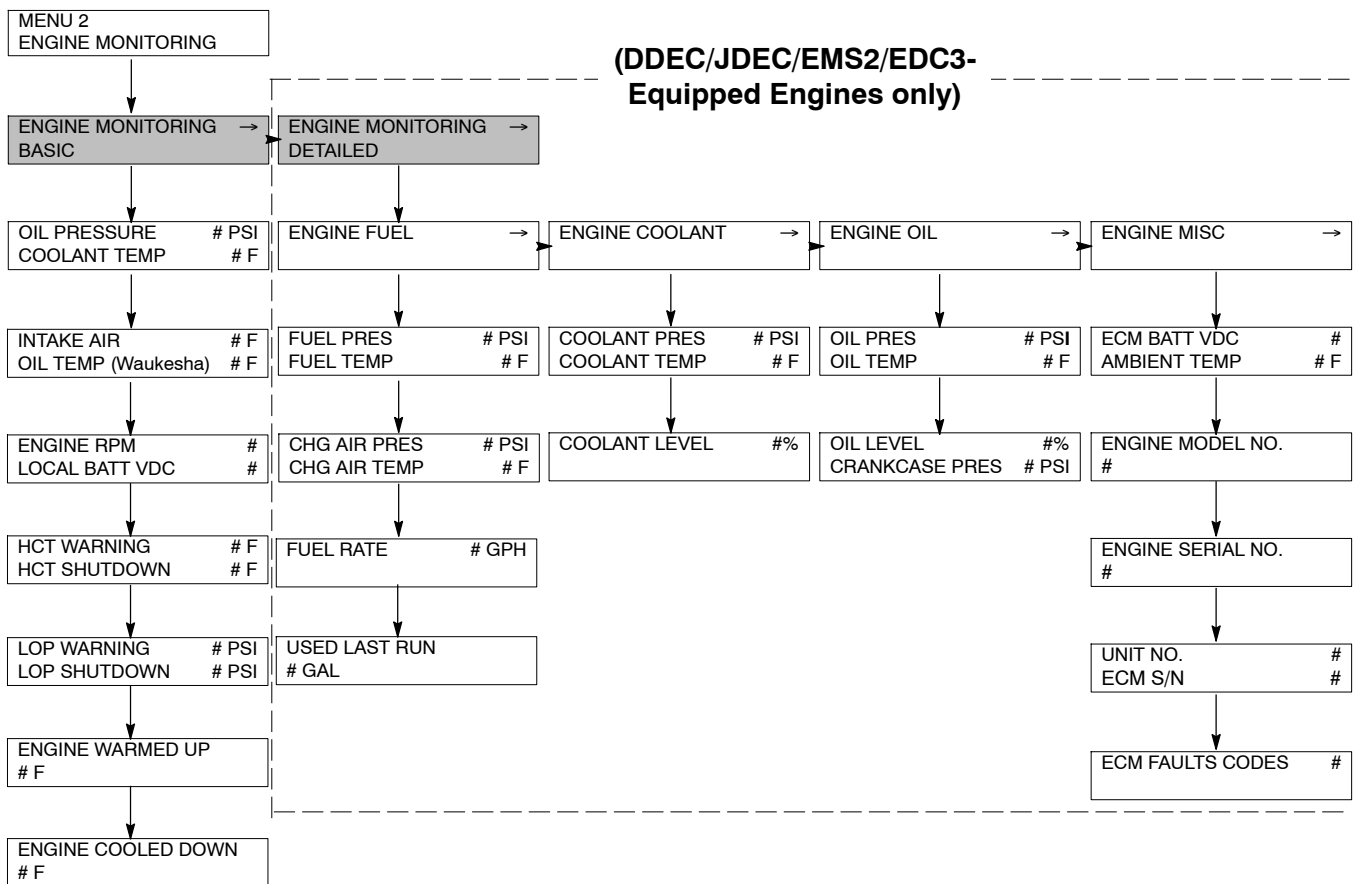


## 2.8.2 Menu 2—Engine Monitoring

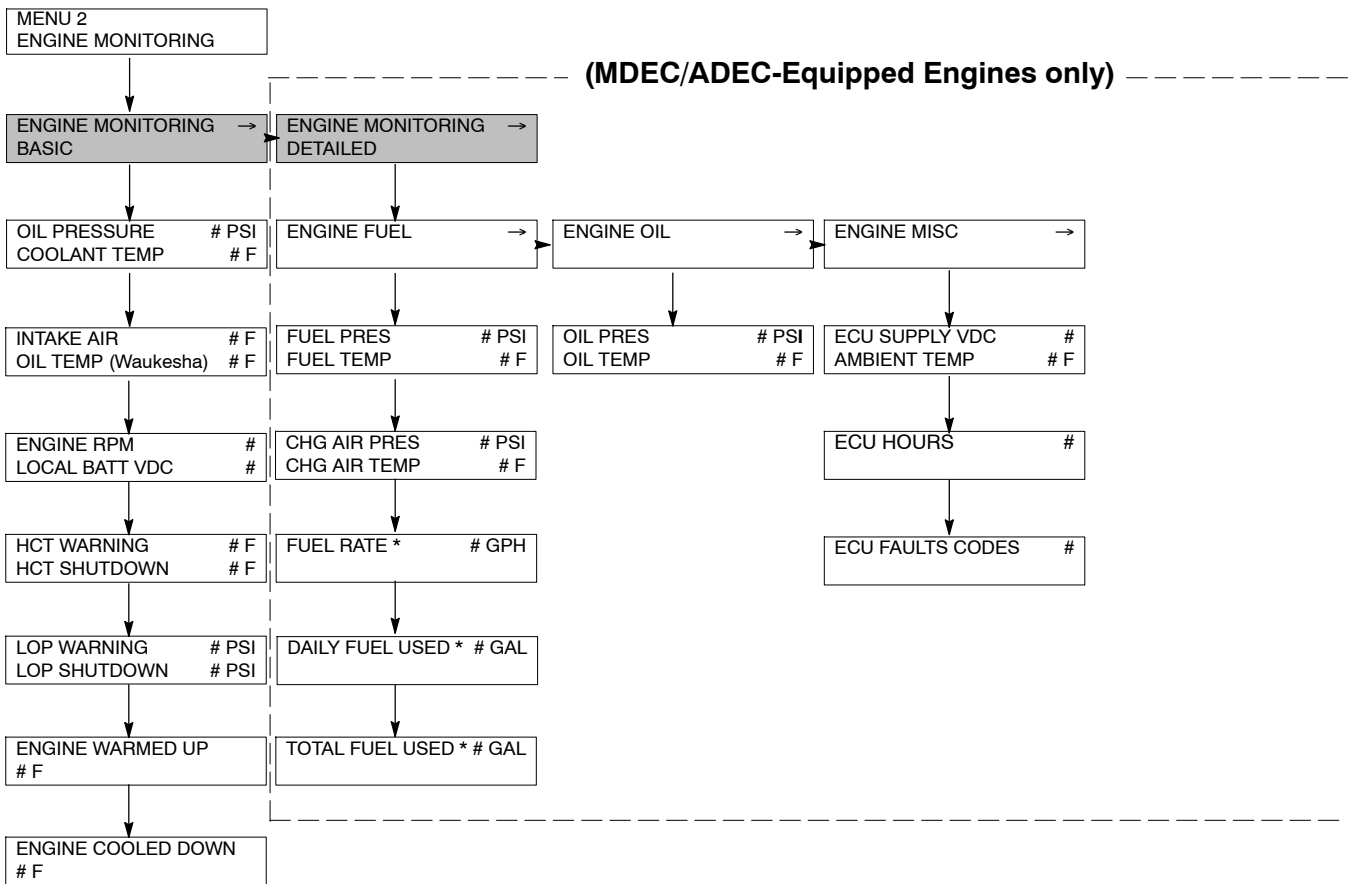
Menu 2 displays engine operating data including oil pressure and temperature, coolant pressure and temperature, fuel pressure and temperature, engine rpm, and battery voltage. Menu 2 also displays engine warning and shutdown setpoints and engine warmed-up and cooled-down temperature setpoints. The detailed engine monitoring functions appear only for DDEC/JDEC/EMS2/EDC3-equipped engine and MDEC/ADEC-equipped engine versions.

**Note:** A right arrow from any submenu moves to the next submenu header.

### Menu 2 Overview



## Menu 2 Overview



\* While these menu displays do appear on the 550 controller, the engine ECM is not currently set up to provide this data.

### 2.8.3 Menu 3—Analog Monitoring

Menu 3 displays battery voltage and up to 7 user-defined analog items dependent upon the generator system.

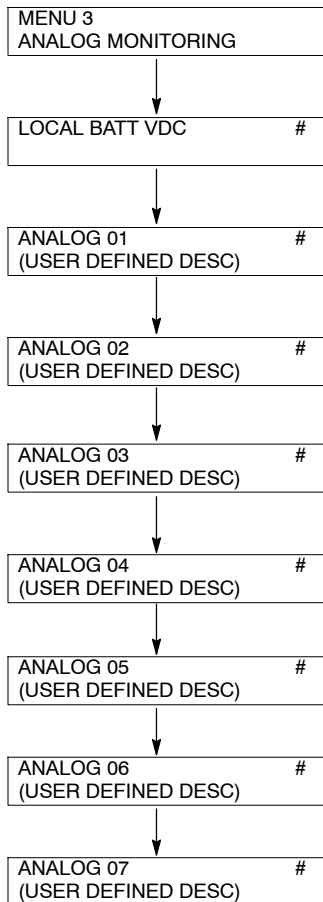
The *User Defined Desc* display refers to a description entered into the controller using the PC software. This description remains as the display for future review until changed by the PC software user. The display has 20 characters maximum.

The default description is *Analog Auxiliary In*.

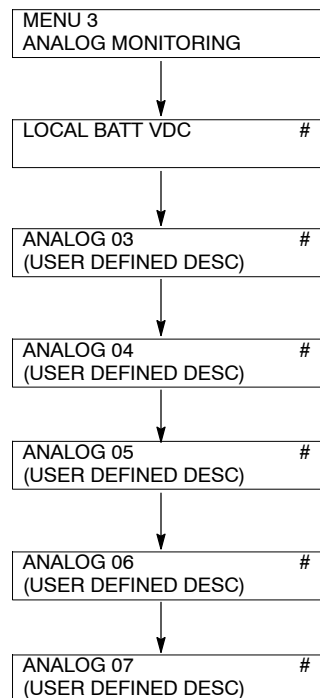
**Note:** If the analog display shows O/R (out of range), no input is connected or the input voltage is beyond the acceptable operating range (0–5 VDC).

**Note:** See **Figure 2-8** in User Inputs for factory reserved inputs which are not user selectable.

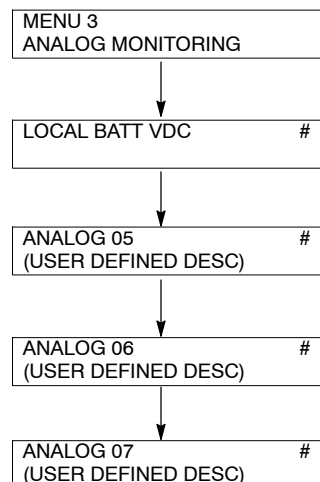
#### Menu 3 Overview (ECM Engines)



#### Menu 3 Overview (Non-ECM Engines)



#### Menu 3 Overview (Waukesha Engines)





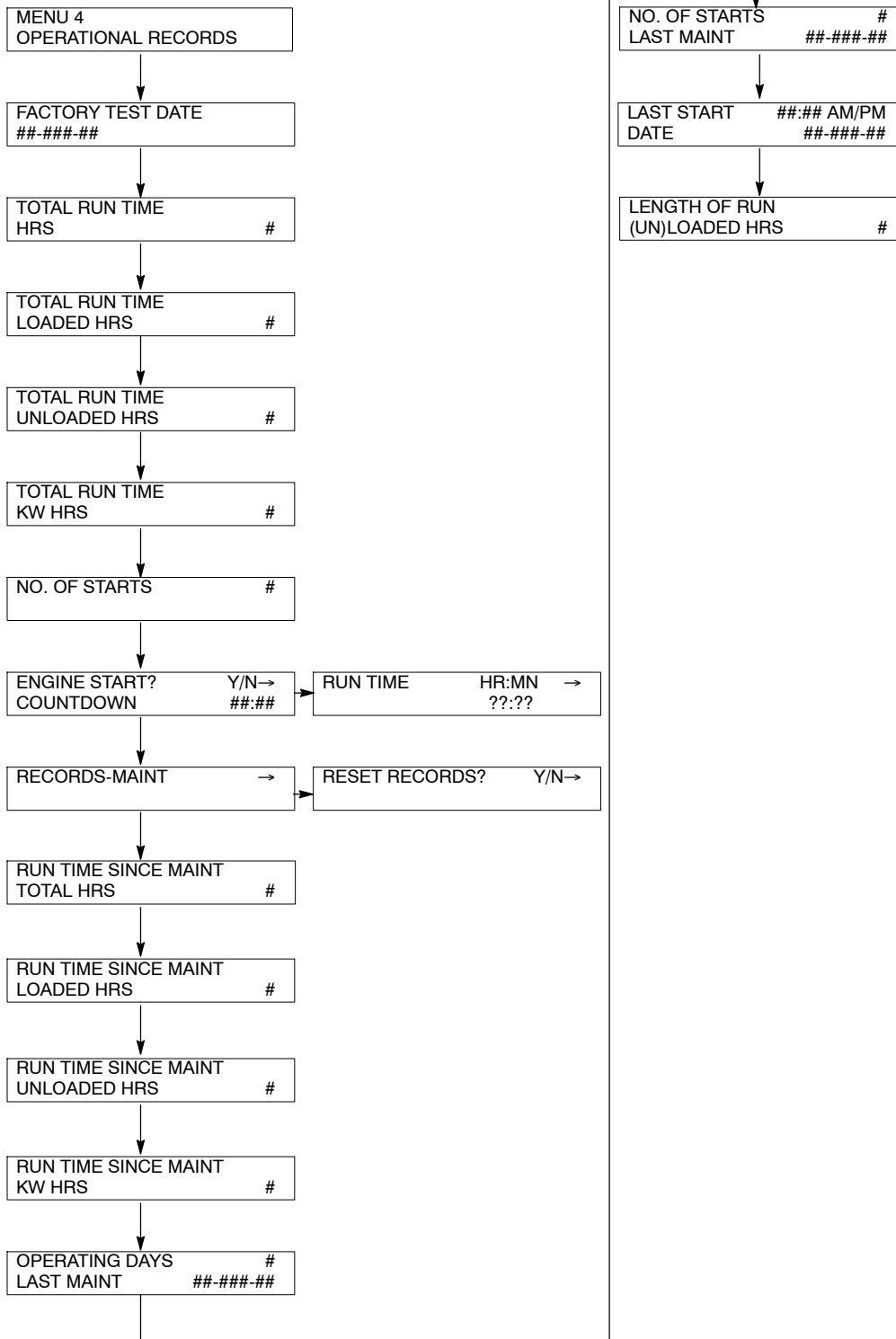
## 2.8.4 Menu 4—Operational Records

Menu 4 displays the generator set's operating record including operating start date, last logged maintenance, total run time loaded and unloaded, run time since last maintenance, number of starts, and number of days the unit ran.

After performing maintenance, enter YES to reset records reflecting the current day. The user must enable the programming mode to edit the display.

See Section 2.9.4 to make changes in this menu.

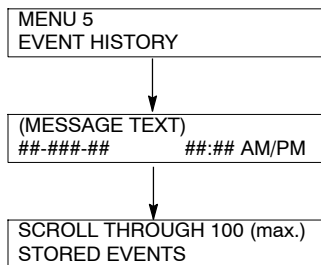
### Menu 4 Overview



## 2.8.5 Menu 5—Event History

Menu 5 stores and displays the times and dates of up to 100 stored status, warning, and shutdown events. After the first 100 events, each additional new event replaces the oldest event. See Menu 10—Output Setup for a list of possible events.

### Menu 5 Overview



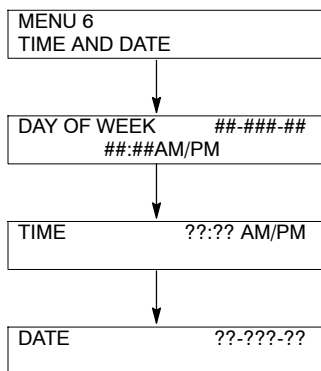
## 2.8.6 Menu 6—Time and Date

Menu 6 shows the internal clock time and calendar date. The controller uses the set clock time to determine exercise run time and event records. The time and date are valid as long as the controller power (starting battery) remains connected.

The user must enable the programming mode to edit the display.

See Section 2.9.6 to change the time and/or date.

### Menu 6 Overview



## 2.8.7 Menu 7—Generator System

Menu 7 shows the generator set system data including voltage, frequency, phase connection, battery voltage, etc. Use the values entered in this menu to determine shutdown values and time delays.

The user must enable the programming mode to edit the display.

See Section 2.9.7 to change system information in this menu.

**Note:** Press the Menu Right → key prior to entering decimal values where necessary.

**Note:** The user defines the data shown in Menu 7. It is NOT data measured by the controller and associated sensing devices. The user defines these values for purposes of calibrating the control.

**Note:** Some alternators are designed to operate at limited voltage, frequency, or phase connections. Settings outside of these parameters may cause a *range error* message.

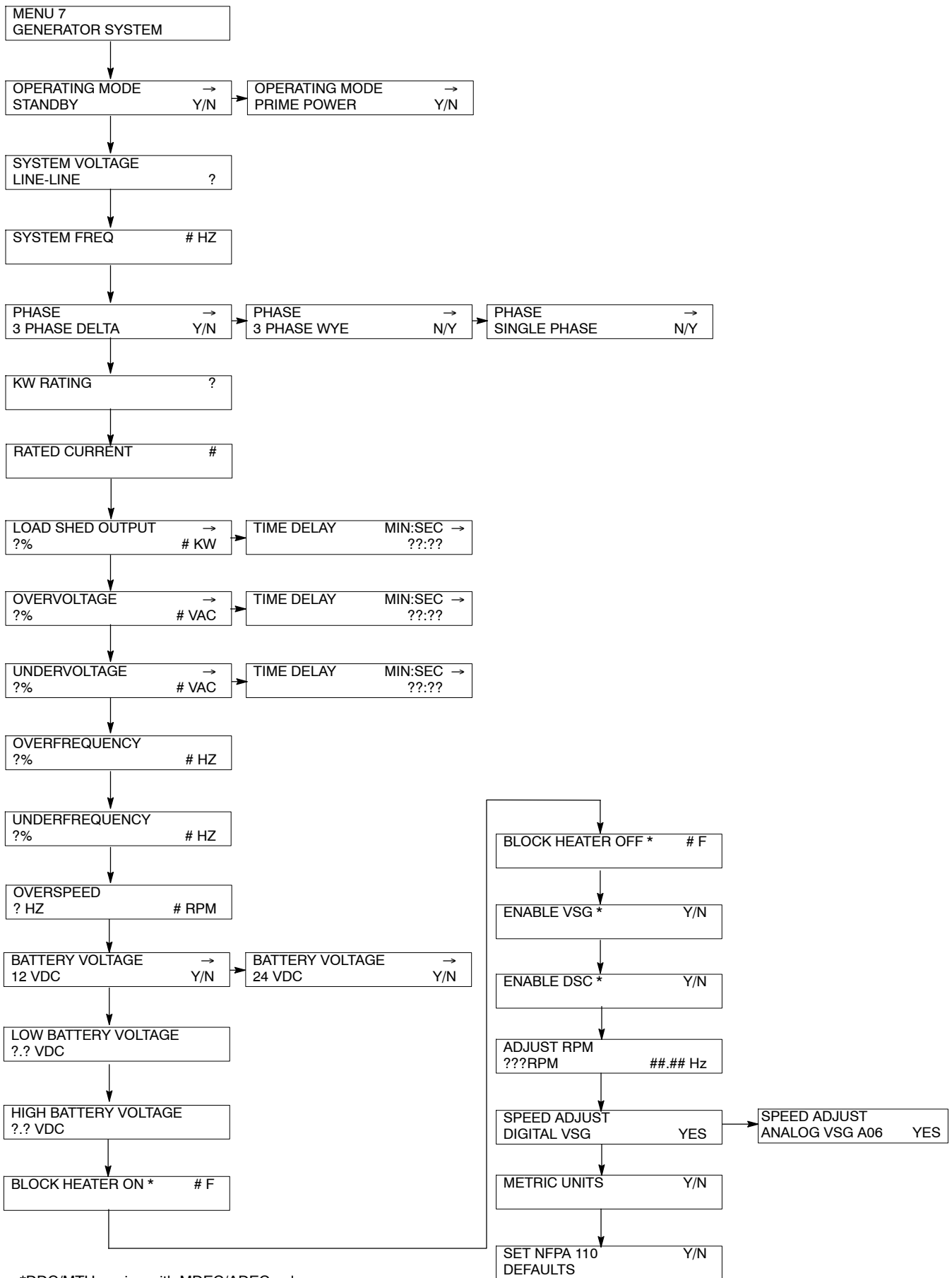
Items marked \* apply only to DDC/MTU engines using MDEC/ADEC.

**Note:** Menus include variable speed governor (VSG) and digital speed control (DSC).

**Note:** For Version 3.01 and higher, the Adjusted RPM Menu will display what the adjusted engine speed is from either an Analog input or the Keypad. When Digital VSG is selected the user can also enter a new Adjusted RPM in the Adjusted RPM menu.

**Note:** For Version 3.01 and higher, the Speed Adjust Select allows the user to select the type of adjustment for engine speed on Volvo, GM, Doosan and KDI engines. The user can select Analog VSG (where a potentiometer or external control device on Analog Input 6 is used to change the desired speed) or Digital VSG (where the user can enter a value on the key pad through the Adjusted RPM Menu just above).

## Menu 7 Overview



\*DDC/MTU engine with MDEC/ADEC only

## 2.8.8 Menu 8—Time Delays

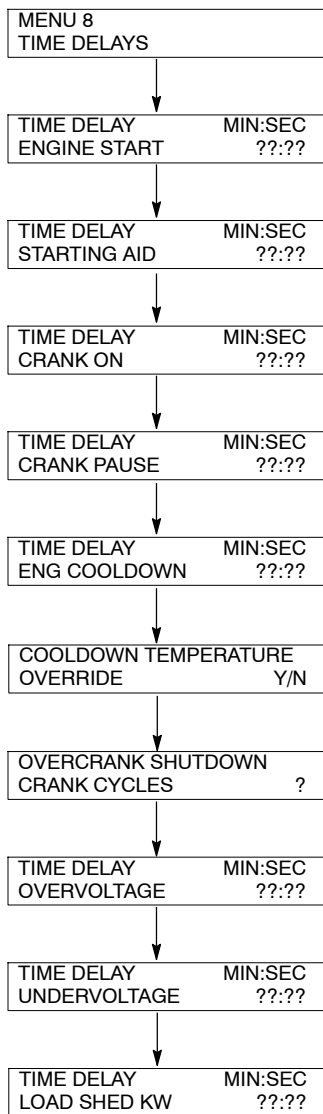
Menu 8 displays the cyclic cranking cycles, various engine related starting and shutdown features, and auxiliary shutdown and inhibit time delays.

The user must enable the programming mode to edit the display.

See Section 2.9.8 to change settings in this menu.

**Cooldown Temperature Override.** This feature allows the user to bypass (override) the temperature-based cooldown. When this feature is enabled, the engine will run in cooldown mode for the entire time defined as TIME DELAY ENG COOLDOWN, regardless of engine temperature.

### Menu 8 Overview



If the Cooldown Temperature Override is not enabled, the unit will cease to run when the engine temperature falls below the ENGINE COOLED DOWN temperature (shown in Menu 2).

Engine cooldown and this cooldown temperature override feature apply to remote shutdown when the master switch is in the AUTO position. No cooldown will occur when the master switch is moved to the OFF position.

## 2.8.9 Menu 9—Input Setup

Menu 9 displays the setup of user-defined digital and analog warning and shutdown inputs. These inputs provide a multitude of choices for configuring customized auxiliary inputs.

The user must enable the programming mode to edit the display.

See Section 2.9.9 to change settings in this menu.

**Note:** Press the down arrow to move to the start of the next input setup.

**Note:** See **Figure 2-8** in User Inputs for factory reserved inputs which are not user selectable.

- **Enabled.** The controller will ignore the input until the inhibit time expires. If the inhibit time is set to zero, the input is monitored at all times, even when the generator is not running. **Analog inputs** have separate warning and shutdown enabled choices.
- **Inhibit Time Delay.** The inhibit time delay is the time period following crank disconnect during which the generator set stabilizes and the controller does not detect the fault or status event. This menu indicates whether or not the input is enabled. If the input is not enabled, the controller will ignore this input signal. The inhibit time delay range is from 0 to 60 seconds.
- **Time Delay (shutdown or warning).** The time delay follows the inhibit time delay. The time delay is the time period between when the controller first detects the fault or status event and the controller warning or shutdown lamp illuminates. The delay prevents any nuisance alarms. The time delay range is from 0 to 60 seconds.

**Additional Analog Input Entries.** The analog input selection typically requires entering four values—low warning, high warning, low shutdown, and high shutdown.

**Battle Switch/Emergency Mode/Fault Override Switch.** The *battle* switch function forces the system to ignore normal fault shutdowns such as low oil pressure and high engine temperature. The battle switch does not override the emergency stop, overspeed, and overfrequency shutdowns. When the battle switch function is enabled the generator set continues to run

regardless of shutdown signals where potential engine/generator damage can occur.

When this input is enabled the yellow warning lamp illuminates and stored warning/shutdown events that are ignored continue to log in Menu 5— Event History.

**Shutdown Type A and Shutdown Type B.** Choose **shutdown type A** for standard shutdown where red lamp illuminates and alarm horn sounds. Choose **shutdown type B** for shutdown where air damper indicator RDO-23 energizes for two seconds, red lamp illuminates, and alarm horn sounds.

**Analog Input A06—Analog Speed Adjust (VSG).** Analog Input A06 may be used for analog speed adjust when external control of engine speed is desired such as paralleling applications or closed transition ATS. To utilize this capability,, “ANALOG VSG A06” must be selected from the Speed Adjust Selection. Refer to 2.9.7, Menu 7.

**Note:** This feature is supported for Doosan, GM, Volvo, and KDI engines only.

**Analog Input A07—Analog Voltage Adjust.** Analog voltage adjust is a feature that the user may choose to enable. The input designated for use as Analog Voltage Adjust is analog input A07.

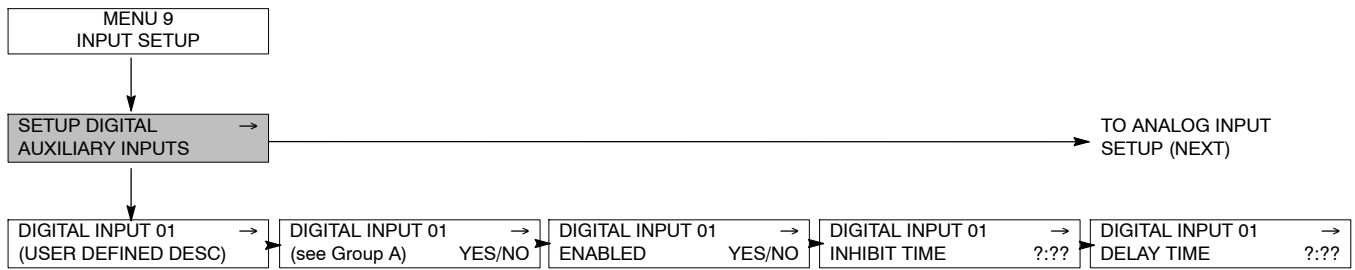
Enable Analog Voltage Adjust through Menu 11. Additionally, Monitor 2 or Monitor 3 may be used to enable Analog Voltage Adjust by entering the proper description (*Analog Volt Adjust*) for A07. When Analog Voltage Adjust is enabled, the description for A07 is *Analog Volt Adjust*. Changing the description using Monitor 2 or Monitor 3 disables the analog voltage adjust feature.

When Analog Voltage Adjust is enabled, no warning or shutdown may be enabled for A07.

**Note:** If the analog input A07 description does not match *Analog Volt Adjust*, input A07 will **not** function as the voltage adjust.

**Identification and Descriptions.** Descriptions for user inputs (auxiliary analog or auxiliary digital) may be entered using the Monitor II software accessory where the user determines the descriptions in upper and lower case.

## Menu 9 Overview



Press the down arrow to scroll through additional DIGITAL auxiliary inputs 1-21 or enter the input number.

### Group A

The preprogrammed selections include the following list. See Appendix E for application and restrictions with specific engines.

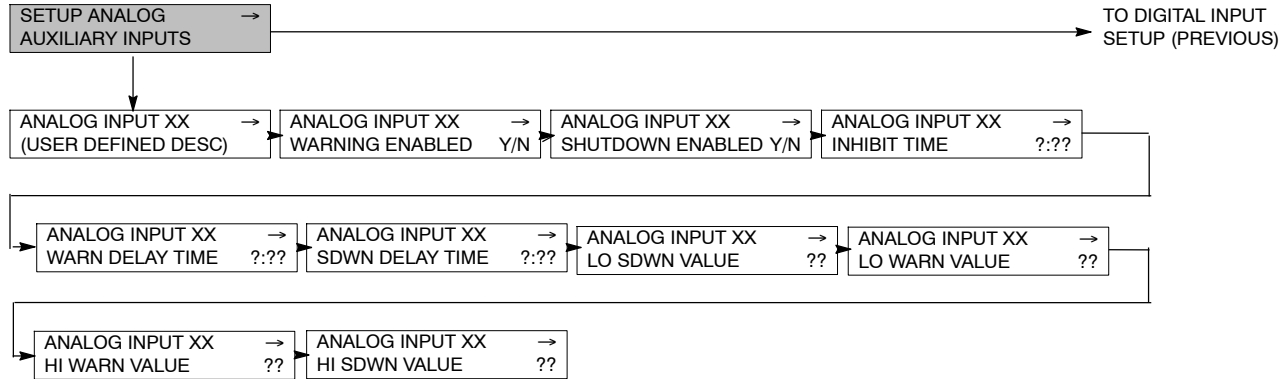
|                 |     |
|-----------------|-----|
| WARNING         | Y/N |
| SHUTDOWN TYPE A | Y/N |
| SHUTDOWN TYPE B | Y/N |
| VOLTAGE RAISE   | Y/N |
| VOLTAGE LOWER   | Y/N |

### Group A, continued

|                   |     |
|-------------------|-----|
| VAR PF MODE       | Y/N |
| REMOTE SHUTDOWN   | Y/N |
| REMOTE RESET      | Y/N |
| AIR DAMPER        | Y/N |
| LOW FUEL          | Y/N |
| FIELD OVERVOLTAGE | Y/N |
| IDLE MODE ACTIVE  | Y/N |
| BATTLE SWITCH     | Y/N |
| GROUND FAULT      | Y/N |
| BAT CHGR FAULT    | Y/N |
| HIGH OIL TEMP     | Y/N |

### Group A, continued

|                   |     |
|-------------------|-----|
| LOW COOLANT LEVEL | Y/N |
| LOW COOLANT TEMP  | Y/N |
| BREAKER CLOSED    | Y/N |
| ENABLE SYNCH      | Y/N |
| AFM SHUTDOWN      | Y/N |
| KNOCK SHUTDOWN    | Y/N |
| DETON WARNING     | Y/N |
| DETON SHUTDOWN    | Y/N |
| LOW FUEL SHUTDOWN | Y/N |



**Note:** For ECM engines, auxiliary analog inputs A01-A07 will appear.

**Note:** For non-ECM engines, auxiliary analog inputs A03-A07 will appear.

**Note:** For Waukesha engines, auxiliary analog inputs A05-A07 will appear.

## 2.8.10 Menu 10—Output Setup

Menu 10 displays the setup of user-defined system, digital and analog status, and fault outputs and relay driver outputs (RDO) 1–31. These RDO outputs provide multiple choices for configuring customized auxiliary outputs. Additional individual outputs are available for monitoring, diagnostics, and control functions.

The user must enable the programming mode to edit the display. See Section 2.9.10 to change this menu.

**Note:** Some data require entry using a PC in the Remote Programming mode. See the Monitor Software operation manual for details.

**Note:** See **Figure 2-8** in User Inputs for factory reserved inputs which are not user selectable.

### Common Faults

The user can program a single fault comprised of faults from 3 common fault programs—system, digital, and analog faults.

Up to 62 user-defined *system* status events and faults are available. See Group B on the following pages for specific descriptions. The NFPA 110 faults are part of the *system* fault program and are comprised of 15 individual faults shown on the next page.

The user can select up to 21 user-defined *digital* status events and faults designated as D01 to D21. Each of the 21 status events and faults are assignable as shutdowns or warnings.

The user can select up to 7 user-defined *analog* status events and faults designated as A01 to A07. Each of the 7 status events and faults are assignable as shutdowns or warnings with high or low settings for a total of up to 7 status events and fault functions.

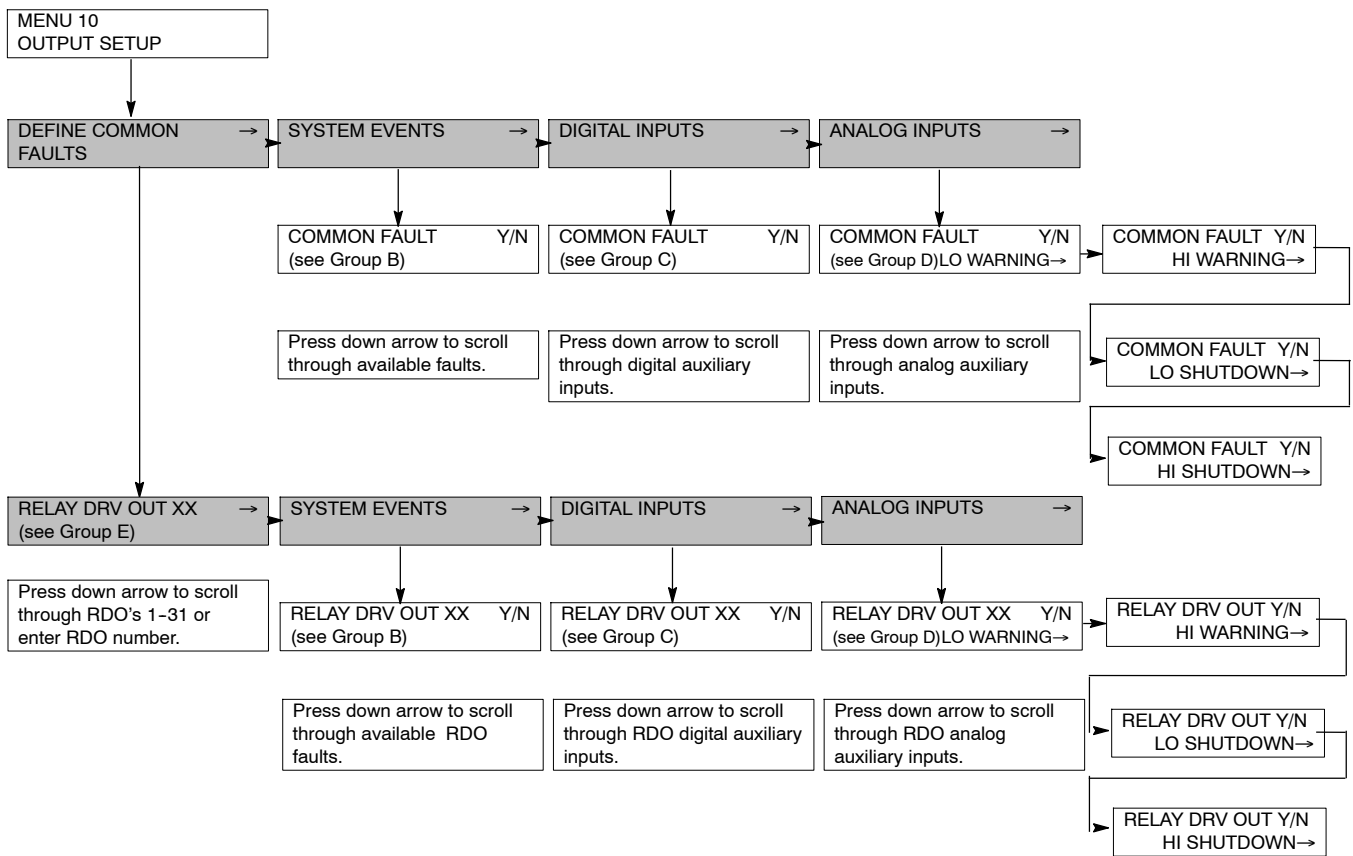
### Relay Driver Outputs (RDOs)

Up to 31 RDOs are available using the system, digital, and analog status events and faults. RDOs provide only the driver. The contact relays that interface with other equipment are optional.

**Note:** *Func(tion) Used By (RDO) XX Reassign?* error message appears when the user attempts to duplicate an existing RDO selection.

**Note:** *Cannot Change NFPA is Enabled.* error message appears when the user attempts to modify RDO setting defaulted as NFPA 110 requirement.

## Menu 10 Overview





## Menu 10 Overview, continued

### Group B

For defined system events, choose from the following 66 status events and faults by changing selection to YES. See Appendix E for application and restrictions with specific engines.

EMERGENCY STOP  
OVER SPEED  
OVER CRANK  
HI COOL TEMP SHUTDWN  
OIL PRESS SHUTDOWN  
LOW COOLANT TEMP (non-ECM engines)  
LOW FUEL  
HI COOL TEMP WARNING  
OIL PRES WARNING  
MASTER NOT IN AUTO  
NFPA 110 FAULT\*  
LOW BATTERY VOLTAGE  
HIGH BATTERY VOLTAGE  
BATTERY CHARGE FAULT  
SYSTEM READY  
LOSS OF ECM COMM (ECM engines)  
NO OIL PRESS SIGNAL  
HI OIL TEMP  
NO COOL TEMP SIGNAL  
LOW COOLANT LEVEL  
SPEED SENSOR FAULT  
LOCKED ROTOR  
MASTER SWITCH ERROR  
MASTER SWITCH OPEN  
MASTER SWITCH TO OFF  
AC SENSING LOSS  
OVER VOLTAGE  
UNDER VOLTAGE  
WEAK BATTERY  
OVER FREQUENCY  
UNDER FREQUENCY  
LOAD SHED KW OVER  
LOAD SHED UNDER FREQ  
OVER CURRENT  
EPS SUPPLYING LOAD  
INTERNAL FAULT  
DELAY ENG COOLDOWN  
DELAY ENG START  
STARTING AID  
GENERATOR RUNNING  
AIR DAMPER CONTROL  
GROUND FAULT  
EEPROM WRITE FAILURE  
CRITICAL OVERVOLTAGE  
ALTERNATOR PROTECTION SHUTDOWN  
AIR DAMPER INDICATOR  
DEFINED COMMON FAULT (RDO only)†  
SCRDOs 1-4 (software controlled RDOs)  
MAINTENANCE DUE  
ENGINE DERATE ACTIVE  
ENGINE STALLED  
J1939 CAN SHUTDOWN

### \*NFPA 110 FAULT

The 15 NFPA 110 Fault Alarms include the following:  
OVERSPEED  
OVERCRANK  
HIGH COOLANT TEMP SHUTDOWN  
OIL PRESSURE SHUTDOWN  
LOW COOLANT TEMPERATURE  
HIGH COOLANT TEMP WARNING  
OIL PRESSURE WARNING  
LOW FUEL  
MASTER NOT IN AUTO  
BATTERY CHARGER FAULT  
LOW BATTERY VOLTAGE  
HIGH BATTERY VOLTAGE  
LOW COOLANT LEVEL  
EPS SUPPLYING LOAD  
AIR DAMPER INDICATOR

### †DEFINED COMMON FAULT

The 5 defined common faults include the following:  
EMERGENCY STOP  
HI COOL TEMP SHUTDOWN  
OIL PRESS SHUTDOWN  
OVERCRANK  
OVERSPEED

### Group B, continued

#### Paralleling applicatons:

SD REVERSE POWER  
SD OVER POWER  
SD LOSS OF FIELD  
SD OVERCURRENT PR  
COMMON PR OUTPUT  
IN SYNCH  
BREAKER TRIP

#### Waukesha-powered models:

FUEL VALVE RELAY  
PRELUBE RELAY  
AFM REMOTE START  
NO OIL TEMP SIGNAL  
HI OIL TEMP WARNING  
NO AIR TEMP SIGNAL  
INTAKE AIR TEMP WARN  
INTAKE AIR TEMP SDWN  
AFM ENG START DELAY

#### DDC/MTU engine with MDEC/ADEC:

HI OIL TEMP WARNING  
INTAKE AIR/TEMP WARN  
INTAKE AIR TEMP SDWN  
ECM YELLOW ALARM  
ECM RED ALARM  
BLOCK HEATER CONTROL  
LOW COOL TEMP SDOWN  
LOAD SHED OVER TEMP

#### 1750/2000REOZMD:

TURBO TEMP WARNING  
TURBO TEMP SHUTDOWN

### Group C

Up to 21 user-defined digital status events and fault inputs designated as D01 to D21 can result in a digital input common fault.

### Group D

Up to 7 analog inputs, user-defined status events and faults designated as A01 to A07. Each of the 7 is assignable as a shutdown or warning with high or low settings.

### Group E

Choose up to 31 status event and fault RDOs from the following:

SYSTEM FAULTS  
(see Group B, 66 Items)  
DIGITAL INPUTS  
(see Group C, 21 Items)  
ANALOG INPUTS  
(see Group D, 7 Items)

## 2.8.11 Menu 11—Voltage Regulator

Menu 11 displays setup of the voltage regulator functions including line-to-line voltages, underfrequency unloading (volts per Hz), reactive droop, power factor, and kVAR adjustments.

The user must enable the programming mode to edit the display.

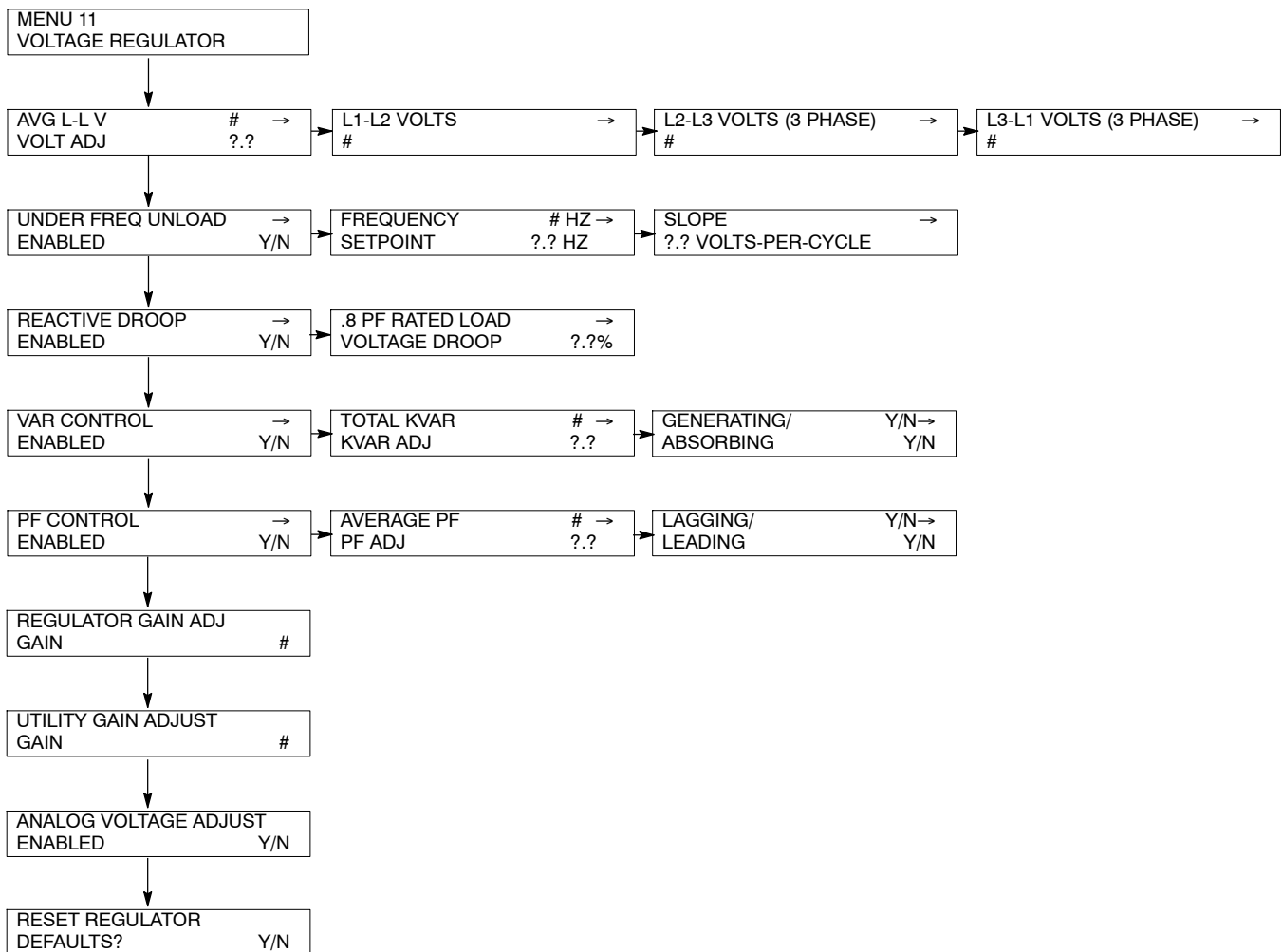
See Section 2.9.11 to make changes in this menu.

**Note:** The individual line-to-line voltages are displayed for review purposes only.

**Note:** Voltage regulator gain is used for adjusting voltage stability and/or response.

**Note:** Utility gain is used for VAR or PF stability adjust while paralleling to a utility.

### Menu 11 Overview



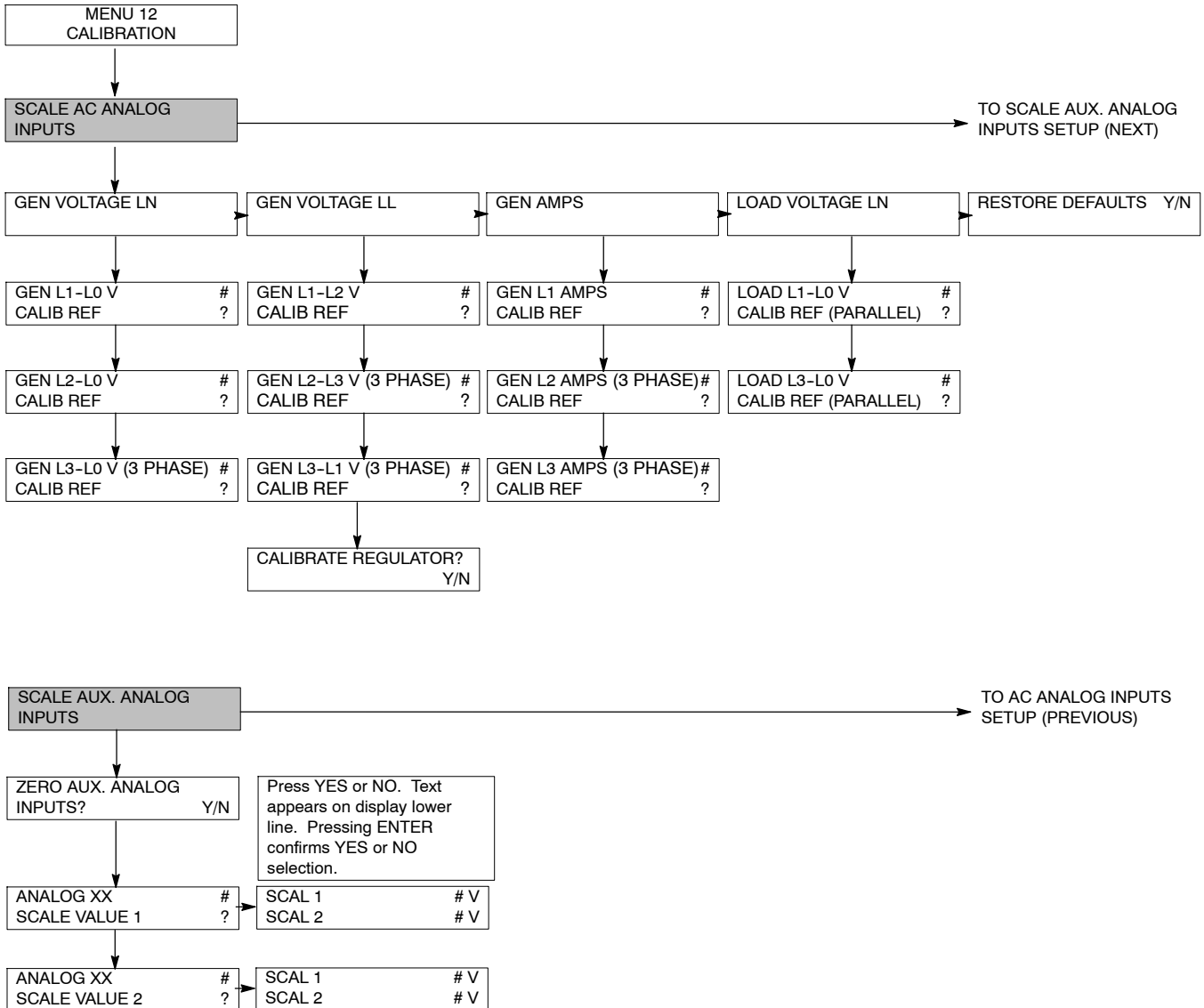
## 2.8.12 Menu 12—Calibration

Menu 12 provides access to the calibration factors for metering (volts and amps) and auxiliary analog inputs. Changing the system voltage or replacing the main logic control circuit board requires calibration adjustment.

The user must enable the programming mode to edit the display.

See Section 2.9.12 to make calibration changes.

### Menu 12 Overview



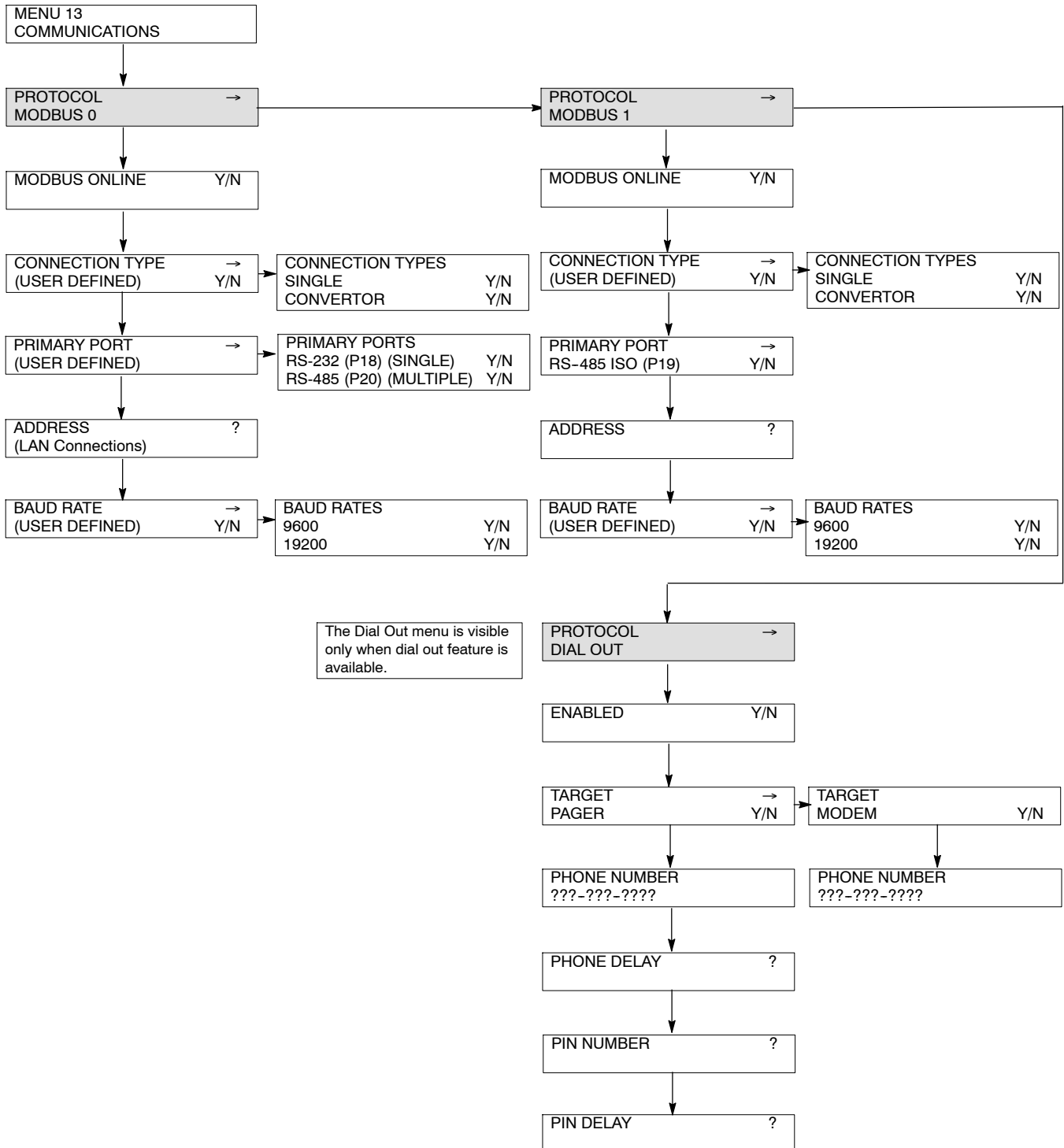
### 2.8.13 Menu 13—Communications

Menu 13 shows the settings for remote communications.

See Section 2.9.13 to make changes in this menu.

See the Modbus® Communications Protocol operation manual for a list of Modbus® registers for the 550 Controller.

#### Menu 13 Overview



Modbus® is a registered trademark of Schneider Electric.

## 2.8.14 Menu 14—Programming Mode

Menu 14 provides local or remote access to the programming function. The user enters a password to access the programming mode.

**Note:** Log into the *local* programming mode to edit the programming access code. *The factory default access code is the number 0.*

Use Menu 14 to change the access code. Record the new number and give the access code only to authorized individuals. Should the controller logic not accept the access code or if the new code number is lost, contact your local authorized distributor/dealer for password information.

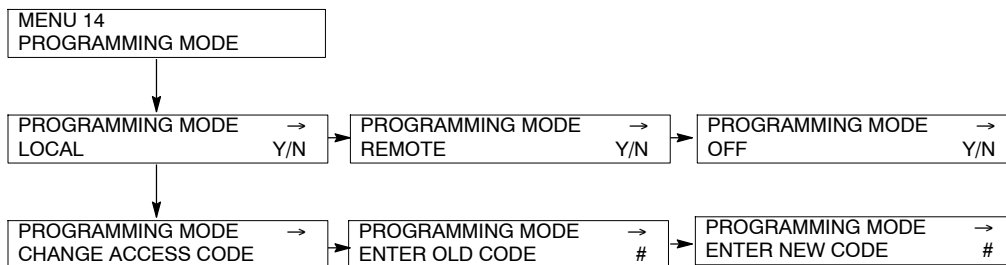
The user chooses one of three programming modes:

- Local—using the controller keypad
- Remote—using a PC
- Off—no programming is permitted

**Note:** Use the generator set controller to initially set up remote programming. Remote programming cannot be accessed from a PC unless the controller is first set for remote programming using Menu 14.

See Section 2.9.14.

### Menu 14 Overview

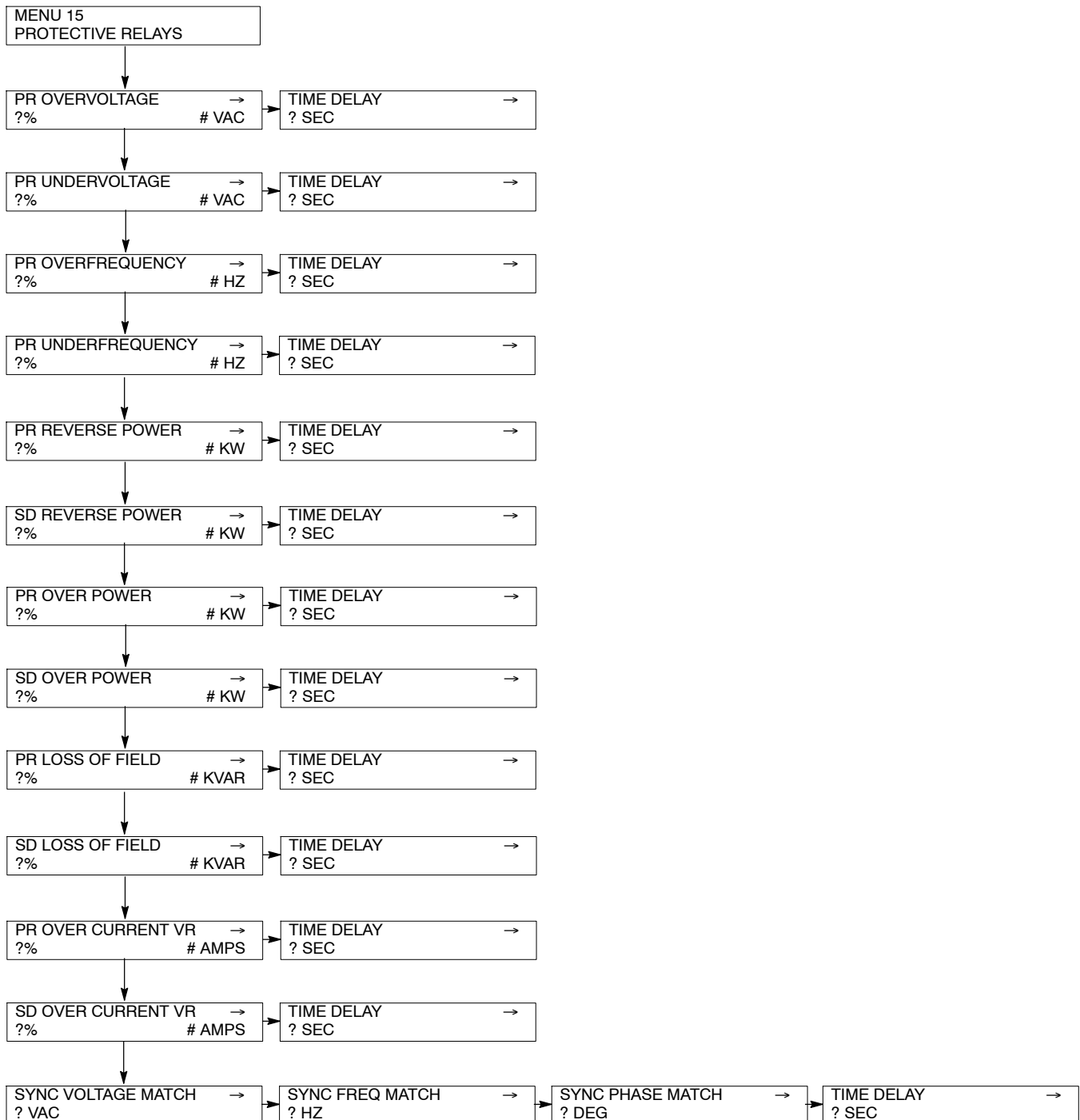


## 2.8.15 Menu 15—Protective Relays (PR)

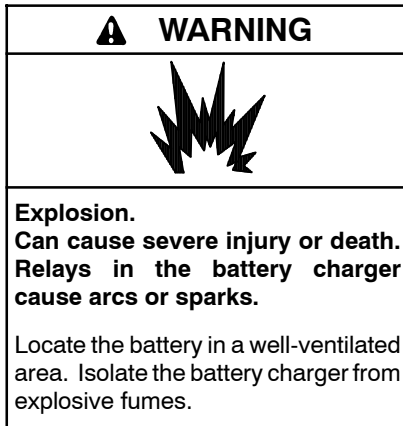
Menu 15 provides protective relay setup and time delays for units with the paralleling protection option. This menu will only be visible and accessible if this option is included. The shutdown (SD) settings override those in menu 7 and/or menu 8.

See Section 2.9.15 to make changes in this menu, when the paralleling option is enabled.

### Menu 15 Overview



## 2.8.16 Menu 18—Battery Chargers (Version 3.4.3 or Higher)



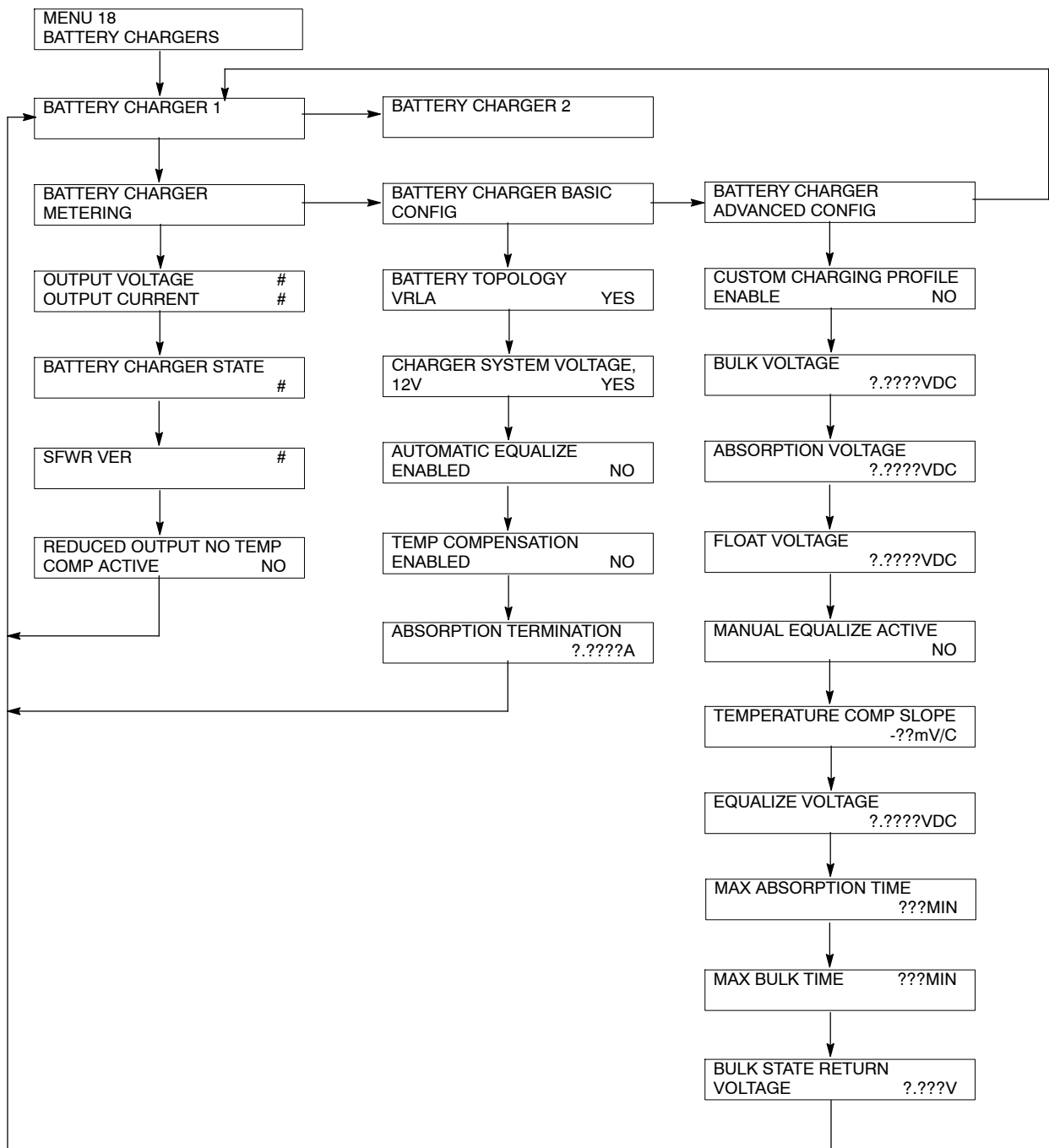
**Battery gases. Explosion can cause severe injury or death.** Incorrect use of the equalize charge state may lead to hazardous situations. Equalization is ONLY applicable for flooded lead acid (FLA) type batteries and will damage gel, absorbed glass mat (AGM), or nickel-cadmium (NiCad) type batteries. In the controller menu or SiteTech™ settings, verify that the battery topology is set correctly for the battery type used. Do not smoke or permit flames, sparks, or other sources of ignition to occur near a battery at any time.

Menu 18 provides battery charger information, settings, and parameter configurations. Use this menu to view the battery metering and output state and to change or enable parameter settings such as equalize charge and temperature compensation. For more information on parameters, refer to the battery charger operation manual and the battery manufacturer's recommended specifications.

**Note:** Incorrect charger output system voltage may cause irreversible damage to the battery and abnormal out gassing. Ensure that the battery charger parameters match the battery manufacturer's specifications before using. In the controller user interface settings, verify that the battery topology and system voltage is set correctly for the battery type that is used.

**Note:** The battery charger menus are designed to work with charger GM87448. Unless connected to charger GM87448 through CAN communication, the battery charger menus, although visible, have no effect on the battery charger.

## Menu 18 Overview, continued

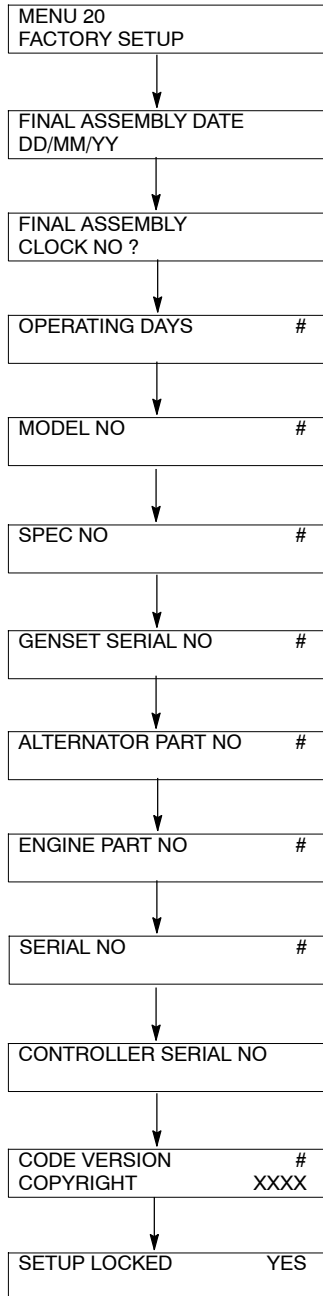




## 2.8.17 Menu 20—Factory Setup (Version 2.10)

Menu 20 provides factory setup information including the number of operating days, generator set information, alternator information, engine information, controller information, and the controller software (code) version.

### Menu 20 Overview

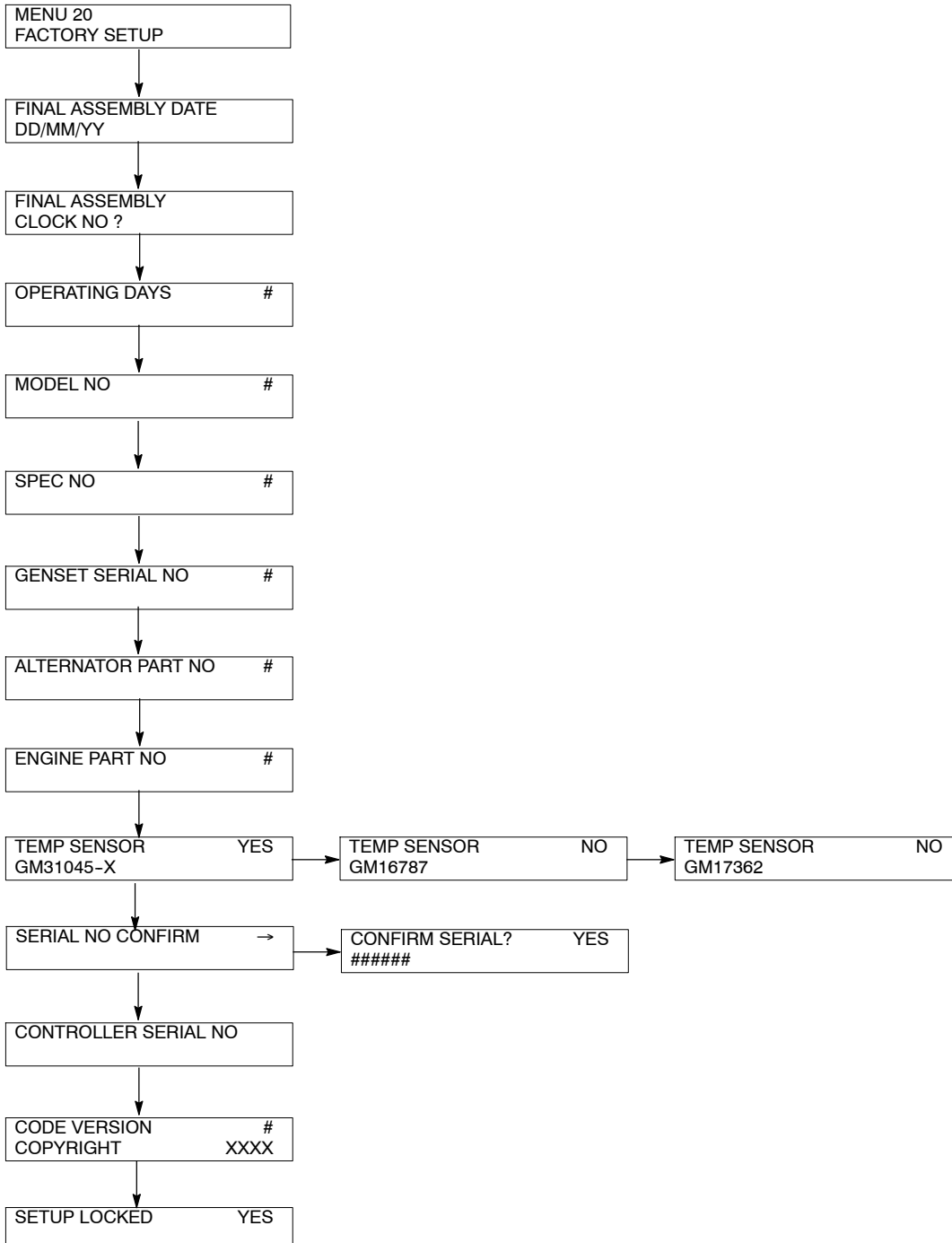


## 2.8.18 Menu 20—Factory Setup (Version 2.21)

Menu 20 provides factory setup information including the number of operating days, generator set information, alternator information, engine information, controller information, and the controller software (code) version. The temperature sensor setup applies to non-ECM engines only.

See Section 2.9.17 to make changes in this menu.

### Menu 20 Overview



**Note:** For Version 2.69 and lower, enter the numeric serial number from the generator set nameplate. For Version 2.70 and higher, confirm that the alpha-numeric number shown on the display matches the serial number shown on the generator set nameplate. If the serial numbers match, press the YES key and then press ENTER. If the serial numbers do not match, the wrong personality parameter file is installed. Refer to the Program Loader documentation for instructions on reloading the personality parameter file.

## 2.8.19 Menu 20—Factory Setup (Version 3.01)

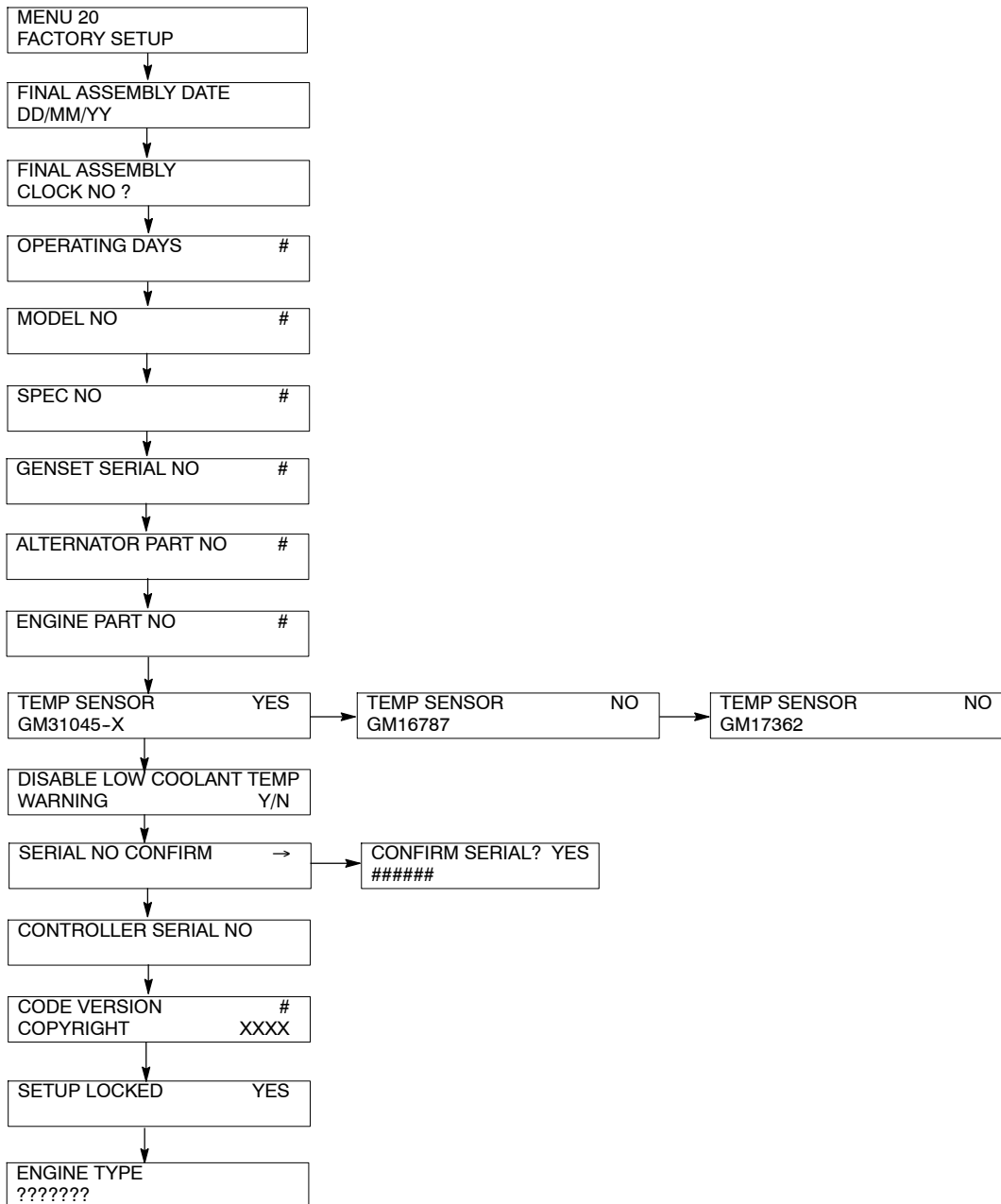
Menu 20 provides factory setup information including the number of operating days, generator set information, alternator information, engine information, controller information, and the controller software (code) version. The temperature sensor setup applies to non-ECM engines only.

See Section 2.9.17 to make changes in this menu.

**Note:** For Version 3.01 and higher, the Engine Type Is displayed for engines with an ECM. The Correct Engine Type is not displayed until the Engine has run.

**Note:** For Version 3.01 and higher, the Low Coolant Temp Warning can be disabled on units with non-ECM engines that are not required to meet NFPA 110. As with older version of firmware on ECM engines, the LCTW may be disabled by selecting **NO** for Warning Enabled, for the respective input. Refer to section 2.9.7 for disabling NFPA defaults and refer to section 2.9.9 for configuration of digital inputs.

### Menu 20 Overview



## 2.9 Local Programming Mode On

The Local Programming Mode On section explains how to program the generator set controller logic. Each menu contains a step-by-step procedure for programming the various logic groups. See Section 1, Specifications, for setting ranges and default settings.

Please read and understand the entire Local Programming Mode On section before attempting any programming. The factory settings are adjustable and programming without full understanding of the logic features and functions can cause inadvertent changes.

Refer to Menu 14—Programming Mode for information regarding menu programming activation. After completing the programming always *place the controller back in the Programming Mode Off position* to prevent inadvertent program changes.

The programming feature alters stored settings and changes characteristics of the logic. Do not operate the controller with the program mode on unless there is a need to edit program logic or clear stored data. Limit programming responsibilities to individuals with training and authority.

The product application requires expertise in the design and programming of control systems. Only qualified personnel should program, install, alter, and apply this product.

Use Section 2.8, Reviewing the Menu Displays, to view the generator set operation data and review previously programmed information and to review the data when no programming is necessary.

Menus displaying the # symbol represent one of the following data types:

- System-calculated data
- System-measured data
- User-entered data

Menus displaying the ? symbol require the user to enter data.

Menus displaying the \* symbol represent access code or password type entries. Actual key entry does not display.

See Section 2.6.3, Request and Error Messages, for error display messages and explanations should they appear while navigating through the menus.

All menu displays apply to both single-phase and three-phase voltages unless otherwise noted as (1 PH) or (3 PH) on the menu overview. The phase designation does not appear in the actual menu displays.

**Note:** Place the generator set master switch in the OFF/ RESET position when using local programming mode on.

**Note:** Use the generator set controller to initially set up the remote programming. Set the controller for remote programming using Menu 14 and remote communication using Menu 13 before attempting remote programming.

**Note:** Press any key on the keypad to activate the controller panel display. The panel display turns off 5 minutes after the last keypad entry.

**Note:** Press the Reset Menu key to clear the Error display.

**Note:** Press the Menu Right → key prior to entering decimal values where necessary.

Refer to Figure 2-18 for a quick reference to the menu number and description.

| Menu No. | Menu Description                                |
|----------|---|
| 1        | Generator Monitoring (Three-Phase Connections)  |
| 1        | Generator Monitoring (Single-Phase Connections) |
| 2        | Engine Monitoring                               |
| 3        | Analog Monitoring                               |
| 4        | Operational Records                             |
| 5        | Event History                                   |
| 6        | Time and Date                                   |
| 7        | Generator System                                |
| 8        | Time Delays                                     |
| 9        | Input Setup                                     |
| 10       | Output Setup                                    |
| 11       | Voltage Regulator                               |
| 12       | Calibration                                     |
| 13       | Communication                                   |
| 14       | Programming Mode                                |
| 15       | Protective Relays                               |
| 18       | Battery Chargers                                |
| 20       | Factory Setup Menu                              |

**Figure 2-18** Menu Number and Description

## 2.9.1 Menu 1—Generator Monitoring

Menu 1 provides generator output data including line-to-line and line-to-neutral voltages, current, frequency, power factor, total kilowatts, percent of maximum kW, total kVA and total kVAR displays. Menu 1 displays three-phase and single-phase connections separately.

















**Note:** For the auto-scroll function, press ENTER at the V & A Summary menu. Press the Reset Menu key or Menu Right → key to stop the auto-scroll function.

**Note:** A right arrow from any submenu moves to the next submenu header.

### Menu 1—Generator Monitoring (Three-Phase Connections)

#### Menu 1 Displays with Key Entries



**Note:** This menu is for monitoring only; no adjustments or user settings can be entered.

| Key Entry   | Display                        | Description  |
|---|--------------------------------|--|
|    | ENTER MENU NO. 1-15            | Input a menu number.                                 |
|    | MAIN MENU NUMBER 1             | Press the Enter key.                                 |
|    | MENU 1<br>GENERATOR MONITORING | Displays the menu number and name.                   |
|    | VOLTS & AMPS →                 | Displays the volts and amps heading.                 |
|    | L1-L2 VOLTS #<br>L1 AMPS #     | Displays L1 and L2 volts and L1 amps.                |
|   | L2-L3 VOLTS #<br>L2 AMPS #     | Displays L2 and L3 volts and L2 amps.                |
|  | L3-L1 VOLTS #<br>L3 AMPS #     | Displays L3 and L1 volts and L3 amps.                |
|  | L1-L0 VOLTS #<br>L1 AMPS #     | Displays L1-L0 volts and L1 amps.                    |
|  | L2-L0 VOLTS #<br>L2 AMPS #     | Displays L2 and L0 volts and L2 amps.                |
|  | L3-L0 VOLTS #<br>L3 AMPS #     | Displays L3-L0 volts and L3 amps.                    |
|  | FREQUENCY # HZ                 | Displays the frequency.                              |
|  | MENU 1<br>GENERATOR MONITORING | Returns the user to the menu number and name.        |
|  | VOLTS & AMPS →                 | Returns the user to volts and amps heading.          |
|  | V & A SUMMARY →                | Displays the volts and amps summary heading.         |
|  | V L1-L2 L2-L3 L3-L1<br># # #   | Displays L1-L2, L2-L3, and L3-L1 volts.              |
|  | V L1-L0 L2-L0 L3-L0<br># # #   | Displays L1-L0, L2-L0, and L3-L0 volts. (3 ph. only) |


















## Menu 1—Generator Monitoring (Three-Phase Connections), continued

### Menu 1 Displays with Key Entries

| Key Entry   | Display     | Description                            |
|---|-------------|--|
|  | L3 KVA #    | Displays L3 kVA.                       |
|  | POWER kVA → | Returns the user to power kVA heading. |

## Menu 1—Generator Monitoring (Single-Phase Connections)

### Menu 1 Displays with Key Entries

| Key Entry   | Display                        | Description   |
|---|--------------------------------|---|
|    | ENTER MENU NO. 1-15            | Input a menu number.                                    |
|    | MAIN MENU NUMBER 1             | Press the Enter key.                                    |
|    | MENU 1<br>GENERATOR MONITORING | Displays the menu number and name.                      |
|    | VOLTS & AMPS →                 | Displays the volts and amps heading.                    |
|   | L1-L2 VOLTS #<br>L1 AMPS #     | Displays L1 and L2 volts and L1 amps.                   |
|  | L1-L2 VOLTS #<br>L2 AMPS #     | Displays L1 and L2 volts and L2 amps.                   |
|  | L1-L0 VOLTS #<br>L1 AMPS #     | Displays L1-L0 volts and L1 amps.                       |
|  | L2-L0 VOLTS #<br>L2 AMPS #     | Displays L2 and L0 volts and L2 amps.                   |
|  | FREQUENCY # HZ                 | Displays the frequency.                                 |
|  | MENU 1<br>GENERATOR MONITORING | Returns the user to the menu number and name.           |
|  | VOLTS & AMPS →                 | Returns the user to volts and amps heading.             |
|  | V & A SUMMARY →                | Displays the volts and amps summary heading.            |
|  | V L1-L2 L1-L0 L2-L0<br># # #   | Displays L1-L2, L1-L0, and L2-L0 volts.                 |
|  | A L1 L2<br># #                 | Displays L1 and L2 amps.                                |
|  | V & A SUMMARY →                | Returns the user to the volts and amps summary heading. |

# Menu 1—Generator Monitoring (Single-Phase Connections), continued

## Menu 1 Displays with Key Entries

| Key Entry | Display                              | Description  |
|-----------|--------------------------------------|--|
|           | POWER KW →                           | Displays the power kilowatt heading.                             |
|           | TOTAL KW #<br>PF # LEADING/LAGGING   | Displays total kilowatts and leading or lagging power factor.    |
|           | L1 KW #<br>PF # LEADING/LAGGING      | Displays total L1 kilowatts and leading or lagging power factor. |
|           | L2 KW #<br>PF # LEADING/LAGGING      | Displays total L2 kilowatts and leading or lagging power factor. |
|           | TOTAL KW #<br>% OF RATED KW #        | Displays the total kW and percent of rated kilowatts.            |
|           | POWER KW →                           | Returns the user to the power kilowatt heading.                  |
|           | POWER KVAR →                         | Displays the power kVAR heading.                                 |
|           | TOTAL KVAR #<br>ABSORBING/GENERATING | Displays total kVAR, absorbing or generating.                    |
|           | L1 KVAR #<br>ABSORBING/GENERATING    | Displays L1 kVAR, absorbing or generating.                       |
|           | L2 KVAR #<br>ABSORBING/GENERATING    | Displays L2 kVAR, absorbing or generating.                       |
|           | POWER KVAR →                         | Returns the user to power kVAR heading.                          |
|           | POWER KVA →                          | Displays the power kVA heading.                                  |
|           | TOTAL KVA #                          | Displays total kVA.  |
|           | L1 KVA #                             | Displays L1 kVA.   |
|           | L2 KVA #                             | Displays L2 kVA.   |
|           | POWER kVA →                          | Returns the user to power kVA heading.                           |



## 2.9.2 Menu 2—Engine Monitoring














Menu 2 provides engine operating data including oil pressure and temperature, coolant temperature, fuel pressure and temperature, engine rpm, and battery voltage. Menu 2 also displays engine warning and shutdown setpoints and engine warmed-up and cooled-down temperature setpoints.

The detailed engine monitoring functions appear only for DDEC (DDC/MTU), JDEC (John Deere), EMS2 (Volvo), EDC3 (Volvo), or MDEC/ADEC (DDC/MTU)-equipped engines.

**Note:** A right arrow from any submenu moves to the next submenu header.

### Menu 2—Engine Monitoring Menu 2 Displays with Key Entries

**Note:** This menu is for monitoring only; no adjustments or user settings can be entered.

| Key Entry   | Display                                   | Description  |
|---|---|--|
|    | ENTER MENU NO. 1-15                       | Input a menu number.   |
|    | MAIN MENU NUMBER 2                        | Press the Enter key.   |
|    | MENU 2<br>ENGINE MONITORING               | Displays the menu number and name.   |
|    | ENGINE MONITORING →<br>BASIC              | Displays the basic engine monitoring heading.                              |
|   | OIL PRESSURE # PSI<br>COOLANT TEMP # F    | Displays the oil pressure and coolant temperature.                         |
|  | INTAKE AIR # F<br>OIL TEMP (Waukesha) # F | Displays the intake air and oil temperature (Waukesha-powered models only) |
|  | ENGINE RPM #<br>LOCAL BATT VDC #          | Displays the engine rpm and local battery VDC.                             |
|  | HCT WARN # F<br>HCT SDOWN # F             | Displays the high coolant temperature warning and shutdown setpoints.      |
|  | LOP WARN # PSI<br>LOP SDOWN # PSI         | Displays the low oil pressure warning and shutdown setpoints.              |
|  | ENGINE WARMED UP<br># F                   | Displays the engine warmed up temperature setpoint.                        |
|  | ENGINE COOLED DOWN<br># F                 | Displays the engine cooled down temperature setpoint.                      |
|  | MENU 2<br>ENGINE MONITORING               | Returns the user to the menu number and name.                              |
|  | ENGINE MONITORING →<br>BASIC              | Returns the user to basic engine monitoring heading.                       |


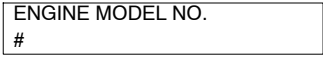

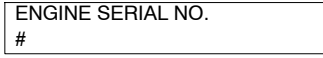



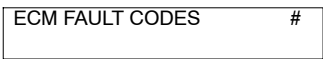

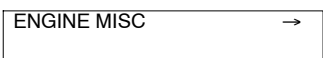
## Menu 2—Engine Monitoring, continued

### Menu 2 Displays with Key Entries

| Key Entry  | Display                                 | Description   |
|--|---|---|
| <b>(DDEC/JDEC/EMS2/EDC3-Equipped Engines only)</b> |   |   |
| MENU<br>→  | ENGINE MONITORING<br>DETAILED →         | Displays the detailed engine monitoring heading.<br><b>Note:</b> The detailed engine monitoring feature requires a DDEC/JDEC/EMS2/EDC3-equipped engine. |
| MENU<br>↓  | ENGINE FUEL →                           | Displays the engine fuel subheading.  |
| MENU<br>↓  | FUEL PRES # PSI<br>FUEL TEMP # F        | Displays the fuel pressure and fuel temperature.  |
| MENU<br>↓  | CHR AIR PRESS # PSI<br>CHR AIR TEMP # F | Displays the charge air pressure and temperature.   |
| MENU<br>↓  | FUEL RATE # GPH                         | Displays the fuel rate per hour.  |
| MENU<br>↓  | USED LAST RUN<br># GAL                  | Displays the amount of fuel used during the last run.   |
| MENU<br>↓  | ENGINE MONITORING<br>DETAILED →         | Returns the user to the detailed engine monitoring heading.   |
| MENU<br>↓  | ENGINE FUEL →                           | Displays the engine fuel subheading.  |
| MENU<br>→  | ENGINE COOLANT →                        | Displays the engine coolant subheading.   |
| MENU<br>↓  | COOLANT PRES # PSI<br>COOLANT TEMP # F  | Displays the coolant pressure and coolant temperature.  |
| MENU<br>↓  | COOLANT LEVEL #%                        | Displays the coolant level as a percent of full capacity.   |
| MENU<br>↓  | ENGINE COOLANT →                        | Returns the user to engine coolant subheading.  |
| MENU<br>→  | ENGINE OIL →                            | Displays the engine oil subheading.   |
| MENU<br>↓  | OIL PRES # PSI<br>OIL TEMP # F          | Displays the oil pressure and oil temperature.  |
| MENU<br>↓  | OIL LEVEL #%<br>CRANKCASE PRES # PSI    | Displays the oil level as a percent of full capacity and crankcase pressure.  |
| MENU<br>↓  | ENGINE OIL →                            | Returns the user to engine oil subheading.  |
| MENU<br>→  | ENGINE MISC →                           | Displays the miscellaneous engine subheading.   |
| MENU<br>↓  | ECM BATT VDC #<br>AMBIENT TEMP # F      | Displays the engine ECM battery VDC and ambient temperature.  |

## Menu 2—Engine Monitoring, continued


















### Menu 2 Displays with Key Entries

| Key Entry   | Display   | Description  |
|---|---|--|
| <b>(DDEC/JDEC/EMS2/EDC3-Equipped Engines only, continued)</b>                     |   |  |
|  |  | Displays the engine model number.                        |
|  |  | Displays the engine serial number.                       |
|  |  | Displays the unit number and ECM serial number.          |
|  |  | Displays the ECM fault codes.                            |
|  |  | Returns the user to the miscellaneous engine subheading. |

---

## Menu 2—Engine Monitoring, continued

### Menu 2 Displays with Key Entries

| Key Entry   | Display                                    | Description   |
|---|--|---|
| <b>(MDEC-Equipped Engines only)</b>   |  |   |
|    | ENGINE MONITORING<br>DETAILED →            | Displays the detailed engine monitoring heading.<br><b>Note:</b> The detailed engine monitoring feature requires a DDC/MTU MDEC/ADEC-equipped engine. |
|    | ENGINE FUEL →                              | Displays the engine fuel subheading.  |
|    | FUEL PRES # PSI<br>FUEL TEMP # F           | Displays the fuel pressure and fuel temperature.  |
|    | CHG AIR PRESSURE # PSI<br>CHG AIR TEMP # F | Displays the turbocharger air pressure and temperature.   |
|    | FUEL RATE * # GPH                          | Displays the fuel rate per hour.  |
|    | DAILY FUEL USED * # GAL                    | Displays the amount of fuel used during the last 24 hours.  |
|    | TOTAL FUEL USED * # GAL                    | Displays the amount of fuel used since the last reset.  |
|   | ENGINE MONITORING<br>DETAILED →            | Returns the user to the detailed engine monitoring heading.   |
|  | ENGINE FUEL →                              | Displays the engine fuel subheading.  |
|  | ENGINE OIL →                               | Displays the engine oil subheading.   |
|  | OIL PRES # PSI<br>OIL TEMP # F             | Displays the oil pressure and oil temperature.  |
|  | ENGINE OIL →                               | Returns the user to engine oil subheading.  |
|  | ENGINE MISC →                              | Displays the miscellaneous engine subheading.   |
|  | ECU SUPPLY VDC #<br>AMBIENT TEMP # F       | Displays the engine ECU supply VDC and ambient temperature.   |
|  | ECU HOURS #                                | Displays the ECU operating hours.   |
|  | ECU FAULT CODES #                          | Displays the ECU fault codes.   |
|  | ENGINE MISC →                              | Returns the user to the miscellaneous engine subheading.  |

\* While these menu displays do appear on the 550 controller, the engine ECM is not currently set up to provide this data.

### 2.9.3 Menu 3—Analog Monitoring

Menu 3 provides the battery voltage and up to 7 user-defined analog monitoring items dependent upon the generator system.

The *User Defined Desc* display refers to a description entered into the controller using the PC software. This description remains as the display for future review until changed by the PC software user. The display has 20 characters maximum.

**Analog Voltage Adjust.** When the analog voltage adjust option is enabled (see Menu 11), analog input 7 is predefined as voltage adjust. The voltage of this input will define the adjustment from the setting in Menu 11, Voltage Regulator. The normal analog input range of 0.5 to 4.5 corresponds to a  $\pm 10\%$  of system voltage.

The midpoint 2.5 volts corresponds to 0 volts offset. If there is no connection at analog input 7, no voltage adjust is recognized.

**Note:** If the analog display shows O/R (out of range), no input is connected.














**Note:** Some data require entry using a PC in the Remote Programming mode. See the monitor software operation manual for details.

**Note:** See **Figure 2-8** in User Inputs for factory reserved inputs which are not user selectable.

**Note:** This menu is for monitoring only; no adjustments or user settings can be entered.












### Menu 3—Analog Monitoring (ECM Engines)

#### Menu 3 Displays with Key Entries

| Key Entry   | Display                            | Description  |
|---|------------------------------------|--|
|    | ENTER MENU NO. 1-15                | Input a menu number.   |
|    | MAIN MENU NUMBER 3                 | Press the Enter key.   |
|   | MENU 3<br>ANALOG MONITORING        | Displays the menu number and name.   |
|  | LOCAL BATT VDC #                   | Displays the local battery VDC.  |
|  | ANALOG 01<br>(USER DEFINED DESC) # | Displays analog 01 and the user-defined description.   |
|  | ANALOG 02<br>(USER DEFINED DESC) # | Displays analog 02 and the user defined description.   |
|  | ANALOG 03<br>(USER DEFINED DESC) # | Displays analog 03 and the user-defined description.   |
|  | ANALOG 04<br>(USER DEFINED DESC) # | Displays analog 04 and the user-defined description.   |
|  | ANALOG 05<br>(USER DEFINED DESC) # | Displays analog 05 and the user-defined description.   |
|  | ANALOG 06<br>(USER DEFINED DESC) # | Displays analog 06 end the user-defined description.   |
|  | ANALOG 07<br>(USER DEFINED DESC) # | Displays analog 07 and the user-defined description.   |
|   | <b>OR</b>                          |  |
|  | ANALOG 07 #<br>ANALOG VOLT ADJUST  | Displays analog 07 voltage adjustment VDC value when analog voltage adjust is enabled.                           |
|  | ANALOG MONITORING<br>MENU 3        | Returns user to analog monitoring heading.<br><b>Note:</b> Enter data using a PC in the Remote Programming Mode. |










## Menu 3—Analog Monitoring (Non-ECM Engines)

### Menu 3 Displays with Key Entries

| Key Entry   | Display  | Description   |
|---|--|---|
|    | ENTER MENU NO. 1-15                            | Input a menu number.  |
|    | MAIN MENU NUMBER 3                             | Press the Enter key.  |
|    | MENU 3<br>ANALOG MONITORING                    | Displays the menu number and name.  |
|    | LOCAL BATT VDC #                               | Displays the local battery VDC.   |
|    | ANALOG 03 #<br>(USER DEFINED DESC)             | Displays analog 03 and the user-defined description.  |
|    | ANALOG 04 #<br>(USER DEFINED DESC)             | Displays analog 04 and the user-defined description.  |
|    | ANALOG 05 #<br>(USER DEFINED DESC)             | Displays analog 05 and the user-defined description.  |
|    | ANALOG 06 #<br>(USER DEFINED DESC)             | Displays analog 06 end the user-defined description.  |
|   | ANALOG 07 #<br>(USER DEFINED DESC)             | Displays analog 07 and the user-defined description.  |
|  | <b>OR</b><br>ANALOG 07 #<br>ANALOG VOLT ADJUST | Displays analog 07 voltage adjustment VDC value when this option is enabled. <b>Note:</b> This function may be overridden by changing the description using the optional Monitor III software or by disabling in Menu 11. |
|  | ANALOG MONITORING<br>MENU 3                    | Returns user to analog monitoring heading.<br><b>Note:</b> Enter data using a PC in the Remote Programming Mode.  |

## Menu 3—Analog Monitoring (Waukesha Engines)

### Menu 3 Displays with Key Entries

| Key Entry  | Display                            | Description   |
|--|------------------------------------|---|
|   | ENTER MENU NO. 1-15                | Input a menu number.  |
|   | MAIN MENU NUMBER 3                 | Press the Enter key.  |
|   | MENU 3<br>ANALOG MONITORING        | Displays the menu number and name.  |
|   | LOCAL BATT VDC #                   | Displays the local battery VDC.   |
|   | ANALOG 05 #<br>(USER DEFINED DESC) | Displays analog 05 and the user-defined description.  |
|   | ANALOG 06 #<br>(USER DEFINED DESC) | Displays analog 06 and the user-defined description.  |
|   | ANALOG 07 #<br>(USER DEFINED DESC) | Displays analog 07 and the user-defined description.  |
| <b>OR</b>  |                                    |   |
|   | ANALOG 07 #<br>ANALOG VOLT ADJUST  | Displays analog 07 voltage adjustment VDC value when this option is enabled. <b>Note:</b> This function may be overridden by changing the description using the optional Monitor III software or by disabling in Menu 11. |
|  | ANALOG MONITORING<br>MENU 3        | Returns user to analog monitoring heading.<br><b>Note:</b> Enter data using a PC in the Remote Programming Mode.  |

## 2.9.4 Menu 4—Operational Records

Menu 4 provides the generator set operational records including the operating start date, last logged maintenance, total run time loaded and unloaded, run time since the last maintenance, number of starts, and number of running days.

**Run Time Feature.** This menu provides the ability to run the generator set for a designated time. After the run time elapses, the generator set shuts down and functions in the standby mode. The generator set controller does not provide weekly scheduled exercise periods.














**Generator set connected to an automatic transfer switch.** Should a utility power failure occur while the unit is in the run time mode, the controller bypasses the run time mode and functions in the standby (backup) mode. If the utility power returns, the generator set continues to run for the duration of the run time period if not timed out.

**Note:** Press the STOP PROG RUN key to stop the generator set when in the run time mode, if necessary.

After performing maintenance, enter yes to reset records reflecting the current day. The user must enable the programming mode to edit the display.

### Menu 4—Operational Records

#### Menu 4 Displays with Key Entries

| Key Entry   | Display                               | Description   |
|---|---------------------------------------|---|
|    | ENTER MENU NO. 1-15                   | Input a menu number.  |
|    | MAIN MENU NUMBER 4                    | Press the Enter key.  |
|   | MENU 4<br>OPERATIONAL RECORDS         | Displays the menu number and name.  |
|  | FACTORY TEST DATE<br>##-##-##         | Displays the factory test date (day-month-year).  |
|  | TOTAL RUN TIME<br>HRS #               | Displays the total run time (hours:minutes).  |
|  | TOTAL RUN TIME<br>LOADED HRS #        | Displays the total run time for loaded hours.   |
|  | TOTAL RUN TIME<br>UNLOADED HRS #      | Displays the total run time for unloaded hours.   |
|  | TOTAL RUN TIME<br>KW HRS #            | Displays the total run time in kW hours.  |
|  | NO. OF STARTS #                       | Displays the number of engine starts.   |
|  | ENGINE START? Y/N→<br>COUNTDOWN ##.## | Displays the start and countdown subheading.  |
|  | RUN TIME HR:MN→<br>??:??              | Displays the run time (hours:minutes) feature. When required, use the numeric keys to enter the selected run time (hours:minutes) and press the Enter key.  |
|  | RUN TIME HR:MN→<br>##.##              | Confirms entry and displays the selected run time (hours:minutes). The generator set will start after activation. <b>Note:</b> Activate the generator set run time feature by pressing the Yes and Enter keys. See the following steps. |
|  | ENGINE START? Y/N→<br>COUNTDOWN ##.## | Returns the user to the start and countdown subheading. Enter Yes to start the generator set.   |



## Menu 4—Operational Records, continued

### Menu 4 Displays with Key Entries

| Key Entry | Display   | Description   |
|-----------|---|---|
|           | ENGINE START? YES→<br>COUNTDOWN    ###:##                                       | Press the Enter key.  |
|           | RUN TIME            HR:MN→<br>###:##  | Confirms the entry. The generator set will begin cranking and run based on the run time (hours:minutes) period and all previously established time (hours:minutes) delays from Menu 8—Time Delays.<br><b>Note:</b> Press the STOP PROG RUN key to stop the generator set when in the run time mode, if necessary. |
|           | RECORDS MAINT           →   | Displays the records maintenance subheading.  |
|           | RESET RECORDS?           →  | Displays the reset records option. After performing maintenance or when required, enter Yes to reset.   |
|           | RESET RECORDS?    YES→  | Enter Yes to reset to the current date and press the Enter key.   |
|           | RESET RECORDS?    YES→  | Confirms the entry.   |
|           | RECORDS MAINT           →   | Returns the user to records maintenance subheading.   |
|           | RUN TIME SINCE MAINT<br>TOTAL HRS                   #                           | Displays the run time since the last maintenance with total hours.  |
|           | RUN TIME SINCE MAINT<br>LOADED HRS                   #                          | Displays the run time since last the maintenance with loaded hours.   |
|           | RUN TIME SINCE MAINT<br>UNLOADED HRS                #                           | Displays the run time since the last maintenance with unloaded hours.   |
|           | RUN TIME SINCE MAINT<br>KW HRS                        #                         | Displays the run time since the last maintenance in kW hours.   |
|           | OPERATING DAYS           #<br>LAST MAINT                ##-###-##               | Displays the operating days since the last maintenance.   |
|           | NO. OF STARTS            #<br>LAST MAINT                ##-###-##               | Displays the number of starts since the last maintenance date (day-month-year).   |
|           | LAST START                ###:## AM/PM<br>DATE                        ##-###-## | Displays last the start time (hours:minutes) and date (day-month-year).   |
|           | LENGTH OF RUN<br>(UN)LOADED HRS            #                                    | Displays the length of last run in (un)loaded hours.  |
|           | MENU 4<br>OPERATIONAL RECORDS   | Returns the user to the operational records heading.  |


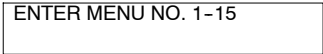

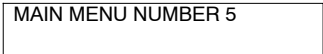



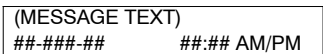

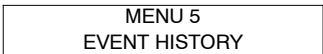
## 2.9.5 Menu 5—Event History

Menu 5 stores and displays the times and dates of up to 100 stored status, warning, and shutdown events. After the first 100 events, each additional new event replaces the oldest event. See Menu 10—Output Setup for a list of possible events.

**Note:** This menu is for monitoring only; no adjustments or user settings can be entered.

### Menu 5—Event History

#### Menu 5 Displays with Key Entries

| Key Entry  | Display  | Description  |
|--|--|--|
|   |   | Input a menu number.   |
|   |   | Press the Enter key.   |
|   |   | Displays the menu number and name.   |
|   |   | Displays the message text, date (day-month-year) and time (hours:minutes). Scroll through up to 100 stored events. See Section 2.4.5, System Warning Lamp, for fault descriptions. |
|  |  | Returns the user to event history heading.   |

## 2.9.6 Menu 6—Time and Date









Menu 6 sets the clock time and date and internal calendar. The controller uses set time for determining the exercise run time and event records. The time and date are valid only if the controller power (starting battery) remains connected.

The user must enable the programming mode to edit the display.

**Note:** A change to the time/date is recorded as a system event. The time/date reset and other events are viewable (up to 100 events). For events that occurred prior to a date change, use the previous date as the reference point for determining the event's actual date.

### Menu 6—Time and Date

#### Menu 6 Displays with Key Entries

| Key Entry   | Display                                 | Description   |
|---|---|---|
|    | ENTER MENU NO. 1-15                     | Input a menu number.  |
|    | MAIN MENU NUMBER 6                      | Press the Enter key.  |
|    | MENU 6<br>TIME AND DATE                 | Displays the menu number and name.  |
|    | DAY OF WEEK   ##-###-##<br>###:## AM/PM | Displays the day of the week, date (day-month-year), and time (hours:minutes).  |
|   | TIME            ?:?:? AM/PM             | Displays the time (hours:minutes) of day entry. When required, use the numeric and am/pm keys to set the time (hours:minutes) of day and press the Enter key. |
|  | DAY OF WEEK   ##-###-##<br>###:## AM/PM | Displays the corrected time (hours:minutes) of day.   |
|  | DATE            ??-??-??                | Displays the date (day-month-year) entry. When required, use the numeric keys to set the <b>day</b> of the month.   |
|   | <b>AND</b>                              |   |
|   | DATE            ??-??-??                | Use the Menu Right → key to select the <b>month</b> .   |
|   | <b>AND</b>                              |   |
|   | DATE            ??-??-??                | Use the numeric keys to set the <b>two-digit year</b> and press the Enter key.  |
|   | <b>AND</b>                              |   |
|  | DAY OF WEEK   ##-###-##<br>###:## AM/PM | Displays the corrected date (day- month-year).  |

## 2.9.7 Menu 7—Generator System

Menu 7 contains the factory-preset generator set voltage and frequency data. Enter the corresponding data if the generator set requires voltage reconnection and/or frequency adjustment. It is imperative that the user enter the correct data because these settings trigger all related shutdowns.

See Section 2.6.3, Request and Error Messages, for error display messages and explanations while navigating the menus.

The user must enable the programming mode to edit the display.

**Note A:** Some alternators have limited voltage and frequency configurations. Inappropriate voltage or frequency entries will cause a RANGE ERROR message.

**Note:** The user defines the data shown in Menu 7. It is NOT data measured by the controller and associated sensing devices. The user defines these values for purposes of calibrating the control.

**Note:** Press the Menu Right → key prior to entering decimal values where necessary.

**Note:** The variable speed governor (VSG) display provides the ability to parallel the generator set.

**Note:** For Version 3.01 and higher, the **Adjusted RPM** menu will display the adjusted engine speed from either an analog input or the keypad. When **Digital VSG** is selected, the user can also enter a new adjusted RPM in the **Adjusted RPM** menu.

**Note:** For Version 3.01 and higher, **Speed Adjust Select** allows the user to select the type of adjustment for engine speed on Volvo, GM, Doosan and KDI engines. The user can select **Analog VSG** (where a potentiometer or external control device on analog input 6 is used to change the desired speed) or **Digital VSG** (where the user can enter a value on the key pad through the Adjusted RPM menu).

# Menu 7—Generator System

## Menu 7 Displays with Key Entries

| Key Entry  | Display                             | Description   |
|------------|-------------------------------------|---|
| RESET MENU | ENTER MENU NO. 1-15                 | Input a menu number.  |
| 7<br>YES   | MAIN MENU NUMBER 7                  | Press the Enter key.  |
| ENTER<br>↵ | MENU 7<br>GENERATOR SYSTEM          | Displays the menu number and name.  |
| MENU<br>▼  | OPERATING MODE →<br>(see note) YES  | Displays the operating mode selection. <b>Note:</b> The display sample may differ depending upon previous entries. The previously selected operating mode appears first, either standby or prime power. |
| MENU<br>▶  | OPERATING MODE →<br>STANDBY NO      | Displays the optional operating mode selection. When required, enter YES for standby operating mode. <b>Note:</b> This display indicates the <i>generator set application</i> .                         |
| 7<br>YES   | OPERATING MODE →<br>STANDBY YES     | Enter YES to change the operating mode selection to standby and press the Enter key.  |
| ENTER<br>↵ | OPERATING MODE →<br>STANDBY YES     | Confirms the entry.   |
| OR         |                                     |   |
| MENU<br>▶  | OPERATING MODE →<br>PRIME POWER NO  | Displays the optional operating mode selection. When required, enter YES for the prime power operating mode. <b>Note:</b> This display indicates the <i>generator set application</i> .                 |
| 7<br>YES   | OPERATING MODE →<br>PRIME POWER YES | Enter YES to change the operating mode selection to prime power and press the Enter key.  |
| ENTER<br>↵ | OPERATING MODE →<br>PRIME POWER YES | Confirms the entry.   |
| MENU<br>▼  | SYSTEM VOLTAGE<br>LINE-LINE ?       | Displays the line-to-line system voltage as entered data. When required, use the numeric keys to set new value. Press the Enter key.  |
| ENTER<br>↵ | SYSTEM VOLTAGE<br>LINE-LINE #       | Displays the corrected line-to-line system voltage. See NOTE A.   |
| MENU<br>▼  | SYSTEM FREQ # HZ                    | Displays the system frequency as entered data. When required, use the numeric keys to set the new value. Press the Enter key.   |

















# Menu 7—Generator System, continued

## Menu 7 Displays with Key Entries

| Key Entry | Display                       | Description  |
|-----------|-------------------------------|--|
|           | SYSTEM FREQ # HZ              | Displays the corrected system frequency. See NOTE A.   |
|           | PHASE<br>(see note) YES       | Displays the phase configuration selection. <b>Note:</b> The display sample may differ depending upon previous entries. The user-selected phase appears first, either wye, delta, or single phase. |
|           | PHASE<br>3 PHASE DELTA NO     | Displays the optional phase configuration selection. When required, use the YES key to choose the delta phase configuration.   |
|           | PHASE<br>3 PHASE DELTA YES    | Enter YES to change the phase configuration to a delta phase configuration and press the Enter key.  |
|           | PHASE<br>3 PHASE DELTA YES    | Confirms the entry. See NOTE A.  |
| OR        |                               |  |
|           | PHASE<br>3 PHASE WYE NO       | Displays the optional phase configuration selection. When required, use the YES key to choose the wye phase configuration.   |
|           | PHASE<br>3 PHASE WYE YES      | Enter YES to change the phase configuration to a wye phase configuration and press the Enter key.  |
|           | PHASE<br>3 PHASE WYE YES      | Confirms the entry. See NOTE A.  |
| OR        |                               |  |
|           | PHASE<br>SINGLE-PHASE NO      | Displays the optional phase configuration selection. When required, use the YES key to choose the single-phase configuration.  |
|           | PHASE<br>SINGLE-PHASE YES     | Enter YES to change the phase configuration to a single-phase configuration and press the Enter key.   |
|           | PHASE<br>SINGLE-PHASE YES     | Confirms the entry. See NOTE A.  |
|           | KW RATING ?                   | Displays the generator set kW rating as entered data. When required, use the numeric keys to set the new value. Press the Enter key.   |
|           | KW RATING #                   | Displays the corrected system kilowatt rating.   |
|           | RATED CURRENT #               | Displays the generator set rated current as entered data. <b>Note:</b> This is a read-only display.  |
|           | LOAD SHED OUTPUT →<br>?% # KW | Displays the load shed output setting. When required, use the numeric keys to set the new value. Press the Enter key. See Menu 10, Output Setup for Group B User-Defined Systems Events            |
|           | LOAD SHED OUTPUT →<br>#% # KW | Displays the corrected load shed output setting.   |
|           | TIME DELAY MIN:SEC →<br>?:??  | Displays the load shed time (minutes:seconds) delay setting. When required, use the numeric keys to set the new value. Press the Enter key.  |
|           | TIME DELAY MIN:SEC →<br>##:## | Displays the corrected load shed time (minutes:seconds) delay setting.   |
|           | LOAD SHED OUTPUT →<br>#% # KW | Returns the user to the load shed output setting.  |

## Menu 7—Generator System, continued

### Menu 7 Displays with Key Entries

| Key Entry   | Display                       | Description  |
|---|-------------------------------|--|
|    | OVERVOLTAGE →<br>?% # VAC     | Displays the overvoltage setting. When required, use the numeric keys to set the new value. Press the Enter key.                               |
|    | OVERVOLTAGE →<br>#% # VAC     | Displays the corrected overvoltage setting.  |
|    | TIME DELAY MIN:SEC →<br>??:?? | Displays the overvoltage time (minutes:seconds) delay setting. When required, use the numeric keys to set the new value. Press the Enter key.  |
|    | TIME DELAY MIN:SEC →<br>##:## | Displays the corrected overvoltage time (minutes:seconds) delay setting.   |
|    | OVERVOLTAGE →<br>#% # VAC     | Returns the user to the overvoltage setting.   |
| <hr/>   |                               |  |
|    | UNDERVOLTAGE →<br>?% # VAC    | Displays the undervoltage setting. When required, use the numeric keys to set the new value. Press the Enter key.                              |
|    | UNDERVOLTAGE →<br>#% # VAC    | Displays the corrected undervoltage setting.   |
|   | TIME DELAY MIN:SEC →<br>??:?? | Displays the undervoltage time (minutes:seconds) delay setting. When required, use the numeric keys to set the new value. Press the Enter key. |
|  | TIME DELAY MIN:SEC →<br>##:## | Displays the corrected overvoltage time (minutes:seconds) delay setting.   |
|  | UNDERVOLTAGE →<br>#% # VAC    | Returns the user to the undervoltage setting.  |
| <hr/>   |                               |  |
|  | OVERFREQUENCY →<br>?% # HZ    | Displays the overfrequency setting. When required, use the numeric keys to set the new value. Press the Enter key.                             |
|  | OVERFREQUENCY →<br>#% # HZ    | Displays the corrected overfrequency setting.  |
|  | UNDERFREQUENCY →<br>?% # HZ   | Displays the underfrequency setting. When required, use the numeric keys to set the new value. Press the Enter key.                            |
|  | UNDERFREQUENCY →<br>#% # HZ   | Displays the corrected underfrequency setting.   |
|  | OVERSPEED →<br>? HZ # RPM     | Displays the overspeed setting. When required, use the numeric keys to set the new value. Press the Enter key.                                 |
|  | OVERSPEED →<br># HZ # RPM     | Displays the corrected overspeed setting.  |

## Menu 7—Generator System, continued

### Menu 7 Displays with Key Entries

| Key Entry  | Display                             | Description   |
|------------|-------------------------------------|---|
| MENU<br>↓  | BATTERY VOLTAGE<br>(see note) → YES | Displays the battery voltage selection. <b>Note:</b> The display sample may differ depending upon previous entries. The user-selected battery voltage appears first, either 12 VDC or 24 VDC. |
| MENU<br>→  | BATTERY VOLTAGE<br>12 VDC → NO      | Displays the 12 VDC battery voltage selection. When required, use the YES key to choose the 12 VDC battery voltage.   |
| 7<br>YES   | BATTERY VOLTAGE<br>12 VDC → YES     | Enter YES to change the battery voltage to 12 VDC and press the Enter key.  |
| ENTER<br>↵ | BATTERY VOLTAGE<br>12 VDC → YES     | Confirms the entry.   |
| OR         |                                     |   |
| MENU<br>→  | BATTERY VOLTAGE<br>24 VDC → NO      | Displays the 24 VDC battery voltage selection. When required, use the YES key to choose the 24 VDC battery voltage.   |
| 7<br>YES   | BATTERY VOLTAGE<br>24 VDC → YES     | Enter YES to change the battery voltage to 24 VDC and press the Enter key.  |
| ENTER<br>↵ | BATTERY VOLTAGE<br>24 VDC → YES     | Confirms the entry.   |
| MENU<br>↓  | LOW BATTERY VOLTAGE<br>?.? VDC      | Displays the low battery voltage setting. When required, use the numeric keys to set the new value. Press the Menu Right → key prior to entering the decimal value.                           |
| AND        |                                     |   |
| MENU<br>→  | LOW BATTERY VOLTAGE<br>?.? VDC      | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
| ENTER<br>↵ | LOW BATTERY VOLTAGE<br>## VDC       | Displays the corrected low battery voltage setting.   |
| MENU<br>↓  | HIGH BATTERY VOLTAGE<br>?.? VDC     | Displays the high battery voltage setting. When required, use the numeric keys to set the new value. Press the Menu Right → key prior to entering the decimal value.                          |
| AND        |                                     |   |
| MENU<br>→  | HIGH BATTERY VOLTAGE<br>?.? VDC     | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
| ENTER<br>↵ | HIGH BATTERY VOLTAGE<br>## VDC      | Displays the corrected high battery voltage setting.  |
| MENU<br>↓  | BLOCK HEATER ON # F                 | Displays the block heater energize temperature setting. When required, use the numeric keys to set the new value. Applies to DDC/MTU engines with MDEC/ADEC only.                             |
| AND        |                                     |   |
| MENU<br>→  | BLOCK HEATER ON ? F                 | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
| ENTER<br>↵ | BLOCK HEATER ON # F                 | Displays the corrected block heater energize temperature setting.   |
| MENU<br>↓  | BLOCK HEATER OFF # F                | Displays the block heater deenergize temperature setting. When required, use the numeric keys to set the new value. Applies to Detroit Diesel engines with MDEC/ADEC engine controls only.    |
| AND        |                                     |   |
| MENU<br>→  | BLOCK HEATER OFF ? F                | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
| ENTER<br>↵ | BLOCK HEATER OFF # F                | Displays the corrected block heater deenergize temperature setting.   |



## Menu 7—Generator System, continued

### Menu 7 Displays with Key Entries

| Key Entry  | Display                         | Description  |
|------------|---------------------------------|--|
| MENU<br>▼  | ENABLE VSG YES/NO               | Displays the variable speed governor (VSG) yes or no selection for paralleling applications. When required, use the numeric keys to set the new value. Applies to DDC/MTU MDEC/ADEC engine only. |
| 7<br>YES   | ENABLE VSG NO<br>ENABLE VSG YES | Entering YES enables the VSG function.   |
| ENTER<br>↵ | ENABLE VSG YES                  | Confirms the entry..   |
| <b>OR</b>  |                                 |  |
| 8<br>NO    | ENABLE VSG YES<br>ENABLE VSG NO | Entering NO disables the VSG function.   |
| ENTER<br>↵ | ENABLE VSG NO                   | Confirms the entry..   |
| MENU<br>▼  | ENABLE DSC YES/NO               | Displays the digital speed control (DSC) yes or no selection for paralleling applications. When required, use the numeric keys to set the new value. Applies to DDC/MTU MDEC/ADEC engine only.   |
| 7<br>YES   | ENABLE DSC NO<br>ENABLE DSC YES | Entering YES enables the DSC function.   |
| ENTER<br>↵ | ENABLE DSC YES                  | Confirms the entry..   |
| <b>OR</b>  |                                 |  |
| 8<br>NO    | ENABLE DSC YES<br>ENABLE DSC NO | Entering NO disables the DSC function.   |
| ENTER<br>↵ | ENABLE DSC NO                   | Confirms the entry..   |



## Menu 7—Generator System, continued

### Menu 7 Displays with Key Entries

| Key Entry  | Display   | Description   |
|------------|---|---|
| MENU<br>↓  | METRIC UNITS Y/N  | Displays the metric units selection.  |
| 7<br>YES   | METRIC UNITS NO<br>METRIC UNITS YES                         | Enter YES to change to metric displays and press the Enter key.   |
| ENTER<br>↵ | METRIC UNITS YES  | Confirms the entry.   |
| <b>OR</b>  |   |   |
| 8<br>NO    | METRIC UNITS YES<br>METRIC UNITS NO                         | Enter NO to change to English displays and press the Enter key.   |
| ENTER<br>↵ | METRIC UNITS NO   | Confirms the entry.   |
| MENU<br>↓  | SET NFPA-110<br>DEFAULTS Y/N                                | Displays the NFPA 110 default yes or no selection. <b>Note:</b> See Menu 10—Output Setup, Overview for a list of the NFPA-110 faults. |
| 7<br>YES   | SET NFPA-110<br>DEFAULTS NO<br>SET NFPA-110<br>DEFAULTS YES | Enter YES to select the NFPA 110 default selection and press the Enter key.   |
| ENTER<br>↵ | SET NFPA-110<br>DEFAULTS YES                                | Confirms the entry.   |
| <b>OR</b>  |   |   |
| 8<br>NO    | SET NFPA-110<br>DEFAULTS YES<br>SET NFPA-110<br>DEFAULTS NO | Enter NO to deselect the NFPA 110 default selection and press the Enter key.  |
| ENTER<br>↵ | SET NFPA-110<br>DEFAULTS NO                                 | Confirms the entry.   |
| MENU<br>↓  | MENU 7<br>GENERATOR SYSTEM                                  | Returns the user to the generator system heading.   |

## 2.9.8 Menu 8—Time Delays

Menu 8 displays the various time delays for cyclic cranking and other engine-related starting and shutdown features.















The user must enable the programming mode to edit the display.

**Cooldown Temperature Override.** This feature allows the user to bypass (override) the temperature-based cooldown. When this feature is enabled, the engine will run in cooldown mode for the entire time defined as TIME DELAY ENG COOLDOWN, regardless of engine temperature.

If the Cooldown Temperature Override is not enabled, the unit will cease to run when the engine temperature falls below the ENGINE COOLED DOWN temperature (shown in Menu 2).

Engine cooldown and this cooldown temperature override feature apply to remote shutdown when the master switch is in the AUTO position. No cooldown will occur when the master switch is moved to the OFF position.

### Menu 8—Time Delays Menu 8 Displays with Key Entries

| Key Entry   | Display  | Description   |
|---|--|---|
|    | ENTER MENU NO. 1-15                                | Input a menu number.  |
|    | MAIN MENU NUMBER 8                                 | Press the Enter key.  |
|    | MENU 8<br>TIME DELAYS                              | Displays the menu number and name.  |
|  | TIME DELAY      MIN:SEC<br>ENGINE START      ??:?? | Displays the engine start time delay in minutes:seconds. When required, use the numeric keys to set the new value. Press the Enter key.   |
|  | TIME DELAY      MIN:SEC<br>ENGINE START      ##:## | Displays the corrected engine start time (minutes:seconds) delay setting.   |
|  | TIME DELAY      MIN:SEC<br>STARTING AID      ??:?? | Displays the starting aid time delay in minutes:seconds. When required, use the numeric keys to set the new value. Press the Enter key.   |
|  | TIME DELAY      MIN:SEC<br>STARTING AID      ##:## | Displays the corrected starting aid time (minutes:seconds) delay setting.   |
|  | TIME DELAY      MIN:SEC<br>CRANK ON      ??:??     | Displays the crank on time delay in minutes:seconds. When required, use the numeric keys to set the new value. Press the Enter key.   |
|  | TIME DELAY      MIN:SEC<br>CRANK ON      ##:##     | Displays the corrected crank on time (minutes:seconds) delay setting.   |
|  | TIME DELAY      MIN:SEC<br>CRANK PAUSE      ??:??  | Displays the crank pause time delay in minutes:seconds. When required, use the numeric keys to set the new value. Press the Enter key.  |
|  | TIME DELAY      MIN:SEC<br>CRANK PAUSE      ##:##  | Displays the corrected crank pause time (minutes:seconds) delay setting.  |
|  | TIME DELAY      MIN:SEC<br>ENG COOLDOWN      ??:?? | Displays the engine cooldown time delay in minutes:seconds. When required, use the numeric keys to set the new value. Press the Enter key.  |
|  | TIME DELAY      MIN:SEC<br>ENG COOLDOWN      ##:## | Displays the corrected engine cooldown time (minutes:seconds) delay setting.  |
|  | COOLDOWN TEMPERATURE<br>OVERRIDE      Y/N          | Displays the cooldown temperature override. When required, Press the Yes key to override the temperature based cooldown or press the No key to enable temperature based cooldown. |

## Menu 8—Time Delays, continued

### Menu 8 Displays with Key Entries

| Key Entry | Display                                  | Description  |
|-----------|--|--|
|           | COOLDOWN TEMPERATURE<br>OVERRIDE YES     | Enter YES to select cooldown temperature override time delay and press the Enter key.  |
|           | COOLDOWN TEMPERATURE<br>OVERRIDE Y/N     | Confirms the entry.  |
|           | OVERCRANK SHUTDOWN<br>CRANK CYCLES ?     | Displays the engine crank cycles before overcrank shutdown. When required, use the numeric keys to set the new value. Press the Enter key. |
|           | OVERCRANK SHUTDOWN<br>CRANK CYCLES #     | Displays the corrected engine crank cycles before overcrank shutdown setting.  |
|           | TIME DELAY MIN:SEC<br>OVERVOLTAGE ??:??  | Displays the overvoltage time delay in minutes:seconds. When required, use the numeric keys to set the new value. Press the Enter key.     |
|           | TIME DELAY MIN:SEC<br>OVERVOLTAGE ##:##  | Displays the corrected overvoltage time (minutes:seconds) delay setting.   |
|           | TIME DELAY MIN:SEC<br>UNDERVOLTAGE ??:?? | Displays the undervoltage time delay in minutes:seconds. When required, use the numeric keys to set the new value. Press the Enter key.    |
|           | TIME DELAY MIN:SEC<br>UNDERVOLTAGE ##:## | Displays the corrected undervoltage time (minutes:seconds) delay setting.  |
|           | TIME DELAY MIN:SEC<br>LOAD SHED KW ??:?? | Displays the load shed time delay in minutes:seconds. When required, use the numeric keys to set the new value. Press the Enter key.       |
|           | TIME DELAY MIN:SEC<br>LOAD SHED KW ##:## | Displays the corrected load shed time (minutes:seconds) delay setting.   |
|           | MENU 8<br>TIME DELAYS                    | Returns the user to the time delays heading.   |

## 2.9.9 Menu 9—Input Setup

Menu 9 provides the setup of user-defined digital and analog warning and shutdown inputs. These inputs provide a multitude of choices for configuring customized auxiliary inputs.

The user must enable the programming mode to edit the display.

**Note:** Press the down arrow to move to the start of the next input setup.

**Note:** The user must scale the analog input value in order to calculate the low/high warning and shutdown analog values based on a 0–5 VDC scale. See Menu 12, Calibration.

**Note:** If the ALARM ACTIVE message appears, the selected input has an active fault disabling the input. This prevents the enabled choice change from yes to no. The LED display indicates whether the fault is a warning or shutdown. Correct the fault condition before attempting the keypad entry.

**Note:** Some data requires entry by a PC in the Remote Programming mode. See the monitor software operation manual for details.

**Digital and Analog Inputs.** After the user selects the input, the setup requires entering the following choices or values: enabled (yes/no), inhibit time, and delay time.

**Note:** See **Figure 2-8** in User Inputs for factory reserved digital and analog inputs which are not user selectable.

- **Enabled.** This menu entry enables the input. The previous yes/no selection does not activate the input. **Digital inputs** have three tier groups: the selection group (25 total), the chosen group (up to 21 total), and the enabled group (up to 21 total based on the chosen group). **Analog inputs** have separate warning and shutdown enabled choices.
- **Inhibit Time Delay.** The inhibit time delay is the time period following crank disconnect during which the generator set stabilizes and the controller does not detect fault or status events. The inhibit time delay range is from 0 to 60 seconds.

- **Time Delay (Shutdown or Warning).** The time delay follows the inhibit time delay. The time delay is the time period between the controller fault or status event detection and the controller warning or shutdown lamp illumination. The delay prevents any nuisance alarms. The time delay range is from 0 to 60 seconds.

**Digital Inputs.** Items identified as *not user selectable* are included for specific applications. (Example: AFM SHUTDOWN is enabled with a Waukesha-powered model.) The user can not disable a digital input when identified as not user selectable.

**Analog Inputs.** View up to 7 user-defined analog inputs A01–A07.

**Analog Input A06—Analog Speed Adjust (VSG).** Analog Input A06 may be used for analog speed adjust when external control of engine speed is desired such as paralleling applications or closed transition ATS. To utilize this capability, “ANALOG VSG A06” must be selected from the Speed Adjust selection. Refer to 2.9.7, Menu 7 for Speed Adjust selection.

**Note:** This feature is supported for Doosan, GM, Volvo, and KDI engines only.

**Analog Input A07—Analog Voltage Adjust.** Analog voltage adjust is a feature that the user may choose to enable. The input designated for use as Analog Voltage Adjust is analog input A07.

Enable Analog Voltage Adjust through Menu 11. Additionally, Monitor 2 or Monitor 3 may be used to enable Analog Voltage Adjust by entering the proper description (*Analog Volt Adjust*) for A07. When Analog Voltage Adjust is enabled, the description for A07 is *Analog Volt Adjust*. Changing the description using Monitor 2 or Monitor 3 disables the analog voltage adjust feature.

When Analog Voltage Adjust is enabled, no warning or shutdown may be enabled for A07.

**Note:** If the analog input A07 description does not match *Analog Volt Adjust*, input A07 will **not** function as the voltage adjust.

**Identification and Descriptions.** Descriptions for user inputs (auxiliary analog or auxiliary digital) may be entered using the Monitor III software accessory where the user determines the descriptions in upper and lower case.

**Analog Input Values.** The analog input selection typically requires entering four values: low warning, high warning, low shutdown, and high shutdown. The analog values and time delays affect how and when the controller reacts. See Figure 2-19. The user must set both the high and low levels so the unit will not inadvertently trigger the adjacent high or low value to cause a warning or shutdown fault.

Each analog input has the following nine features:

- One warning enabled and one shutdown enabled
- One inhibit time period
- One warning delay and one shutdown delay
- Two warning levels (high and low)
- Two shutdown levels (high and low)

**Note:** The user must scale the analog input value in order to calculate the low/high warning and shutdown values based on a 0-5 VDC scale. See Menu 12—Calibration.

| Analog Values                                       | Time after Crank Disconnect                                       |  |                        |
|---|---|--|------------------------|
|   | Inhibit Time Period →   | Time Delay Period →  | Time Delay Complete    |
| High shutdown value is above the high warning value | The controller <i>does not</i> view the analog input signal value | The controller <i>does</i> view the analog input signal value and the <i>time delay begins</i> | High shutdown function |
| High warning value is above the acceptable value    |   |  | High warning function  |
| Acceptable analog value                             |   |  | System ready status    |
| Low warning value is below the acceptable value     |   |  | Low warning function   |
| Low shutdown value is below the low warning value   |   |  | Low shutdown function  |

**Figure 2-19** Analog Input Logistics

**Battle Switch/Fault Shutdown Override Switch.** The *battle* switch function forces the system to ignore normal fault shutdowns such as low oil pressure and high engine temperature. The battle switch does not override the emergency stop, overspeed, and overfrequency shutdowns. When the battle switch function is enabled the generator set continues to run regardless of shutdown signals where potential engine/generator damage can occur.

When this input is enabled the yellow warning lamp illuminates and stored warning/shutdown events that are ignored continue to log in Menu 5—Event History.

**Idle Mode Active.** The idle time is defined by the digital input time delay. Set the desired time in minutes:seconds, up to 10 minutes (600 seconds). If manual control of the idle mode is desired, an unlimited time can be entered as 9:99. The generator set will remain at idle speed as long as the input is active and the generator set master switch is in the AUTO position. See Section 6.1.6 for idle mode operation.

**Shutdown Type A and Shutdown Type B.** Choose **shutdown type A** for standard shutdowns where the red lamp illuminates and the alarm horn sounds. Choose **shutdown type B** for shutdowns where air damper indicator RDO-23 energizes for two seconds, the red lamp illuminates, and the alarm horn sounds.

# Menu 9—Input Setup

## Menu 9 Displays with Key Entries

| Key Entry | Display                                    | Description   |
|-----------|--|---|
|           | ENTER MENU NO. 1-15                        | Input a menu number.  |
|           | MAIN MENU NUMBER 9                         | Press the Enter key.  |
|           | MENU 9<br>INPUT SETUP                      | Displays the menu number and name.  |
|           | SETUP DIGITAL<br>AUXILIARY INPUTS →        | Displays the setup of digital auxiliary inputs heading.   |
|           | DIGITAL INPUT 01<br>(USER DEFINED DESC) →  | Displays the digital input 01 with the user-defined description.<br><b>Note:</b> Press the down arrow to move to the start of the next input setup. |
|           | DIGITAL INPUT 01 →<br>(see Group A) YES/NO | Identifies the signal source for digital input 01. Use the menu down ↓ key to select the digital input.   |

### Group A

The preprogrammed selections include the following list. See Appendix E for application and restrictions with specific engines.

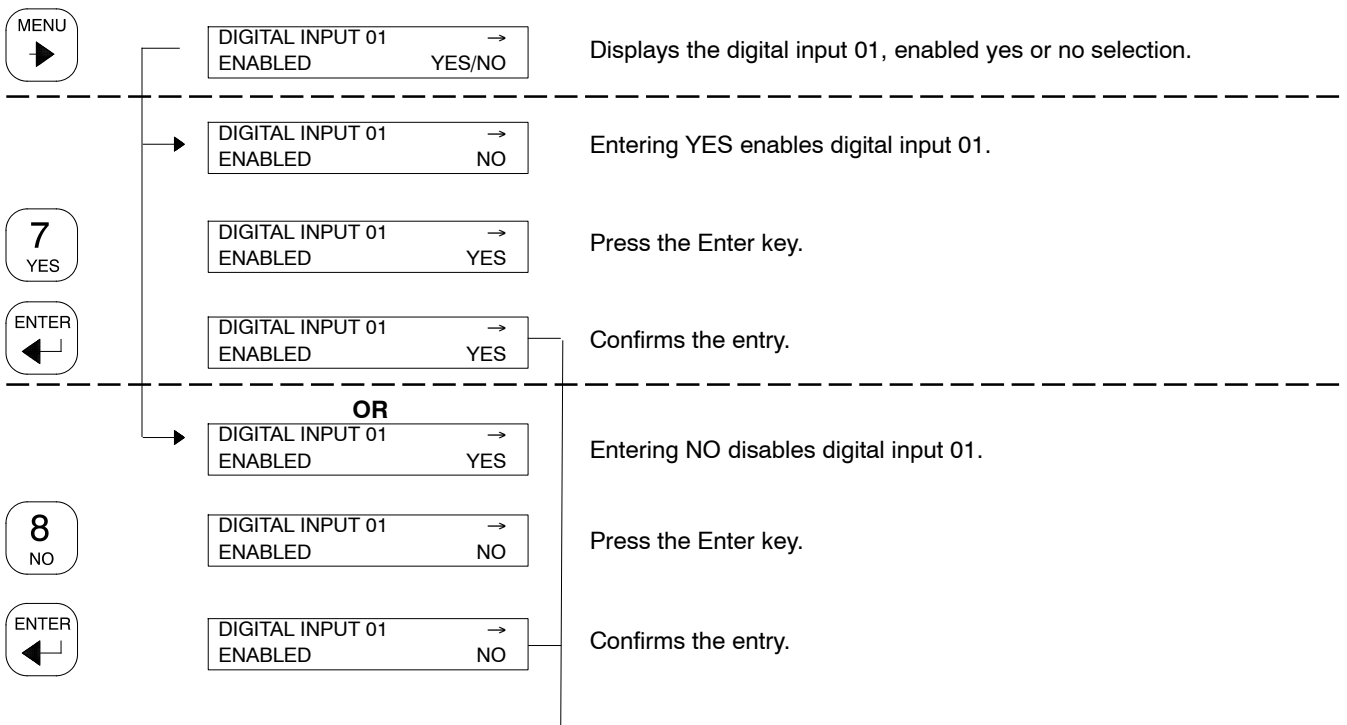
|                 |     |
|-----------------|-----|
| WARNING         | Y/N |
| SHUTDOWN TYPE A | Y/N |
| SHUTDOWN TYPE B | Y/N |
| VOLTAGE RAISE   | Y/N |
| VOLTAGE LOWER   | Y/N |

### Group A, continued

|                   |     |
|-------------------|-----|
| VAR PF MODE       | Y/N |
| REMOTE SHUTDOWN   | Y/N |
| REMOTE RESET      | Y/N |
| AIR DAMPER        | Y/N |
| LOW FUEL          | Y/N |
| FIELD OVERVOLTAGE | Y/N |
| IDLE MODE ACTIVE  | Y/N |
| BATTLE SWITCH     | Y/N |
| GROUND FAULT      | Y/N |
| BAT CHGR FAULT    | Y/N |
| HIGH OIL TEMP     | Y/N |

### Group A, continued

|                   |     |
|-------------------|-----|
| LOW COOLANT LEVEL | Y/N |
| LOW COOLANT TEMP  | Y/N |
| BREAKER CLOSED    | Y/N |
| ENABLE SYNCH      | Y/N |
| AFM SHUTDOWN      | Y/N |
| KNOCK SHUTDOWN    | Y/N |
| DETON WARNING     | Y/N |
| DETON SHUTDOWN    | Y/N |
| LOW FUEL SHUTDOWN | Y/N |





## Menu 9—Input Setup, continued

### Menu 9 Displays with Key Entries

| Key Entry | Display  | Description   |
|-----------|--|---|
|           | DIGITAL INPUT 01<br>INHIBIT TIME           ?::??           | Displays the digital input 01 inhibit time (minutes:seconds) setting. When required, use the numeric keys to set the new values. Press the Enter key.   |
|           | DIGITAL INPUT 01<br>INHIBIT TIME           #:##            | Displays the corrected inhibit time (minutes:seconds) setting.  |
|           | DIGITAL INPUT 01<br>DELAY TIME             ?::??           | Displays the digital input 01 delay time (minutes:seconds) setting. When required, use the numeric keys to set the new values. Press the Enter key.   |
|           | DIGITAL INPUT 01<br>DELAY TIME             #:##            | Displays the corrected delay time (minutes:seconds) setting.  |
|           | DIGITAL INPUT 01<br>(USER DEFINED DESC)                    | Returns the user to digital input 01.   |
|           | DIGITAL INPUT XX<br>(USER DEFINED DESC)                    | Displays digital inputs 02 to 21. <b>Note:</b> Press the down arrow to scroll through additional digital auxiliary inputs or enter the input number. <b>Note:</b> Press the right arrow at each digital auxiliary input to enable the selection, inhibit time setting, and delay time setting. See Digital Input 01 instructions for complete procedure and Group A selections. See Figure 2-8 in User Inputs for factory reserved digital and analog inputs which are not user selectable. |
|           | MENU 9<br>INPUT SETUP                                      | Returns the user to the menu number and name.   |
|           | SETUP DIGITAL<br>AUXILIARY INPUTS                          | Returns the user to setup digital auxiliary inputs.   |
|           | SETUP ANALOG<br>AUXILIARY INPUTS                           | Displays the setup of analog auxiliary inputs heading.  |
|           | ANALOG INPUT 01<br>(USER DEFINED DESC)                     | Displays the analog input 01 with user-defined description. <b>Note:</b> ECM engines have inputs 01–07 and non-ECM engines have inputs 03–07. Waukesha engines have inputs 05–07. <b>Note:</b> Press the down arrow to move to the start of the next input setup.   |
|           | ANALOG INPUT 01<br>WARNING ENABLED       Y/N               | Displays the analog input 01, warning enabled yes or no selection.  |
|           | ANALOG INPUT 01<br>WARNING ENABLED       NO                | Entering YES enables the warning analog input 01.   |
|           | ANALOG INPUT 01<br>WARNING ENABLED       YES               | Press the Enter key.  |
|           | <b>AND</b><br>ANALOG INPUT 01<br>WARNING ENABLED       YES | Confirms the entry.   |
|           | <b>OR</b><br>ANALOG INPUT 01<br>WARNING ENABLED       YES  | Entering NO disables the warning analog input 01.   |
|           | ANALOG INPUT 01<br>WARNING ENABLED       NO                | Press the Enter key.  |
|           | <b>AND</b><br>ANALOG INPUT 01<br>WARNING ENABLED       NO  | Confirms the entry.   |








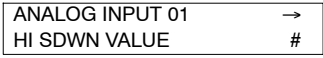

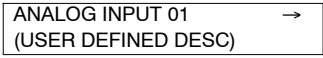

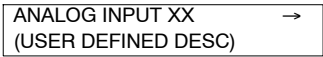



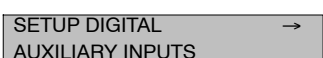
## Menu 9—Input Setup, continued

### Menu 9 Displays with Key Entries

| Key Entry | Display   | Description  |
|-----------|---|--|
| MENU →    | ANALOG INPUT 01<br>SHUTDOWN ENABLED → Y/N               | Displays the analog input 01, shutdown enabled selection.  |
|           | ANALOG INPUT 01<br>SHUTDOWN ENABLED → NO                | Entering YES enables the shutdown analog input 01.   |
| 7<br>YES  | ANALOG INPUT 01<br>SHUTDOWN ENABLED → YES               | Press the Enter key.   |
| ENTER ↵   | <b>AND</b><br>ANALOG INPUT 01<br>SHUTDOWN ENABLED → YES | Confirms the entry.  |
|           | <b>OR</b><br>ANALOG INPUT 01<br>SHUTDOWN ENABLED → YES  | Entering NO disables the shutdown analog input 01.   |
| 8<br>NO   | ANALOG INPUT 01<br>SHUTDOWN ENABLED → NO                | Press the Enter key.   |
| ENTER ↵   | <b>AND</b><br>ANALOG INPUT 01<br>SHUTDOWN ENABLED → NO  | Confirms the entry.  |
| MENU →    | ANALOG INPUT 01<br>INHIBIT TIME → ?:??                  | Displays the analog input 01, inhibit time (minutes:seconds) setting. When required, use the numeric keys to set the new values. Press the Enter key.  |
| ENTER ↵   | ANALOG INPUT 01<br>INHIBIT TIME → #:##                  | Displays the corrected inhibit time (minutes:seconds) setting.   |
| MENU →    | ANALOG INPUT 01<br>WARN DELAY TIME → ?:??               | Displays the analog input 01, warning time (minutes:seconds) delay setting. When required, use the numeric keys to set the new values. Press the Enter key.  |
| ENTER ↵   | ANALOG INPUT 01<br>WARN DELAY TIME → #:##               | Displays the corrected warning time (minutes:seconds) delay setting.   |
| MENU →    | ANALOG INPUT 01<br>SDWN DELAY TIME → ?:??               | Displays the analog input 01, shutdown time (minutes:seconds) delay setting. When required, use the numeric keys to set the new values. Press the Enter key.   |
| ENTER ↵   | ANALOG INPUT 01<br>SDWN DELAY TIME → #:##               | Displays the corrected shutdown time (minutes:seconds) delay setting.  |
| MENU →    | ANALOG INPUT 01<br>LO SDWN VALUE → ?                    | Displays the analog input 01, low shutdown value. When required, use the numeric keys to set the new values. Press the Enter key.<br><b>Note:</b> The user must scale the analog input value in order to calculate the low/high warning and shutdown values based on a 0-5 VDC scale. See Menu 12—Calibration. |
| ENTER ↵   | ANALOG INPUT 01<br>LO SDWN VALUE → #                    | Displays the corrected low shutdown value.   |
| MENU →    | ANALOG INPUT 01<br>LO WARN VALUE → ?                    | Displays the analog input 01, low warning value. When required, use the numeric keys to set the new values. Press the Enter key.<br><b>Note:</b> The user must scale the analog input value in order to calculate the low/high warning and shutdown values based on a 0-5 VDC scale. See Menu 12—Calibration.  |
| ENTER ↵   | ANALOG INPUT 01<br>LO WARN VALUE → #                    | Displays the corrected low warning value.  |

## Menu 9—Input Setup, continued

### Menu 9 Displays with Key Entries

| Key Entry   | Display   | Description  |
|---|---|--|
|    |    | Displays the analog input 01, high warning value. When required, use the numeric keys to set the new values. Press the Enter key.<br><b>Note:</b> The user must scale the analog input value in order to calculate the low/high warning and shutdown values based on a 0–5 VDC scale. See Menu 12—Calibration.   |
|    |    | Displays the corrected high warning value.   |
|    |    | Displays the analog input 01, high shutdown value. When required, use the numeric keys to set the new values. Press the Enter key.<br><b>Note:</b> The user must scale the analog input value in order to calculate the low/high warning and shutdown values based on a 0–5 VDC scale. See Menu 12—Calibration.  |
|    |    | Displays the corrected high shutdown value.  |
|    |    | Returns the user to analog input 01.   |
|    |    | Displays analog inputs A02 to A07. <b>Note:</b> Press the down arrow to scroll through additional analog auxiliary inputs or enter the input number. <b>Note:</b> ECM engines have inputs A01–A07 and non-ECM engines have inputs A03–A07. Waukesha engines have inputs A05–A07.<br><b>Note:</b> Press the right arrow at each analog auxiliary input for the following selections and settings:<br>Warning enabled<br>Shutdown enabled<br>Inhibit time<br>Warning delay time<br>Shutdown delay time<br>Low shutdown value<br>Low warning value<br>High warning value<br>High shutdown value |
|  |  | See the Analog Input 01 instructions for the complete procedure. Returns the user to the setup analog auxiliary input heading.   |
|  |  | Returns the user to the setup digital auxiliary input heading.   |

## 2.9.10 Menu 10—Output Setup

Menu 10 provides setup of the user-defined system, digital and analog status and fault outputs, and relay driver outputs (RDO) 1–31. These outputs provide a multitude of choices for configuring customized auxiliary outputs. Additional individual outputs are available for monitoring, diagnostic, and control functions.

The user must enable the programming mode to edit the display.

**Note:** Some data require entry using a PC in the Remote Programming mode. See the monitor software operation manual for details.

### Common Faults

The user can program a single fault comprised of status and fault events from 3 common fault programs—system, digital, and analog faults.

Up to 66 user-defined *system events* are available, which provide status and fault information. See Group B on the following pages for specific descriptions. The NFPA-110 faults are part of the *system* fault program and are comprised of 15 individual faults shown on this page.

Up to 21 user-defined *digital* status and fault events designated as D01 to D21 are available. Each of the 21 status events and faults are assignable as shutdowns or warnings.

Up to 7 user-defined *analog* status events and faults designated as A01 to A07 are available. Each of the 7 status events and faults are assignable as shutdowns or warnings with high or low settings for a total of up to 7 status events and fault functions.

### Relay Driver Outputs (RDOs)

Up to 31 *RDOs* are available using the system, digital, and analog status events and faults. RDOs provide only the relay driver, not the relay. The contact relays that interface with other equipment are user supplied.

**Note:** *Func(Function) Used by (RDO) XX Reassign?* appears when the user attempts to assign an RDO to a function already assigned.

**Note:** *Cannot Change (because the) NFPA is Enabled* appears when the user attempts to modify an RDO setting that is a NFPA 110 default requirement.

### Software Controlled RDOs (SCRDOs)

The SCRDO is set up and enabled using the keypad or PC. See the monitor software operation manual when reactivating the SCRDO. The user can deactivate an SCRDO at the controller. The user cannot reactivate the SCRDO at the controller. The procedure to deactivate the SCRDO appears at the end of Menu 10—Output Setup, Displays with Entry Keys—Deactivating the SCRDO. The user must enable the programming mode to edit the display.

### NFPA 110 Faults

The 15 NFPA 110 fault alarms include the following:

- Overspeed
- Overcrank
- High Coolant Temperature Shutdown
- Oil Pressure Shutdown
- Low Coolant Temperature
- High Coolant Temperature Warning
- Oil Pressure Warning
- Low Fuel
- Master Not in Auto
- Battery Charger Fault
- Low Battery Voltage
- High Battery Voltage
- Low Coolant Level
- EPS Supplying Load
- Air Damper Indicator

### Defined Common Faults

The 5 defined common faults include the following:

- Emergency Stop
- High Coolant Temperature Shutdown
- Oil Pressure Shutdown
- Overcrank
- Overspeed

# Menu 10—Output Setup

## Menu 10 Displays with Key Entries

| Key Entry     | Display                           | Description   |
|---------------|-----------------------------------|---|
| RESET MENU    | ENTER MENU NO. 1-15               | Input a menu number.  |
| 1 0 LAMP TEST | MAIN MENU NUMBER 10               | Press the Enter key.  |
| ENTER         | MENU 10<br>OUTPUT SETUP           | Displays the menu number and name.  |
| MENU          | DEFINE COMMON FAULTS →            | Displays the common faults heading.   |
| MENU          | SYSTEM EVENTS →                   | Displays the system events heading.   |
| MENU          | COMMON FAULT Y/N<br>(see Group B) | Gives the user the option to add or delete the selection from the defined system events group. Press the Menu Down key to continue to the next selection (repeat as necessary). |
| 7 YES         | COMMON FAULT YES<br>(see Group B) | Press the Enter key.  |
| ENTER         | COMMON FAULT YES<br>(see Group B) | Confirms the entry.   |
| <b>OR</b>     |                                   |   |
| 8 NO          | COMMON FAULT YES<br>(see Group B) | Entering NO removes the selection from the defined system event group.  |
| ENTER         | COMMON FAULT NO<br>(see Group B)  | Press the Enter key.  |
| ENTER         | COMMON FAULT NO<br>(see Group B)  | Confirms the entry.   |

**Group B**  
**For defined system events, choose from the following 66 status events and faults by changing selection to YES. See Appendix E for application and restrictions with specific engines.**  
 EMERGENCY STOP  
 OVER SPEED  
 OVER CRANK  
 HI COOL TEMP SHUTDWN  
 OIL PRESS SHUTDOWN  
 LOW COOLANT TEMP (non-ECM engines)  
 LOW FUEL  
 HI COOL TEMP WARNING  
 OIL PRES WARNING  
 MASTER NOT IN AUTO  
 NFPA 110 FAULT (see Menu 10 introduction for list)  
 LOW BATTERY VOLTAGE  
 HIGH BATTERY VOLTAGE  
 BATTERY CHARGE FAULT  
 SYSTEM READY  
 LOSS OF ECM COMM (ECM engines)

**Group B, continued**  
 NO OIL PRESS SIGNAL  
 HI OIL TEMP  
 NO COOL TEMP SIGNAL  
 LOW COOLANT LEVEL  
 SPEED SENSOR FAULT  
 LOCKED ROTOR  
 MASTER SWITCH ERROR  
 MASTER SWITCH OPEN  
 MASTER SWITCH TO OFF  
 AC SENSING LOSS  
 OVER VOLTAGE  
 UNDER VOLTAGE  
 WEAK BATTERY  
 OVER FREQUENCY  
 UNDER FREQUENCY  
 LOAD SHED KW OVER  
 LOAD SHED UNDER FREQ  
 OVER CURRENT  
 EPS SUPPLYING LOAD  
 INTERNAL FAULT  
 DELAY ENG COOLDOWN  
 DELAY ENG START  
 STARTING AID  
 GENERATOR SET RUNNING

**Group B, continued**  
 AIR DAMPER CONTROL  
 GROUND FAULT  
 EEPROM WRITE FAILURE  
 CRITICAL OVERVOLTAGE  
 ALTERNATOR PROTECTION SHUTDOWN  
 AIR DAMPER INDICATOR  
 DEFINED COMMON FAULT (RDO only) (see Menu 10 introduction for list)  
 SCRDOs 1-4 (software controlled RDOs)  
 MAINTENANCE DUE  
 ENGINE DERATE ACTIVE  
 ENGINE STALLED (ECM engine)  
 J1939 CAN SHUTDOWN (ECM engine)  
**Paralleling Applications only:**  
 SD REVERSE POWER  
 SD OVER POWER  
 SD LOSS OF FIELD  
 SD OVERCURRENT PR  
 COMMON PR OUTPUT  
 IN SYNCH  
 BREAKER TRIP

**Group B, continued Waukesha-Powered models only:**  
 FUEL VALVE RELAY  
 PRELUBE RELAY  
 AFM REMOTE START  
 NO OIL TEMP SIGNAL  
 HI OIL TEMP WARNING  
 NO AIR TEMP SIGNAL  
 INTAKE AIR TEMP WARN  
 INTAKE AIR TEMP SDWN  
 AFM ENG START RELAY  
**DDC/MTU engine with MDEC/ADEC only:**  
 HI OIL TEMP WARNING  
 INTAKE AIR TEMP WARN  
 INTAKE AIR TEMP SDWN  
 ECM YELLOW ALARM  
 ECM RED ALARM  
 BLOCK HEATER CONTROL  
 LOW COOL TEMP SDOWN  
 LOAD SHED OVER TEMP  
**1750/2000REOZMD only:**  
 TURBO TEMP WARNING  
 TURBO TEMP SHUTDOWN

# Menu 10—Output Setup, continued

## Menu 10 Displays with Key Entries

| Key Entry  | Display   | Description   |
|--|---|---|
|  | DIGITAL INPUTS →                                    | Displays the digital inputs heading.  |
|  | COMMON FAULT Y/N<br>Dxx (see Group C)               | Gives the user the option to add or delete selection from the defined digital faults starting with D01. <b>Note:</b> Press the Menu Down key to continue to the next selection D02–D21 (repeat as necessary). |
|  | COMMON FAULT NO<br>Dxx (see Group C)                | Entering YES adds the selection to the defined digital fault group.   |
|  | COMMON FAULT YES<br>Dxx (see Group C)               | Press the Enter key.  |
|  | COMMON FAULT YES<br>Dxx (see Group C)               | Confirms the entry.   |
| <b>OR</b>  |   |   |
|  | COMMON FAULT YES<br>Dxx (see Group C)               | Entering NO removes the selection from the defined digital fault group.   |
|  | COMMON FAULT NO<br>Dxx (see Group C)                | Press the Enter key.  |
|  | COMMON FAULT NO<br>Dxx (see Group C)                | Confirms the entry.   |
| <p><b>Group C</b><br/>Up to 21 PC user-defined digital status and fault inputs designated as D01 to D21 can result in a digital input common fault.</p>  |   |   |
|  | ANALOG INPUTS →                                     | Displays the analog inputs heading.   |
|  | COMMON FAULT Y/N<br>Axx(see Group D) LO<br>WARNING→ | Gives the user the option to add or delete selection from the defined analog faults starting with A01. <b>Note:</b> Press the Menu Down key to continue to the next selection A02–A07 (repeat as necessary).  |
| <p><b>Group D</b><br/>Up to 7 analog inputs, PC user-defined status events and faults designated as A01 to A07. Each of the 7 is assignable as a shutdown or warning with high and low settings.</p> |   |   |

# Menu 10—Output Setup, continued

## Menu 10 Displays with Key Entries

| Key Entry | Display  | Description   |
|-----------|--|---|
| (A)       | COMMON FAULT Y/N<br>A01 LO WARNING→  | Indicates whether the previously user-defined analog output was selected (yes or no) as a low warning fault.  |
| 7<br>YES  | COMMON FAULT NO<br>A01 LO WARNING→<br>COMMON FAULT YES<br>A01 LO WARNING→              | Entering YES adds the low warning selection to the defined analog fault group.<br>Press the Enter key.        |
| ENTER     | COMMON FAULT YES<br>A01 LO WARNING→  | Confirms the entry.   |
| 8<br>NO   | <b>OR</b><br>COMMON FAULT YES<br>A01 LO WARNING→<br>COMMON FAULT NO<br>A01 LO WARNING→ | Entering NO removes the low warning selection from the defined analog fault group.<br>Press the Enter key.    |
| ENTER     | COMMON FAULT NO<br>A01 LO WARNING→   | Confirms the entry.   |
| MENU      | COMMON FAULT Y/N<br>A01 HI WARNING→  | Indicates whether the previously user-defined analog output was selected (yes or no) as a high warning fault. |
| 7<br>YES  | COMMON FAULT NO<br>A01 HI WARNING→<br>COMMON FAULT YES<br>A01 HI WARNING→              | Entering YES adds the high warning selection to the defined analog fault group.<br>Press the Enter key.       |
| ENTER     | COMMON FAULT YES<br>A01 HI WARNING→  | Confirms the entry.   |
| 8<br>NO   | <b>OR</b><br>COMMON FAULT YES<br>A01 HI WARNING→<br>COMMON FAULT NO<br>A01 HI WARNING→ | Entering NO removes the high warning selection from the defined analog fault group.<br>Press the Enter key.   |
| ENTER     | COMMON FAULT NO<br>A01 HI WARNING→   | Confirms the entry.   |

# Menu 10—Output Setup, continued

## Menu 10 Displays with Key Entries

| Key Entry  | Display   | Description   |
|------------|---|---|
| MENU<br>→  | COMMON FAULT Y/N<br>A01 LO SHUTDOWN→  | Indicates whether the previously user-defined analog output was selected (yes or no) as a low shutdown fault.   |
| 7<br>YES   | COMMON FAULT NO<br>A01 LO SHUTDOWN→   | Entering YES adds the low shutdown selection to the defined analog fault group.   |
| ENTER<br>↵ | COMMON FAULT YES<br>A01 LO SHUTDOWN→  | Press the Enter key.  |
| ENTER<br>↵ | COMMON FAULT YES<br>A01 LO SHUTDOWN→  | Confirms the entry.   |
| 8<br>NO    | OR<br>COMMON FAULT YES<br>A01 LO SHUTDOWN→  | Entering NO removes the low shutdown selection from the defined analog fault group.   |
| ENTER<br>↵ | COMMON FAULT NO<br>A01 LO SHUTDOWN→   | Press the Enter key.  |
| ENTER<br>↵ | COMMON FAULT NO<br>A01 LO SHUTDOWN→   | Confirms the entry.   |
| MENU<br>→  | COMMON FAULT Y/N<br>A01 HI SHUTDOWN→  | Indicates whether the previously user-defined analog output was selected (yes or no) as a high shutdown fault.  |
| 7<br>YES   | COMMON FAULT NO<br>A01 HI SHUTDOWN→   | Entering YES adds the high shutdown selection to the defined analog fault group.  |
| ENTER<br>↵ | COMMON FAULT YES<br>A01 HI SHUTDOWN→  | Press the Enter key.  |
| ENTER<br>↵ | COMMON FAULT YES<br>A01 HI SHUTDOWN→  | Confirms the entry.   |
| 8<br>NO    | OR<br>COMMON FAULT YES<br>A01 HI SHUTDOWN→  | Entering NO removes the high shutdown selection from the defined analog fault group.  |
| ENTER<br>↵ | COMMON FAULT NO<br>A01 HI SHUTDOWN→   | Press the Enter key.  |
| ENTER<br>↵ | COMMON FAULT NO<br>A01 HI SHUTDOWN→   | Confirms the entry.   |
| MENU<br>→  | COMMON FAULT Y/N<br>A01 LO WARNING→   | Returns the user to common fault (analog inputs) heading. Press the Menu Down key to continue to the next selection A02–A07 (repeat as necessary).  |
| MENU<br>↓  | COMMON FAULT Y/N<br>Axx(see Group D) LO<br>WARNING→<br><b>Group D</b><br>Up to 7 analog inputs, PC user-defined status events and faults designated as A01 to A07. Each of the 7 is assignable as a shutdown or warning with high and low settings. | Gives the user the option to add or delete selection from the next defined analog fault. <b>Note:</b> Use the A01 common fault analog input setup procedure shown above for A02–A07. Go to <b>A</b> |



# Menu 10—Output Setup, continued

## Menu 10 Displays with Key Entries

| Key Entry | Display                            | Description   |
|-----------|------------------------------------|---|
|           | ANALOG INPUTS →                    | Returns the user to analog inputs heading.  |
|           | DEFINE COMMON FAULTS →             | Returns the user to the define common faults heading.   |
| ©         | RELAY DRV OUT 01 (user defined) →  | Gives the user previously selected items for relay driver outputs (RDO) starting with 01. <b>Note:</b> Press the down arrow to continue to the next relay driver output 02-31 or enter the RDO number.<br><b>Note:</b> The RDO can be assigned from the SYSTEM EVENTS, DIGITAL INPUTS, or ANALOG INPUTS groups. The start of each of these groups are highlighted on the following pages. |
|           | SYSTEM EVENTS →                    | Displays the system events heading.   |
| <hr/>     |                                    |   |
|           | RELAY DRV OUT 01 Y/N (see Group B) | Gives the user the option to assign a system event to an RDO. Press the Menu Down key to continue to the next selection (repeat as necessary).  |
|           | RELAY DRV OUT 01 NO (see Group B)  | Entering YES adds the selection to the RDO group.<br><b>Note:</b> <i>Func(Function) Used by (RDO) XX Reassign?</i> appears when the user attempts to assign an RDO to a function already assigned.<br><b>Note:</b> <i>Cannot Change (because the) NFPA is Enabled</i> appears when the user attempts to modify the RDO setting that is a NFPA 110 default requirement.                    |
|           | RELAY DRV OUT 01 YES (see Group B) | Press the Enter key.  |
|           | RELAY DRV OUT 01 YES (see Group B) | Confirms the entry.   |

### Group B

For defined system events, choose from the following 66 status events and faults by changing selection to YES. See Appendix E for application and restrictions with specific engines.

- EMERGENCY STOP
- OVER SPEED
- OVER CRANK
- HI COOL TEMP SHUTDWN
- OIL PRESS SHUTDOWN
- LOW COOLANT TEMP (non-ECM engines)
- LOW FUEL
- HI COOL TEMP WARNING
- OIL PRES WARNING
- MASTER NOT IN AUTO
- NFPA 110 FAULT\*
- LOW BATTERY VOLTAGE
- HIGH BATTERY VOLTAGE
- BATTERY CHARGE FAULT
- SYSTEM READY
- LOSS OF ECM COMM (ECM engines)
- NO OIL PRESS SIGNAL
- HI OIL TEMP
- NO COOL TEMP SIGNAL
- LOW COOLANT LEVEL
- SPEED SENSOR FAULT
- LOCKED ROTOR
- MASTER SWITCH ERROR
- MASTER SWITCH OPEN

### Group B, continued

- MASTER SWITCH TO OFF
- AC SENSING LOSS
- OVER VOLTAGE
- UNDER VOLTAGE
- WEAK BATTERY
- OVER FREQUENCY
- UNDER FREQUENCY
- LOAD SHED KW OVER
- LOAD SHED UNDER FREQ
- OVER CURRENT
- EPS SUPPLYING LOAD
- INTERNAL FAULT
- DELAY ENG COOLDOWN
- DELAY ENG START
- STARTING AID
- GENERATOR SET RUNNING
- AIR DAMPER CONTROL
- GROUND FAULT
- EEPROM WRITE FAILURE
- CRITICAL OVERVOLTAGE
- ALTERNATOR PROTECTION SHUTDOWN
- AIR DAMPER INDICATOR
- DEFINED COMMON FAULT (RDO only)†
- SCRDOs 1-4 (software controlled RDOs)
- MAINTENANCE DUE
- ENGINE DERATE ACTIVE
- ENGINE STALLED (ECM engines)
- J1939 CAN ENGINE SHUTDOWN (ECM engines)

### Group B, continued

**Paralleling Applications:**

- SD REVERSE POWER
- SD OVER POWER
- SD LOSS OF FIELD
- SD OVERCURRENT PR
- COMMON PR OUTPUT
- IN SYNCH
- BREAKER TRIP

**Waukesha-powered models:**

- FUEL VALVE RELAY
- PRELUBE RELAY
- AFM REMOTE START
- NO OIL TEMP SIGNAL
- HI OIL TEMP WARNING
- NO AIR TEMP SIGNAL
- INTAKE AIR TEMP WARN
- INTAKE AIR TEMP SDWN
- AFM ENG START DELAY

**DDC/MTU engine with MDEC/ADEC:**

- HI OIL TEMP WARNING
- INTAKE AIR TEMP WARN
- INTAKE AIR TEMP SDWN
- ECM YELLOW ALARM
- ECM RED ALARM
- BLOCK HEATER CONTROL
- LOW COOL TEMP SDOWN
- LOAD SHED OVER TEMP

**1750/2000REOZMD only:**

- TURBO TEMP WARNING
- TURBO TEMP SHUTDOWN

### \*NFPA 110 FAULT

The 15 NFPA-110 Fault Alarms include the following:

- OVERSPEED
- OVERCRANK
- HIGH COOLANT TEMP SHUTDOWN
- OIL PRESSURE SHUTDOWN
- LOW COOLANT TEMPERATURE
- HIGH COOLANT TEMP WARNING
- OIL PRESSURE WARNING
- LOW FUEL
- MASTER NOT IN AUTO
- BATTERY CHARGER FAULT
- LOW BATTERY VOLTAGE
- HIGH BATTERY VOLTAGE
- LOW COOLANT LEVEL
- EPS SUPPLYING LOAD
- AIR DAMPER INDICATOR







†DEFINED COMMON FAULT

The 5 defined common faults include the following:

- EMERGENCY STOP
- HI COOL TEMP SHUTDOWN
- OIL PRESS SHUTDOWN
- OVERCRANK
- OVERSPEED

# Menu 10—Output Setup, continued

## Menu 10 Displays with Key Entries

| Key Entry   | Display  | Description  |
|---|--|--|
|    | DIGITAL INPUTS →   | Displays the digital inputs heading.   |
|    | RELAY DRV OUT 01 Y/N<br>Dxx (see Group C)  | Gives the user the option to assign a digital input to an RDO starting with D01. Press the Menu Down key to continue to the next selection D02-D21 (repeat as necessary).<br><br><b>Note:</b> <i>Func(Function) Used by (RDO) XX Reassign?</i> appears when the user attempts to assign an RDO to a function already assigned.   |
| <hr/>   |  |  |
|   | RELAY DRV OUT 01 NO<br>Dxx (see Group C)   | Entering YES adds the selection to the RDO group.<br><b>Note:</b> <i>Func(Function) Used by (RDO) XX Reassign?</i> appears when the user attempts to assign an RDO to a function already assigned.<br><b>Note:</b> <i>Cannot Change (because the) NFPA is Enabled</i> appears when the user attempts to modify the RDO setting that is a NFPA 110 default requirement. |
|    | RELAY DRV OUT 01 YES<br>Dxx (see Group C)  | Press the Enter key.   |
|    | RELAY DRV OUT 01 YES<br>Dxx (see Group C)  | Confirms the entry.  |
|   | <b>Group C</b><br>Up to user-defined digital status and fault inputs designated as D01 to D21 can result in a digital input common fault.  |  |
| <hr/>   |  |  |
|  | ANALOG INPUTS →  | Displays the analog inputs heading.  |
|  | RELAY DRV OUT 01 Y/N<br>Axx(see Group D) LO<br>WARNING→  | Gives the user the option to assign an analog input to an RDO starting with A01. <b>Note:</b> Press the Menu Down key to continue to the next selection A02-A07 (repeat as necessary).   |
|   | <b>Group D</b><br>Up to 7 analog inputs, user-defined status events and faults designated as A01 to A07. Each of the 7 is assignable as a shutdown or warning with high or low settings. |  |
| <hr/>   |  |  |

# Menu 10—Output Setup, continued

## Menu 10 Displays with Key Entries

| Key Entry  | Display                                 | Description  |
|------------|---|--|
| MENU<br>▶  | RELAY DRV OUT 01 Y/N<br>A01 LO WARNING→ | Indicates whether the previously user-defined analog RDO was selected (yes or no) as a low warning fault.  |
| 7<br>YES   | RELAY DRV OUT 01 NO<br>A01 LO WARNING→  | Entering YES adds the low warning selection to the defined analog RDO group.                               |
| ENTER<br>↵ | RELAY DRV OUT 01 YES<br>A01 LO WARNING→ | Press the Enter key.   |
| ENTER<br>↵ | RELAY DRV OUT 01 YES<br>A01 LO WARNING→ | Confirms the entry.  |
| <b>OR</b>  |   |  |
| 8<br>NO    | RELAY DRV OUT 01 YES<br>A01 LO WARNING→ | Entering NO removes the low warning selection from the defined analog RDO group.                           |
| ENTER<br>↵ | RELAY DRV OUT 01 NO<br>A01 LO WARNING→  | Press the Enter key.   |
| ENTER<br>↵ | RELAY DRV OUT 01 NO<br>A01 LO WARNING→  | Confirms the entry.  |
| MENU<br>▶  | RELAY DRV OUT 01 Y/N<br>A01 HI WARNING→ | Indicates whether the previously user-defined analog RDO was selected (yes or no) as a high warning fault. |
| 7<br>YES   | RELAY DRV OUT 01 NO<br>A01 HI WARNING→  | Entering YES adds the high warning selection to the defined analog RDO group.                              |
| ENTER<br>↵ | RELAY DRV OUT 01 YES<br>A01 HI WARNING→ | Press the Enter key.   |
| ENTER<br>↵ | RELAY DRV OUT 01 YES<br>A01 HI WARNING→ | Confirms the entry.  |
| <b>OR</b>  |   |  |
| 8<br>NO    | RELAY DRV OUT 01 YES<br>A01 HI WARNING→ | Entering NO removes the high warning selection from the defined analog RDO group.                          |
| ENTER<br>↵ | RELAY DRV OUT 01 NO<br>A01 HI WARNING→  | Press the Enter key.   |
| ENTER<br>↵ | RELAY DRV OUT 01 NO<br>A01 HI WARNING→  | Confirms the entry.  |

## Menu 10—Output Setup, continued

### Menu 10 Displays with Key Entries

| Key Entry  | Display   | Description   |
|------------|---|---|
| MENU<br>▶  | RELAY DRV OUT 01 Y/N<br>A01 LO SHUTDOWN→                | Indicates whether the previously user-defined analog RDO was selected (yes or no) as a low shutdown fault.  |
| 7<br>YES   | RELAY DRV OUT 01 NO<br>A01 LO SHUTDOWN→                 | Entering YES adds the low shutdown selection to the defined analog RDO group.   |
| ENTER<br>↵ | RELAY DRV OUT 01 YES<br>A01 LO SHUTDOWN→                | Press the Enter key.  |
| ENTER<br>↵ | RELAY DRV OUT 01 YES<br>A01 LO SHUTDOWN→                | Confirms the entry.   |
| OR         |   |   |
| 8<br>NO    | RELAY DRV OUT 01 YES<br>A01 LO SHUTDOWN→                | Entering NO removes the low shutdown selection from the defined analog RDO group.   |
| ENTER<br>↵ | RELAY DRV OUT 01 NO<br>A01 LO SHUTDOWN→                 | Press the Enter key.  |
| ENTER<br>↵ | RELAY DRV OUT 01 NO<br>A01 LO SHUTDOWN→                 | Confirms the entry.   |
| MENU<br>▶  | RELAY DRV OUT 01 Y/N<br>A01 HI SHUTDOWN→                | Indicates whether the previously user-defined analog RDO was selected (yes or no) as a high shutdown fault.   |
| 7<br>YES   | RELAY DRV OUT 01 NO<br>A01 HI SHUTDOWN→                 | Entering YES adds the high shutdown selection to the defined analog RDO group.  |
| ENTER<br>↵ | RELAY DRV OUT 01 YES<br>A01 HI SHUTDOWN→                | Press the Enter key.  |
| ENTER<br>↵ | RELAY DRV OUT 01 YES<br>A01 HI SHUTDOWN→                | Confirms the entry.   |
| OR         |   |   |
| 8<br>NO    | RELAY DRV OUT 01 YES<br>A01 HI SHUTDOWN→                | Entering NO removes the high shutdown selection from the defined analog RDO group.  |
| ENTER<br>↵ | RELAY DRV OUT 01 NO<br>A01 HI SHUTDOWN→                 | Press the Enter key.  |
| ENTER<br>↵ | RELAY DRV OUT 01 NO<br>A01 HI SHUTDOWN→                 | Confirms the entry.   |
| MENU<br>▶  | RELAY DRV OUT 01 Y/N<br>A01 LO WARNING→                 | Returns the user to the analog RDO (analog inputs) heading. Press the Menu Down key to continue to the next selection A02-A07 (repeat as necessary).                          |
| MENU<br>▼  | RELAY DRV OUT 01 Y/N<br>Axx(see Group D) LO<br>WARNING→ | Gives the user the option to add or delete a selection for the next analog RDO. <b>Note:</b> Use the A01 analog RDO setup procedure shown above for A02-A07. Go to <b>(B)</b> |
| MENU<br>▼  | ANALOG INPUTS →   | Returns the user to the analog inputs heading. Press the Menu Right key.  |
| MENU<br>▶  | RELAY DRV OUT 01 →<br>(user defined)                    | Returns the user to the RDO 01 heading.   |
| MENU<br>▼  | RELAY DRV OUT XX →<br>(user defined)                    | Gives the user the option to add or delete a selection for the next RDO. <b>Note:</b> Use the RDO 01 setup procedure shown above for RDOs 02-31. Go to <b>(C)</b>             |

## Menu 10—Output Setup, continued

### Menu 10 Displays with Key Entries— Deactivating the SCRDO

| Key Entry     | Display                                    | Description  |
|---------------|--|--|
| RESET MENU    | ENTER MENU NO. 1-15                        | Input a menu number.   |
| 1 0 LAMP TEST | MAIN MENU NUMBER 10                        | Press the Enter key.   |
| ENTER         | MENU 10<br>OUTPUT SETUP                    | Displays the menu number and name  |
| MENU          | DEFINE COMMON FAULTS →                     | Displays the common faults heading.  |
| MENU          | RELAY DRV OUT XX →<br>S'WARE CONTROLLED #X | Gives the user previously selected items for the relay driver outputs (RDO). Press the down arrow to scroll through relay driver outputs 1-31 or enter the RDO number. Locate the SCRDO display. |
| MENU          | DEACTIVATE RDO? →                          | When required (SCRDO is currently active), enter the YES key to deactivate the SCRDO.  |
| 7 YES         | DEACTIVATE RDO? YES →                      | Press the Enter key.   |
| ENTER         | RELAY DRV OUT XX →<br>S'WARE CONTROLLED #X |  |

## 2.9.11 Menu 11—Voltage Regulator

Menu 11 provides the setup of the voltage regulator functions including the line-to-line voltages, underfrequency unloading (volts per Hz), reactive droop, power factor, and kVAR adjustments. See Section 1.3.3, Voltage Regulator Adjustments, and Appendix C, Voltage Regulator Definitions and Adjustments, for additional information.

The user must enable the programming mode to edit the display.

**Note:** Press the Menu Right → key prior to entering the decimal values where necessary.












**Note:** 350–2000 kW models only, see 1.3.2 Voltage Regulator and Calibration Specifications regarding the use of the Marathon® DVR® 2000 voltage regulator on some earlier generator sets.

**Analog Voltage Adjust.** Analog input A07 is the voltage adjustment for paralleling applications only. This input adjusts the input up or down from the value entered in Menu 11, Voltage Regulator. If the keypad entry does not match the displayed value for voltage adjust, the analog input is likely not at zero (2.5 VDC). Analog input A07 can be monitored or checked in Menu 3, Analog Monitoring.

**Note:** Utility paralleling applications require enabling the VAR/PF controls. The Utility Gain Adjust is used for VAR or PF stability adjustment while paralleling to a utility.

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### Menu 11—Voltage Regulator Menu 11 Displays with Key Entries

| Key Entry   | Display                            | Description   |
|---|------------------------------------|---|
|    | ENTER MENU NO. 1-15                | Input a menu number.  |
|   | MAIN MENU NUMBER 11                | Press the Enter key.  |
|    | MENU 11<br>VOLTAGE REGULATOR       | Displays the menu number and name.  |
| <hr/>   |                                    |   |
|    | AVG L-L V #→<br>VOLT ADJ ??        | Displays the average running line-to-line volts and voltage adjustment. Enter the desired nominal voltage using the numeric keys. Press the Menu Right → key prior to entering the decimal value. |
|    | AND<br>AVG L-L V #→<br>VOLT ADJ ?? | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
|    | AVG L-L V #→<br>VOLT ADJ ##        | Confirms the entry.   |
| <hr/>   |                                    |   |
|    | L1-L2 VOLTS →<br>#                 | Displays L1-L2 volts.   |
|    | L2-L3 VOLTS →<br>#                 | Displays L2-L3 volts (3 phase only).  |
|    | L3-L1 VOLTS →<br>#                 | Displays L3-L1 volts (3 phase only).  |
|    | AVG L-L V #→<br>VOLT ADJ #         | Returns the user to the average line-to-line volts and voltage adjustment heading.  |

## Menu 11—Voltage Regulator, continued

### Menu 11 Displays with Key Entries

| Key Entry  | Display                            | Description   |
|------------|------------------------------------|---|
| MENU<br>↓  | UNDER FREQ UNLOAD →<br>ENABLED N/Y | Displays the under frequency (volts per Hz) unloading (yes or no) selection.  |
| 7<br>YES   | UNDER FREQ UNLOAD →<br>ENABLED NO  | Entering YES enables the underfrequency unloading feature.  |
| ENTER<br>↵ | UNDER FREQ UNLOAD →<br>ENABLED YES | Press the Enter key.  |
| ENTER<br>↵ | UNDER FREQ UNLOAD →<br>ENABLED YES | Confirms the entry.   |
| OR         |                                    |   |
| 8<br>NO    | UNDER FREQ UNLOAD →<br>ENABLED YES | Entering NO disables the underfrequency unloading feature.  |
| ENTER<br>↵ | UNDER FREQ UNLOAD →<br>ENABLED NO  | Press the Enter key.  |
| ENTER<br>↵ | UNDER FREQ UNLOAD →<br>ENABLED NO  | Confirms the entry.   |
| MENU<br>→  | FREQUENCY # HZ→<br>SETPOINT ?.? HZ | Displays the present operating frequency and underfrequency unloading cut-in point. Enter the desired underfrequency cut-in point using the numeric keys. Press the Menu Right → key prior to entering the decimal value. |
| AND        |                                    |   |
| MENU<br>→  | FREQUENCY # HZ→<br>SETPOINT ?.? HZ | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
| ENTER<br>↵ | FREQUENCY # HZ→<br>SETPOINT ## HZ  | Confirms the entry.   |
| MENU<br>→  | SLOPE →<br>?.? VOLTS-PER-CYCLE     | Displays the underfrequency unloading slope (volts-per-cycle). Enter the desired underfrequency unloading slope using the numeric keys. Press the Menu Right → key prior to entering the decimal value.                   |
| AND        |                                    |   |
| MENU<br>→  | SLOPE →<br>?.? VOLTS-PER-CYCLE     | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
| ENTER<br>↵ | SLOPE →<br>## VOLTS-PER-CYCLE      | Confirms the entry.   |
| MENU<br>→  | UNDER FREQ UNLOAD →<br>ENABLED N/Y | Returns the user to the underfrequency unloading heading.   |

# Menu 11—Voltage Regulator, continued

## Menu 11 Displays with Key Entries

| Key Entry  | Display                                   | Description   |
|------------|---|---|
| MENU<br>↓  | REACTIVE DROOP →<br>ENABLED N/Y           | Displays the reactive droop selection (yes or no).  |
| <hr/>      |   |   |
| 7<br>YES   | REACTIVE DROOP →<br>ENABLED NO            | Entering YES enables the reactive droop feature.  |
| ENTER<br>↵ | REACTIVE DROOP →<br>ENABLED YES           | Press the Enter key.  |
| ENTER<br>↵ | REACTIVE DROOP →<br>ENABLED YES           | Confirms the entry.   |
| <hr/>      |   |   |
| <b>OR</b>  |   |   |
| 8<br>NO    | REACTIVE DROOP →<br>ENABLED YES           | Entering NO disables the reactive droop feature.  |
| ENTER<br>↵ | REACTIVE DROOP →<br>ENABLED NO            | Press the Enter key.  |
| ENTER<br>↵ | REACTIVE DROOP →<br>ENABLED NO            | Confirms the entry.   |
| <hr/>      |   |   |
| MENU<br>→  | .8 PF RATED LOAD →<br>VOLTAGE DROOP ?.?%  | Displays the reactive (voltage) droop as a percentage of the rated voltage at rated load. When required, enter the desired reactive droop using the numeric keys. Press the Menu Right → key prior to entering the decimal value. |
| <hr/>      |   |   |
| <b>AND</b> |   |   |
| MENU<br>→  | .8 PF RATED LOAD →<br>VOLTAGE DROOP ?.?%  | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
| ENTER<br>↵ | .8 PF RATED LOAD →<br>VOLTAGE DROOP #.##% | Confirms the entry.   |
| <hr/>      |   |   |



# Menu 11—Voltage Regulator, continued

## Menu 11 Displays with Key Entries

| Key Entry  | Display                            | Description   |
|------------|------------------------------------|---|
| MENU<br>→  | REACTIVE DROOP<br>ENABLED →<br>N/Y | Returns the user to reactive droop selection heading.   |
| MENU<br>↓  | VAR CONTROL<br>ENABLED →<br>N/Y    | Displays the VAR control selection (yes or no).   |
| 7<br>YES   | VAR CONTROL<br>ENABLED →<br>NO     | Entering YES enables the VAR control feature.<br><b>Note:</b> A YES entry disables the PF control if previously activated.  |
| ENTER<br>↵ | VAR CONTROL<br>ENABLED →<br>YES    | Press the Enter key.  |
| ENTER<br>↵ | VAR CONTROL<br>ENABLED →<br>YES    | Confirms the entry.   |
| OR         |                                    |   |
| 8<br>NO    | VAR CONTROL<br>ENABLED →<br>YES    | Entering NO disables the VAR control feature.   |
| ENTER<br>↵ | VAR CONTROL<br>ENABLED →<br>NO     | Press the Enter key.  |
| ENTER<br>↵ | VAR CONTROL<br>ENABLED →<br>NO     | Confirms the entry.   |
| MENU<br>→  | TOTAL KVAR #→<br>KVAR ADJ ??       | Displays total kVAR (running) and kVAR adjustment settings. Enter the desired kVAR adjustment using the numeric keys. Press the Menu Right → key prior to entering the decimal value.                   |
| AND        |                                    |   |
| MENU<br>→  | TOTAL KVAR #→<br>KVAR ADJ ??       | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
| ENTER<br>↵ | TOTAL KVAR #→<br>KVAR ADJ ##       | Confirms the entry.   |
| MENU<br>→  | GENERATING/<br>ABSORBING N/Y→      | Displays the generating <i>or</i> absorbing kVAR selection.<br><b>Note:</b> The display sample may differ depending upon the previous entries. The generating selection is the factory default setting. |
| OR         |                                    |   |
| 8<br>NO    | GENERATING YES→                    | Displays the generating kVAR selection. When required, use the NO key to choose absorbing kVAR.   |
| ENTER<br>↵ | GENERATING NO→                     | Press the Enter key.  |
| ENTER<br>↵ | ABSORBING YES→                     | Confirms the entry.   |
| OR         |                                    |   |
| 8<br>NO    | ABSORBING YES→                     | Displays the absorbing kVAR selection. When required, use the NO key to choose generating kVAR.   |
| ENTER<br>↵ | ABSORBING NO→                      | Press the Enter key.  |
| ENTER<br>↵ | GENERATING YES→                    | Confirms the entry.   |
| MENU<br>→  | VAR CONTROL<br>ENABLED →<br>N/Y    | Returns the user to VAR control selection heading.  |









# Menu 11—Voltage Regulator, continued

## Menu 11 Displays with Key Entries

| Key Entry  | Display                        | Description   |
|------------|--------------------------------|---|
| MENU<br>▼  | PF CONTROL<br>ENABLED →<br>N/Y | Displays the power factor control selection (yes or no).  |
| 7<br>YES   | PF CONTROL<br>ENABLED →<br>NO  | Entering YES enables the power factor control feature.<br><b>Note:</b> A YES entry disables the kVAR control if previously activated.   |
| ENTER<br>↵ | PF CONTROL<br>ENABLED →<br>YES | Press the Enter key.  |
| 8<br>NO    | PF CONTROL<br>ENABLED →<br>YES | Confirms the entry.   |
| <b>OR</b>  |                                |   |
| 8<br>NO    | PF CONTROL<br>ENABLED →<br>NO  | Entering NO disables the power factor control feature.  |
| ENTER<br>↵ | PF CONTROL<br>ENABLED →<br>NO  | Press the Enter key.  |
| ENTER<br>↵ | PF CONTROL<br>ENABLED →<br>NO  | Confirms the entry.   |
| MENU<br>▶  | AVERAGE PF #→<br>PF ADJ ??     | Displays the present running average power factor and power factor adjustment settings. Enter the desired kVAR adjustment using the numeric keys. Press the Menu Right → key prior to entering the decimal value. |
| <b>AND</b> |                                |   |
| MENU<br>▶  | AVERAGE PF #→<br>PF ADJ ??     | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
| ENTER<br>↵ | AVERAGE PF #→<br>PF ADJ ##     | Confirms the entry.   |
| MENU<br>▶  | LAGGING/<br>LEADING N/Y→       | Displays the lagging <i>or</i> leading PF selection.<br><b>Note:</b> The display sample may differ depending upon the previous entries. The lagging selection is the factory default setting.                     |
| 8<br>NO    | LAGGING YES→                   | Displays the lagging PF selection. When required, use the NO key to choose leading PF.  |
| ENTER<br>↵ | LAGGING NO→                    | Press the Enter key.  |
| ENTER<br>↵ | LEADING YES→                   | Confirms the entry.   |
| <b>OR</b>  |                                |   |
| 8<br>NO    | LEADING YES→                   | Displays the leading PF selection. When required, use the NO key to choose lagging PF.  |
| ENTER<br>↵ | LEADING NO→                    | Press the Enter key.  |
| ENTER<br>↵ | LAGGING YES→                   | Confirms the entry.   |
| MENU<br>▶  | PF CONTROL<br>ENABLED →<br>N/Y | Returns the user to the power factor control selection heading.   |

## Menu 11—Voltage Regulator, continued

### Menu 11 Displays with Key Entries

| Key Entry   | Display | Description  |
|---|---------|--|
|  |         | Displays the generator set voltage regulator gain adjustment. When required, use the numeric keys to enter the desired gain value. |
|  |         | Confirms the entry.  |
|  |         | Displays the utility (VAR/PF) gain adjustment. When required, use the numeric keys to enter the desired gain value.                |
|  |         | Confirms the entry.  |
|  |         | Displays current status and provides a means to change the status.   |
|  |         | Displays the reset regulator defaults selection.   |
|  |         | When required, use the YES key to reset the regulator defaults.  |
|  |         | Confirms the entry.  |

## 2.9.12 Menu 12—Calibration

Menu 12 provides the calibration of the voltage and current sensing logic. Changing the system voltage or replacing the main logic control circuit board requires a calibration adjustment.

The user must enable the programming mode to edit the display.










Connect a meter with a minimum accuracy of  $\pm 1\%$  to the generator set output leads to calibrate the voltage-sensing logic. Configure the generator set controller for the system operating configuration using Menu 7—Generator System. Adjust the generator set voltage using Menu 11—Voltage Regulator, when required and adjust the frequency at the generator set governor before making calibration adjustments.

Reduce the voltage regulator gain using Menu 11, Voltage Regulator until the voltage is stable prior to calibration.

The user must scale the analog input value in order to calculate the low/high warning and shutdown analog values based on a 0–5 VDC scale.

### Menu 12—Calibration

#### Menu 12 Displays with Key Entries (Scale AC Analog Inputs)

| Key Entry   | Display   | Description   |
|---|---|---|
|    | ENTER MENU NO. 1-15                                 | Input a menu number.  |
|   | MAIN MENU NUMBER 12                                 | Press the Enter key.  |
|    | MENU 12<br>CALIBRATION                              | Displays the menu number and name.  |
|    | SCALE AC ANALOG<br>INPUTS                           | Displays the scale AC analog inputs heading.  |
|    | GEN VOLTAGE LN                                      | Displays the generator set voltage line-to-neutral heading.   |
|    | GEN L1-L0 V           #<br>CALIB REF            ??. | <b>Note:</b> The generator set must be running for the following steps. Measure the generator set output voltage for single and three-phase models between L1-L0 using a voltmeter and enter the result using the numeric keys. Press the Menu Right → key prior to entering the decimal value. |
| <b>AND</b>  |   |   |
|    | GEN L1-L0 V           #<br>CALIB REF            ??. | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
|    | GEN L1-L0 V           #<br>CALIB REF            #.# | Confirms the entry.   |

ECM engines have user-defined analog inputs A01–A07. Non-ECM engines have user-defined analog inputs A03–A07 where analog inputs A01 and A02 are reserved for the engine coolant temperature A01 and oil pressure A02 displays.

**Analog Input A06—Analog Speed Adjust (VSG).** Analog Input A06 may be used for analog speed adjust when external control of engine speed is desired such as paralleling applications or closed transition ATS. To utilize this capability, set the Speed Adjust to ANALOG VSG A06 in Menu 7. Refer to 2.9.7, Menu 7















**Analog input A07** is the voltage adjustment for paralleling applications only. This input adjusts the input up or down from the value entered in Menu 11, Voltage Regulator. Calibration is not necessary.

**Note:** Press the Menu Right → key prior to entering decimal values where necessary.

Changes to the generator set system parameters causes a CHECK CALIBRATION display message. If the generator set system parameters are changed, verify the controller display calibration by comparing the results to a known measured value.















## Menu 12—Calibration, continued

### Menu 12 Displays with Key Entries (Scale AC Analog Inputs)

| Key Entry   | Display   | Description   |
|---|---|---|
|    | <div style="border: 1px solid black; padding: 2px;">           GEN L2-L0 V           #<br/>           CALIB REF            ??.         </div> | Measure the generator set output voltage for three-phase models between L2-L0 using a voltmeter and enter the result using the numeric keys. Press the Menu Right → key prior to entering the decimal value.  |
|   | <b>AND</b>  |   |
|    | <div style="border: 1px solid black; padding: 2px;">           GEN L2-L0 V           #<br/>           CALIB REF            ??.         </div> | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
|    | <div style="border: 1px solid black; padding: 2px;">           GEN L2-L0 V           #<br/>           CALIB REF            ##         </div>  | Confirms the entry.   |
|   |   |   |
|    | <div style="border: 1px solid black; padding: 2px;">           GEN L3-L0 V           #<br/>           CALIB REF            ??.         </div> | <b>Three-Phase Models only.</b> Measure the generator set output voltage for three-phase models between L3-L0 using a voltmeter and enter the result using the numeric keys. Press the Menu Right → key prior to entering the decimal value.  |
|   | <b>AND</b>  |   |
|    | <div style="border: 1px solid black; padding: 2px;">           GEN L3-L0 V           #<br/>           CALIB REF            ??.         </div> | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
|    | <div style="border: 1px solid black; padding: 2px;">           GEN L3-L0 V           #<br/>           CALIB REF            #         </div>   | Confirms the entry.   |
|   |   |   |
|   | <div style="border: 1px solid black; padding: 2px;">           GEN VOLTAGE LN         </div>  | Returns the user to the generator set voltage line-to-neutral heading.  |
|  | <div style="border: 1px solid black; padding: 2px;">           GEN VOLTAGE LL         </div>  | Displays the generator set voltage line-to-line heading.  |
|   |   |   |
|  | <div style="border: 1px solid black; padding: 2px;">           GEN L1-L2 V           #<br/>           CALIB REF            ??.         </div> | <b>Note:</b> The generator set must be running for the following steps. Measure the generator set output voltage for single and three-phase models between L1-L2 using a voltmeter and enter the result using the numeric keys. Press the Menu Right → key prior to entering the decimal value. |
|   | <b>AND</b>  |   |
|  | <div style="border: 1px solid black; padding: 2px;">           GEN L1-L2 V           #<br/>           CALIB REF            ??.         </div> | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
|  | <div style="border: 1px solid black; padding: 2px;">           GEN L1-L2 V           #<br/>           CALIB REF            ##         </div>  | Confirms the entry.   |
|   |   |   |
|  | <div style="border: 1px solid black; padding: 2px;">           GEN L2-L3 V           #<br/>           CALIB REF            ??.         </div> | <b>Three-Phase Models only.</b> Measure the generator set output voltage for three-phase models between L2-L3 using a voltmeter and enter the result using the numeric keys. Press the Menu Right → key prior to entering the decimal value.  |
|   | <b>AND</b>  |   |
|  | <div style="border: 1px solid black; padding: 2px;">           GEN L2-L3 V           #<br/>           CALIB REF            ??.         </div> | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
|  | <div style="border: 1px solid black; padding: 2px;">           GEN L2-L3 V           #<br/>           CALIB REF            ##         </div>  | Confirms the entry.   |

## Menu 12—Calibration, continued

### Menu 12 Displays with Key Entries (Scale AC Analog Inputs)

| Key Entry   | Display   | Description  |
|---|---|--|
|    | <div style="border: 1px solid black; padding: 2px;">           GEN L3-L1 V           #<br/>           CALIB REF            ??.         </div> | <b>Three-Phase Models only.</b> Measure the generator set output voltage for three-phase models between L3-L1 using a voltmeter and enter the result using the numeric keys. Press the Menu Right → key prior to entering the decimal value.   |
|   | <b>AND</b>  |  |
|    | <div style="border: 1px solid black; padding: 2px;">           GEN L3-L1 V           #<br/>           CALIB REF            ??.         </div> | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.   |
|    | <div style="border: 1px solid black; padding: 2px;">           GEN L3-L1 V           #<br/>           CALIB REF            #         </div>   | Confirms the entry.  |
|   |   |  |
|    | <div style="border: 1px solid black; padding: 2px;">           CALIBRATE REGULATOR?<br/> <span style="float: right;">Y/N</span> </div>        | Displays the calibrate regulator selection.<br><b>Note:</b> After changing the meter calibration the voltage regulator should be calibrated—enter YES.   |
|    | <div style="border: 1px solid black; padding: 2px;">           CALIBRATE REGULATOR?<br/> <span style="float: right;">YES</span> </div>        | When required, use the YES key to calibrate the voltage regulator.   |
|    | <div style="border: 1px solid black; padding: 2px;">           CALIBRATE REGULATOR?<br/> <span style="float: right;">Y/N</span> </div>        | Confirms the entry.  |
|   |   |  |
|    | <div style="border: 1px solid black; padding: 2px;">           GEN VOLTAGE LL         </div>  | Returns the user to the generator set line-to-line voltage heading.  |
|   | <div style="border: 1px solid black; padding: 2px;">           GEN AMPS         </div>  | Displays the generator set amps heading.   |
|   |   |  |
|  | <div style="border: 1px solid black; padding: 2px;">           GEN L1 AMPS           #<br/>           CALIB REF            ??.         </div> | <b>Note:</b> The generator set must be running for the following steps. Measure the generator set output current for single- and three-phase models at L1 using an AC ammeter and enter the result using the numeric keys. Press the Menu Right → key prior to entering the decimal value. |
|   | <b>AND</b>  |  |
|  | <div style="border: 1px solid black; padding: 2px;">           GEN L1 AMPS           #<br/>           CALIB REF            ??.         </div> | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.   |
|  | <div style="border: 1px solid black; padding: 2px;">           GEN L1 AMPS           #<br/>           CALIB REF            #         </div>   | Confirms the entry.  |
|   |   |  |
|  | <div style="border: 1px solid black; padding: 2px;">           GEN L2 AMPS           #<br/>           CALIB REF            ??.         </div> | Measure the generator set output current for three-phase models at L2 using an AC ammeter and enter the result using the numeric keys. Press the Menu Right → key prior to entering the decimal value.   |
|   | <b>AND</b>  |  |
|  | <div style="border: 1px solid black; padding: 2px;">           GEN L2 AMPS           #<br/>           CALIB REF            ??.         </div> | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.   |
|  | <div style="border: 1px solid black; padding: 2px;">           GEN L2 AMPS           #<br/>           CALIB REF            #         </div>   | Confirms the entry.  |

## Menu 12—Calibration, continued

### Menu 12 Displays with Key Entries (Scale AC Analog Inputs)

| Key Entry | Display   | Description   |
|-----------|---|---|
|           | <div style="border: 1px solid black; padding: 2px;">           GEN L3 AMPS #<br/>           CALIB REF ??         </div>             | <b>Three-Phase Models only.</b> Measure the generator set output current for three-phase models at L3 using an AC ammeter and enter the result using the numeric keys. Press the Menu Right → key prior to entering the decimal value.  |
|           | <b>AND</b>  |   |
|           | <div style="border: 1px solid black; padding: 2px;">           GEN L3 AMPS #<br/>           CALIB REF ??         </div>             | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
|           | <div style="border: 1px solid black; padding: 2px;">           GEN L3 AMPS #<br/>           CALIB REF #         </div>              | Confirms the entry.   |
|           |   |   |
|           | <div style="border: 1px solid black; padding: 2px;">           GEN AMPS         </div>  | Returns the user to the generator set amps heading.   |
|           | <div style="border: 1px solid black; padding: 2px;">           LOAD VOLTAGE LN         </div>                                       | Displays the load voltage line-to-neutral voltage heading.  |
|           |   |   |
|           | <div style="border: 1px solid black; padding: 2px;">           LOAD L1-L0 V #<br/>           CALIB REF (PARALLEL) ??         </div> | <b>Note:</b> The generator sets must be running for the following steps.<br><b>Paralleling Applications.</b> Measure the load voltage between L1-L0 using a voltmeter and enter the result using the numeric keys. Press the Menu Right → key prior to entering the decimal value.                        |
|           | <b>AND</b>  |   |
|           | <div style="border: 1px solid black; padding: 2px;">           GEN L1-L0 V #<br/>           CALIB REF ??         </div>             | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
|           | <div style="border: 1px solid black; padding: 2px;">           GEN L1-L0 V #<br/>           CALIB REF #         </div>              | Confirms the entry.   |
|           |   |   |
|           | <div style="border: 1px solid black; padding: 2px;">           LOAD L3-L0 V #<br/>           CALIB REF (PARALLEL) ??         </div> | <b>Note:</b> The generator sets must be running for the following steps.<br><b>Paralleling Applications.</b> Measure the load voltage for three-phase models between L3-L0 using a voltmeter and enter the result using the numeric keys. Press the Menu Right → key prior to entering the decimal value. |
|           | <b>AND</b>  |   |
|           | <div style="border: 1px solid black; padding: 2px;">           GEN L3-L0 V #<br/>           CALIB REF ??         </div>             | Use the numeric keys to enter the <i>decimal</i> value. Press the Enter key.  |
|           | <div style="border: 1px solid black; padding: 2px;">           GEN L3-L0 V #<br/>           CALIB REF #         </div>              | Confirms the entry.   |
|           |   |   |
|           | <div style="border: 1px solid black; padding: 2px;">           LOAD VOLTAGE LN         </div>                                       | Returns the user to the load voltage line-to-neutral voltage heading.   |
|           | <div style="border: 1px solid black; padding: 2px;">           RESTORE DEFAULTS? Y/N         </div>                                 | Displays the restore defaults selection.  |
|           |   |   |
|           | <div style="border: 1px solid black; padding: 2px;">           RESTORE DEFAULTS? YES         </div>                                 | When required, enter YES to activate the restore calibration defaults setting. Press the Enter key. <b>Note:</b> Entering Yes will delete all of the previously entered voltage and current data based on system voltage and kW and restore the calibration default settings.                             |
|           | <div style="border: 1px solid black; padding: 2px;">           RESTORE DEFAULTS? Y/N         </div>                                 | Confirms the entry.   |
|           |   |   |
|           | <div style="border: 1px solid black; padding: 2px;">           GEN VOLTAGE LN         </div>  | Returns the user to the generator set voltage line-to-neutral heading.  |

## Menu 12—Calibration, continued

### Menu 12 Displays with Key Entries (Scale Aux. Analog Inputs)

No calibration is available for inputs A01-A02 for non-ECM engines. No calibration is available for inputs A01-A04 for Waukesha engines.

| Key Entry | Display                          | Description   |
|-----------|----------------------------------|---|
|           | ENTER MENU NO. 1-15              | Input a menu number.  |
|           | MAIN MENU NUMBER 12              | Press the Enter key.  |
|           | MENU 12<br>CALIBRATION           | Displays the menu number and name.  |
|           | SCALE AC ANALOG<br>INPUTS        | Displays the scale AC analog inputs heading.  |
|           | SCALE AUX. ANALOG<br>INPUTS →    | Displays the scale auxiliary analog inputs heading.   |
|           | ZERO AUX. ANALOG<br>INPUTS?      | Gives the user the option to calibrate the auxiliary analog inputs for zero input signals. <b>Note:</b> ECM engines have inputs A01-A07 and non-ECM engines have inputs A03-A07. A07 may be used for analog voltage adjust. Waukesha engines have inputs A05- A07.  |
|           | ZERO AUX. ANALOG<br>INPUTS? YES  | When required, enter YES to activate the auto-zero auxiliary analog inputs feature. Press the Enter key.  |
|           | ZERO AUX. ANALOG<br>INPUTS? YES  | Confirms the entry.   |
|           | ANALOG 01 #<br>SCALE VALUE 1 ?   | Displays the analog 01 and scale value 1 settings. Use the numeric keys to enter the minimum value based on the previously calculated 5 VDC analog input value.   |
|           | SCAL 1 #-#. #V<br>SCAL 2 #-#. #V | <b>Note:</b> Press the Menu Right → key to review both the scale value 1 and scale value 2 settings any time during the setup procedure.  |
|           | ANALOG 01 #<br>SCALE VALUE 2 ?   | Displays analog 01 and scale value 2 settings. Use the numeric keys to enter the maximum value based on the previously calculated 5 VDC analog value.   |
|           | SCALE AUX. ANALOG<br>INPUTS →    | Returns the user to the scale auxiliary analog inputs heading.  |
|           | ZERO AUX. ANALOG<br>INPUTS?      | Press the down arrow to go to the desired analog XX.  |
|           | ANALOG XX #<br>SCALE VALUE 1 ?   | Displays scale auxiliary analog inputs 01 to 07.<br><b>Note:</b> Press the down arrow to scroll through the additional analog auxiliary inputs 02-07.<br><b>Note:</b> Press the down arrow to scroll through the additional analog scale value 1 and value 2 for each analog selection.<br><b>Note:</b> Press the right arrow at each analog auxiliary input that provides display of the scale 1 and scale 2 voltage settings. |



### 2.9.13 Menu 13—Communications

Menu 13 enables communication with the controller for monitoring or controlling the generator set. KBUS allows a variety of connection types while Modbus® follows Modbus® RTU protocols. Use the LAN (local area network) to gain remote access to multiple devices/addresses. Use the KBUS enable *local* programming mode to edit displays in this menu. Use the monitor software operation manual when accessing this menu, programming from a remote location, and determining address and system identification information.

The user must enable the programming mode to edit the display.

See Section 2.7 for descriptions of the different types of connections.

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The user must enable local programming to make changes in Menu 13; see Section 2.9.14. After the communications settings have been appropriately entered, set the programming mode to REMOTE to utilize remote programming.















## Menu 13—Communications

### Menu 13 Displays with Key Entries

| Key Entry  | Display                | Description  |
|------------|------------------------|--|
| RESET MENU | ENTER MENU NO. 1-15    | Input a menu number.                               |
| 1 3        | MAIN MENU NUMBER 13    | Press the Enter key.                               |
| ENTER      | MENU 13 COMMUNICATIONS | Displays the menu number and name.                 |
| MENU       | PROTOCOL KBUS →        | Displays the KBUS protocol heading.                |
| MENU       | KBUS ONLINE Y/N        | Displays the KBUS online selection.                |
| -----      |                        |  |
| 7 YES      | KBUS ONLINE NO         | Entering YES activates the online KBUS selection.  |
|            | KBUS ONLINE YES        | Press the Enter key.                               |
| ENTER      | KBUS ONLINE YES        | Confirms the entry.                                |
| -----      |                        |  |
| <b>OR</b>  |                        |  |
| 8 NO       | KBUS ONLINE YES        | Entering NO deactivates the online KBUS selection. |
|            | KBUS ONLINE NO         | Press the Enter key.                               |
| ENTER      | KBUS ONLINE NO         | Confirms the entry.                                |
| -----      |                        |  |

## Menu 13—Communications, continued

### Menu 13 Displays with Key Entries

| Key Entry   | Display   | Description                       |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|---|---|-----------------------------------|---|-----|--|--|-----|--------------|--|-----|--|--|-----|--|--|-----|------------|--|-----|-----------------|--|-----|--|
|    | <table border="1"> <tr> <td>CONNECTION TYPE<br/>(USER DEFINED)</td> <td>→</td> <td>Y/N</td> </tr> </table>  | CONNECTION TYPE<br>(USER DEFINED) | → | Y/N | Displays the user-defined connection type. Press the Down arrow key if the correct connection type is displayed. If the desired connection type is not displayed, press the Right arrow key until the desired connection type appears.               |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| CONNECTION TYPE<br>(USER DEFINED)   | →   | Y/N                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|    | <table border="1"> <tr> <td colspan="3">CONNECTION TYPES</td> </tr> <tr> <td>LOCAL SINGLE</td> <td></td> <td>Y/N</td> </tr> <tr> <td>LOCAL LAN</td> <td></td> <td>N/Y</td> </tr> <tr> <td>LOCAL LAN CONV</td> <td></td> <td>N/Y</td> </tr> <tr> <td>REMOTE SINGLE</td> <td></td> <td>N/Y</td> </tr> <tr> <td>REMOTE LAN</td> <td></td> <td>N/Y</td> </tr> <tr> <td>REMOTE LAN CONV</td> <td></td> <td>N/Y</td> </tr> </table> | CONNECTION TYPES                  |   |     | LOCAL SINGLE   |  | Y/N | LOCAL LAN    |  | N/Y | LOCAL LAN CONV   |  | N/Y | REMOTE SINGLE  |  | N/Y | REMOTE LAN |  | N/Y | REMOTE LAN CONV |  | N/Y | Entering YES selects the connection type shown. <b>Note:</b> Selecting one connection type deselects any previously selected choice. |
| CONNECTION TYPES  |   |                                   |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| LOCAL SINGLE  |   | Y/N                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| LOCAL LAN   |   | N/Y                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| LOCAL LAN CONV  |   | N/Y                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| REMOTE SINGLE   |   | N/Y                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| REMOTE LAN  |   | N/Y                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| REMOTE LAN CONV   |   | N/Y                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| <hr/>   |   |                                   |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|    | <table border="1"> <tr> <td>CONNECTION TYPE<br/>(USER DEFINED)</td> <td>→</td> <td>YES</td> </tr> </table>  | CONNECTION TYPE<br>(USER DEFINED) | → | YES | Press the Enter key.   |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| CONNECTION TYPE<br>(USER DEFINED)   | →   | YES                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|    | <table border="1"> <tr> <td>CONNECTION TYPE<br/>(USER DEFINED)</td> <td>→</td> <td>YES</td> </tr> </table>  | CONNECTION TYPE<br>(USER DEFINED) | → | YES | Confirms the entry.  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| CONNECTION TYPE<br>(USER DEFINED)   | →   | YES                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| <hr/>   |   |                                   |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|    | <table border="1"> <tr> <td>PRIMARY PORT<br/>(USER DEFINED)</td> <td>→</td> <td>Y/N</td> </tr> </table>   | PRIMARY PORT<br>(USER DEFINED)    | → | Y/N | Displays the user-defined primary port subheading. Press the Down arrow key if the correct primary port type is displayed. If the desired primary port type is not displayed, press the Right arrow key until the desired primary port type appears. |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| PRIMARY PORT<br>(USER DEFINED)  | →   | Y/N                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|   | <table border="1"> <tr> <td colspan="3">PRIMARY PORTS</td> </tr> <tr> <td>RS-232</td> <td></td> <td>Y/N</td> </tr> <tr> <td>RS-485 ISO 1</td> <td></td> <td>N/Y</td> </tr> </table>   | PRIMARY PORTS                     |   |     | RS-232   |  | Y/N | RS-485 ISO 1 |  | N/Y | Entering YES selects the primary port shown. <b>Note:</b> Selecting one primary port deselects any previously selected choice. |  |     |  |  |     |            |  |     |                 |  |     |  |
| PRIMARY PORTS   |   |                                   |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| RS-232  |   | Y/N                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| RS-485 ISO 1  |   | N/Y                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| <hr/>   |   |                                   |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|  | <table border="1"> <tr> <td>PRIMARY PORT<br/>(USER DEFINED)</td> <td>→</td> <td>YES</td> </tr> </table>   | PRIMARY PORT<br>(USER DEFINED)    | → | YES | Press the Enter key.   |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| PRIMARY PORT<br>(USER DEFINED)  | →   | YES                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|  | <table border="1"> <tr> <td>PRIMARY PORT<br/>(USER DEFINED)</td> <td>→</td> <td>YES</td> </tr> </table>   | PRIMARY PORT<br>(USER DEFINED)    | → | YES | Confirms the entry.  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| PRIMARY PORT<br>(USER DEFINED)  | →   | YES                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| <hr/>   |   |                                   |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|  | <table border="1"> <tr> <td>ADDRESS<br/>(LAN Connections)</td> <td></td> <td>?</td> </tr> </table>  | ADDRESS<br>(LAN Connections)      |   | ?   | Displays the LAN connection address number. Use the numeric keys to enter the desired address 1-128. Use one address number per unit and use consecutive numbers. Individual addresses are necessary for the software to call up the desired unit.   |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| ADDRESS<br>(LAN Connections)  |   | ?                                 |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|  | <table border="1"> <tr> <td>ADDRESS<br/>(LAN Connections)</td> <td></td> <td>#</td> </tr> </table>  | ADDRESS<br>(LAN Connections)      |   | #   | Confirms the entry.  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| ADDRESS<br>(LAN Connections)  |   | #                                 |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|  | <table border="1"> <tr> <td>SYSTEM ID<br/>(Remote Connections)</td> <td></td> <td>?</td> </tr> </table>   | SYSTEM ID<br>(Remote Connections) |   | ?   | Displays the system ID request. Use the numeric keys to enter the required system ID of remote connections. The system ID is a password. The user must use the same password for all devices at a site.  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| SYSTEM ID<br>(Remote Connections)   |   | ?                                 |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|  | <table border="1"> <tr> <td>SYSTEM ID<br/>(Remote Connections)</td> <td></td> <td>#</td> </tr> </table>   | SYSTEM ID<br>(Remote Connections) |   | #   | Confirms the entry.  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| SYSTEM ID<br>(Remote Connections)   |   | #                                 |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|  | <table border="1"> <tr> <td>BAUD RATE<br/>(USER DEFINED)</td> <td>→</td> <td>Y/N</td> </tr> </table>  | BAUD RATE<br>(USER DEFINED)       | → | Y/N | Displays the user-defined baud rate selection. Press the Down arrow key if the correct baud rate is displayed. If the desired baud rate is not displayed, press the Right arrow key until the desired baud rate appears.                             |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| BAUD RATE<br>(USER DEFINED)   | →   | Y/N                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
|  | <table border="1"> <tr> <td colspan="3">BAUD RATES</td> </tr> <tr> <td>1200</td> <td></td> <td>Y/N</td> </tr> <tr> <td>2400</td> <td></td> <td>N/Y</td> </tr> <tr> <td>9600</td> <td></td> <td>N/Y</td> </tr> </table>  | BAUD RATES                        |   |     | 1200   |  | Y/N | 2400         |  | N/Y | 9600   |  | N/Y | Entering YES selects the baud rate shown. <b>Note:</b> Selecting one baud rate deselects any previously selected choice. |  |     |            |  |     |                 |  |     |  |
| BAUD RATES  |   |                                   |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| 1200  |   | Y/N                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| 2400  |   | N/Y                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |
| 9600  |   | N/Y                               |   |     |  |  |     |              |  |     |  |  |     |  |  |     |            |  |     |                 |  |     |  |

## Menu 13—Communications, continued

### Menu 13 Displays with Key Entries








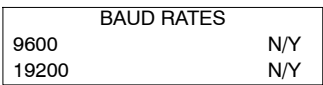

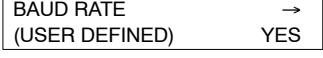




| Key Entry  | Display   | Description   |
|------------|---|---|
| 7<br>YES   | BAUD RATE<br>(USER DEFINED) → YES   | Press the Enter key.  |
| ENTER<br>← | BAUD RATE<br>(USER DEFINED) → YES   | Confirms the entry.   |
| MENU<br>↓  | MENU 13<br>COMMUNICATIONS   | Returns the user to the menu number and name.   |
| MENU<br>↓  | PROTOCOL<br>KBUS →  | Returns the user to KBUS protocol heading.  |
| MENU<br>→  | PROTOCOL<br>MODBUS 0 →  | Displays the Modbus protocol heading.   |
| MENU<br>↓  | MODBUS ONLINE Y/N   | Displays the Modbus online selection (yes or no).   |
| 7<br>YES   | MODBUS ONLINE NO  | Entering YES activates the online Modbus selection.   |
| ENTER<br>← | MODBUS ONLINE YES   | Press the Enter key.  |
| ENTER<br>← | MODBUS ONLINE YES   | Confirms the entry.   |
| 8<br>NO    | OR<br>MODBUS ONLINE YES   | Entering NO deactivates the online Modbus selection.  |
| ENTER<br>← | MODBUS ONLINE NO  | Press the Enter key.  |
| ENTER<br>← | MODBUS ONLINE NO  | Confirms the entry.   |
| MENU<br>↓  | CONNECTION TYPE<br>(USER DEFINED) → Y/N                                   | Displays the user-defined connection types. Press the Down arrow key if the correct connection type is displayed. If the desired connection type is not displayed, press the Right arrow key until the desired connection type appears. |
| MENU<br>→  | CONNECTION TYPES<br>SINGLE Y/N<br>CONVERTOR N/Y                           | Entering YES selects the connection type shown. <b>Note:</b> Selecting one connection type deselects any previously selected choice.  |
| 7<br>YES   | CONNECTION TYPE<br>(USER DEFINED) → YES                                   | Press the Enter key.  |
| ENTER<br>← | CONNECTION TYPE<br>(USER DEFINED) → YES                                   | Confirms the entry.   |
| MENU<br>↓  | PRIMARY PORT<br>(USER DEFINED) → Y/N                                      | Displays the user-defined primary ports. Press the Down arrow if the correct primary port is displayed. If the desired primary port is not displayed, press the Right arrow key until the desired primary port appears.                 |
| MENU<br>→  | PRIMARY PORTS<br>RS-232 (P18) (SINGLE) Y/N<br>RS-485 (P20) (MULTIPLE) N/Y | Entering YES selects the primary port shown. <b>Note:</b> Selecting one primary port deselects any previously selected choice.  |

## Menu 13—Communications, continued

### Menu 13 Displays with Key Entries

| Key Entry | Display                              | Description  |
|-----------|--------------------------------------|--|
|           | PRIMARY PORT<br>(USER DEFINED) → YES | Press the Enter key.   |
|           | PRIMARY PORT<br>(USER DEFINED) → YES | Confirms the entry.  |
|           | ADDRESS<br>(LAN Connections) ?       | Displays the LAN connection address number. Use the numeric keys to enter the desired address 1-128. Use one address number per unit and use consecutive numbers. Individual addresses are necessary for the software to call up the desired unit. |
|           | ADDRESS<br>(LAN Connections) #       | Confirms the entry.  |
|           | BAUD RATE<br>(USER DEFINED) → Y/N    | Displays the user-defined baud rate. Press the Down arrow key if the correct baud rate is displayed. If the desired baud rate is not displayed, press the Right arrow key until the desired baud rate appears.                                     |
|           | BAUD RATES<br>9600 N/Y<br>19200 N/Y  | Entering YES selects the baud rate shown. <b>Note:</b> Selecting one baud rate deselects any previously selected choice.   |
|           | PROTOCOL<br>MODBUS 0 →               | Returns the user to protocol Modbus 0 heading.   |

| Key Entry  | Display   | Description   |
|------------|---|---|
| MENU<br>↓  | MENU 13<br>COMMUNICATIONS                       | Returns the user to the menu number and name.   |
| MENU<br>↓  | PROTOCOL<br>KBUS →                              | Returns the user to KBUS protocol heading.  |
| MENU<br>→  | PROTOCOL<br>MODBUS 1 →                          | Displays the Modbus protocol heading.   |
| MENU<br>↓  | MODBUS ONLINE Y/N                               | Displays the Modbus online selection (yes or no).   |
| <hr/>      |   |   |
|            | MODBUS ONLINE NO                                | Entering YES activates the online Modbus selection.   |
| 7<br>YES   | MODBUS ONLINE YES                               | Press the Enter key.  |
| ENTER<br>↵ | MODBUS ONLINE YES                               | Confirms the entry.   |
| <hr/>      |   |   |
|            | <b>OR</b><br>MODBUS ONLINE YES                  | Entering NO deactivates the online Modbus selection.  |
| 8<br>NO    | MODBUS ONLINE NO                                | Press the Enter key.  |
| ENTER<br>↵ | MODBUS ONLINE NO                                | Confirms the entry.   |
| <hr/>      |   |   |
| MENU<br>↓  | CONNECTION TYPE<br>(USER DEFINED) Y/N →         | Displays the user-defined connection types. Press the Down arrow key if the correct connection type is displayed. If the desired connection type is not displayed, press the Right arrow key until the desired connection type appears. |
| MENU<br>→  | CONNECTION TYPES<br>SINGLE Y/N<br>CONVERTOR N/Y | Entering YES selects the connection type shown. Choices are a single or RS-232 to RS-485 convertor. <b>Note:</b> Selecting one connection type deselects any previously selected choice.  |
| <hr/>      |   |   |
| 7<br>YES   | CONNECTION TYPE<br>(USER DEFINED) YES →         | Press the Enter key.  |
| ENTER<br>↵ | CONNECTION TYPE<br>(USER DEFINED) YES →         | Confirms the entry.   |
| <hr/>      |   |   |
| MENU<br>↓  | PRIMARY PORT<br>RS-458 ISO (P19) Y/N →          | Displays the RS-485 ISO (P19) primary port. Press the YES button to select the RS-485 ISO (P19) primary port.   |
| 7<br>YES   | PRIMARY PORT<br>RS-458 ISO (P19) YES →          | Press the Enter key.  |
| ENTER<br>↵ | PRIMARY PORT<br>RS-458 ISO (P19) Y/N →          | Confirms the entry.   |

| Key Entry   | Display   | Description   |
|---|---|---|
|  |  | Displays the address number. Use the numeric keys to enter the desired address 1-128. Use one address number per unit and use consecutive numbers. Individual addresses are necessary for the software to call up the desired unit. |
|  |  | Confirms the entry.   |
|  |  | Displays the user-defined baud rate. Press the Down arrow key if the correct baud rate is displayed. If the desired baud rate is not displayed, press the Right arrow key until the desired baud rate appears.                      |
|  |  | Entering YES selects the baud rate shown. <b>Note:</b> Selecting one baud rate deselects any previously selected choice.  |
| <hr style="border-top: 1px dashed black;"/>                                       |   |   |
|  |  | Press the Enter key.  |
|  |  | Confirms the entry.   |
| <hr style="border-top: 1px dashed black;"/>                                       |   |   |
|  |  | Returns the user to protocol Modbus 1 heading.  |

## 2.9.14 Menu 14—Programming Mode

Menu 14 allows altering controller data either locally using the keypad or remotely using a PC or other device.

The user must enter a password (access code) to enable the programming mode.

**Local Programming.** Local programming is data alteration using the controller keypad and display.

**Remote Programming.** Remote programming is data alteration using devices connected to a communication port using KBUS or Modbus® including Monitor III software.

**Note:** Log into the *local* programming mode to edit the programming access code. *The factory default access code is the number 0.*

Use Menu 14 to change the access code. Record the new number and give the access code to authorized individuals only. Should the controller logic not accept the access code or if the new code number is lost, contact your local authorized distributor/dealer for password information.

The user chooses one of three programming modes:

- Local—using the controller keypad
- Remote—using a PC
- Off—no programming is permitted

Enter Yes to one mode to change the other two choices to No.

**Note:** Use the generator set controller to initially set up remote programming. Remote programming is not allowed from a PC unless the controller is first set for remote programming using Menu 14.

**Note:** After completing the programming always *place the controller back in the Programming Mode Off position* to prevent inadvertent program changes.

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## Menu 14—Programming Mode, continued

### Menu 14 Displays with Key Entries

| Key Entry | Display   | Description  |
|-----------|---|--|
|           | ENTER MENU NO. 1-15                                     | Input a menu number.   |
|           | MAIN MENU NUMBER 14                                     | Press the Enter key.   |
|           | MENU 14<br>PROGRAMMING MODE                             | Displays the menu number and name.   |
|           | PROGRAMMING MODE →<br>(USER DEFINED) Y/N                | Displays the user-defined programming mode. Press the Down arrow key if the correct programming mode is displayed. If the desired programming mode is not displayed, press the Right arrow key until the desired programming mode appears. |
|           | PROGRAMMING MODES<br>OFF Y/N<br>LOCAL N/Y<br>REMOTE N/Y | Entering YES selects the programming mode shown.<br><b>Note:</b> Selecting one programming mode deselects any previously selected choice.  |
|           | PROGRAMMING MODE →<br>(USER DEFINED) YES                | Press the Enter key.   |
|           | PROGRAMMING MODE<br>ENTER CODE *                        | Changing the programming mode requires entering the access code. Enter the access code and press the Enter key.<br><b>Note:</b> The factory default access code is the number 0.   |
|           | PROGRAMMING MODE →<br>(USER DEFINED) YES                | Confirms the entry.  |
|           | PROGRAMMING MODE →<br>CHANGE ACCESS CODE                | Displays the programming mode and changes the access code. Press the Down arrow key if you do not wish to change the access code. To change the access code, press the Right arrow key.  |
|           | PROGRAMMING MODE<br>ENTER OLD CODE *                    | Enter the old access code and press the Enter key.   |
|           | PROGRAMMING MODE<br>ENTER NEW CODE *                    | Enter the new access code and press the Enter key.   |
|           | PROGRAMMING MODE →<br>CHANGE ACCESS CODE                | Confirms the entry.  |
|           | MENU 14<br>PROGRAMMING MODE                             | Returns the user to the programming mode heading.  |



### 2.9.15 Menu 15—Protective Relays (PR)

Menu 15 provides the necessary protective relays for units with the optional paralleling protection feature. If

the generator set personality profile did not include the paralleling option this menu will not appear on the display. Available with PD-Series switchgear only.





















### Menu 15—Protective Relays

#### Menu 15 Displays with Key Entries

| Key Entry | Display                       | Description   |
|-----------|-------------------------------|---|
|           | ENTER MENU NO. 1-15           | Input a menu number.  |
|           | MAIN MENU NUMBER 15           | Press the Enter key.  |
|           | MENU 15<br>PROTECTIVE RELAYS  | Displays the menu number and name.  |
|           | PR OVERVOLTAGE →<br>?% #VAC   | Displays the overvoltage % value. When required, use the numeric keys to enter the desired overvoltage % value and press the Enter key.     |
|           | PR OVERVOLTAGE →<br>#% #VAC   | Displays the corrected overvoltage % value.   |
|           | TIME DELAY →<br>?SEC          | Displays the overvoltage time delay. When required, use the numeric keys to enter the desired time delay value and press the Enter key.     |
|           | TIME DELAY →<br>#SEC          | Displays the corrected overvoltage time delay value.  |
|           | PR OVERVOLTAGE →<br>?% #VAC   | Returns the user to the overvoltage % value display.  |
|           | PR UNDERVOLTAGE →<br>?% #VAC  | Displays the undervoltage % value. When required, use the numeric keys to enter the desired undervoltage % value and press the Enter key.   |
|           | PR UNDERVOLTAGE →<br>#% #VAC  | Displays the corrected undervoltage % value.  |
|           | TIME DELAY →<br>?SEC          | Displays the undervoltage time delay. When required, use the numeric keys to enter the desired time delay value and press the Enter key.    |
|           | TIME DELAY →<br>#SEC          | Displays the corrected undervoltage time delay value.   |
|           | PR UNDERVOLTAGE →<br>?% #VAC  | Returns the user to the undervoltage % value display.   |
|           | PR OVERFREQUENCY →<br>?% #HZ  | Displays the overfrequency % value. When required, use the numeric keys to enter the desired overfrequency % value and press the Enter key. |
|           | PR OVERFREQUENCY →<br>#% #HZ  | Displays the corrected overfrequency % value.   |
|           | TIME DELAY →<br>?SEC          | Displays the overfrequency time delay. When required, use the numeric keys to enter the desired time delay value and press the Enter key.   |
|           | TIME DELAY →<br>#SEC          | Displays the corrected overfrequency time delay value.  |
|           | PR OVERFREQUENCY →<br>?% #VAC | Returns the user to the overfrequency % value display.  |





















## Menu 15—Protective Relays, continued

### Menu 15 Displays with Key Entries

| Key Entry   | Display                       | Description   |
|---|-------------------------------|---|
|    | PR UNDERFREQUENCY →<br>?% #HZ | Displays the underfrequency % value. When required, use the numeric keys to enter the desired underfrequency % value and press the Enter key.                 |
|    | PR UNDERFREQUENCY →<br>#% #HZ | Displays the corrected underfrequency % value.  |
|    | TIME DELAY →<br>?SEC          | Displays the underfrequency time delay. When required, use the numeric keys to enter the desired time delay value and press the Enter key.                    |
|    | TIME DELAY →<br>#SEC          | Displays the corrected underfrequency time delay value.   |
|    | PR UNDERFREQUENCY →<br>?% #HZ | Returns the user to the underfrequency % value display.   |
|    | PR REVERSE POWER →<br>?% #KW  | Displays the reverse power % value. When required, use the numeric keys to enter the desired reverse power % value and press the Enter key.                   |
|    | PR REVERSE POWER →<br>#% #KW  | Displays the corrected reverse power % value.   |
|    | TIME DELAY →<br>?SEC          | Displays the reverse power time delay. When required, use the numeric keys to enter the desired time delay value and press the Enter key.                     |
|   | TIME DELAY →<br>#SEC          | Displays the corrected reverse power time delay value.  |
|  | PR REVERSE POWER →<br>?% #KW  | Returns the user to the reverse power % value display.  |
|  | SD REVERSE POWER →<br>?% #KW  | Displays the reverse power shutdown % value. When required, use the numeric keys to enter the desired reverse power shutdown % value and press the Enter key. |
|  | SD REVERSE POWER →<br>#% #KW  | Displays the corrected reverse power shutdown % value.  |
|  | TIME DELAY →<br>?SEC          | Displays the reverse power shutdown time delay. When required, use the numeric keys to enter the desired time delay value and press the Enter key.            |
|  | TIME DELAY →<br>#SEC          | Displays the corrected reverse power shutdown time delay value.   |
|  | SD REVERSE POWER →<br>?% #KW  | Returns the user to the reverse power shutdown % value display.   |
|  | PR OVER POWER →<br>?% #KW     | Displays the over power % value. When required, use the numeric keys to enter the desired over power % value and press the Enter key.                         |
|  | PR OVER POWER →<br>#% #KW     | Displays the corrected over power % value.  |
|  | TIME DELAY →<br>?SEC          | Displays the over power time delay. When required, use the numeric keys to enter the desired time delay value and press the Enter key.                        |
|  | TIME DELAY →<br>#SEC          | Displays the corrected over power time delay value.   |
|  | PR OVER POWER →<br>?% #KW     | Returns the user to the over power % value display.   |















## Menu 15—Protective Relays, continued

### Menu 15 Displays with Key Entries


| Key Entry   | Display                         | Description   |
|---|---------------------------------|---|
|    | SD OVER POWER →<br>?% #KW       | Displays the over power shutdown % value. When required, use the numeric keys to enter the desired over power shutdown % value and press the Enter key.               |
|    | SD OVER POWER →<br>#% #KW       | Displays the corrected over power shutdown % value.   |
|    | TIME DELAY →<br>?SEC            | Displays the over power shutdown time delay. When required, use the numeric keys to enter the desired time delay value and press the Enter key.                       |
|    | TIME DELAY →<br>#SEC            | Displays the corrected over power shutdown time delay value.  |
|    | SD OVER POWER →<br>?% #KW       | Returns the user to the over power shutdown % value display.  |
|    | PR LOSS OF FIELD →<br>?% #KVAR  | Displays the loss of field % value. When required, use the numeric keys to enter the desired loss of field % value and press the Enter key.                           |
|    | PR LOSS OF FIELD →<br>#% #KVAR  | Displays the corrected loss of field % value.   |
|    | TIME DELAY →<br>?SEC            | Displays the loss of field time delay. When required, use the numeric keys to enter the desired time delay value and press the Enter key.                             |
|   | TIME DELAY →<br>#SEC            | Displays the corrected loss of field time delay value.  |
|  | PR LOSS OF FIELD →<br>?% #KVAR  | Returns the user to the loss of field % value display.  |
|  | SD LOSS OF FIELD →<br>?% #KVAR  | Displays the loss of field shutdown % value. When required, use the numeric keys to enter the desired loss of field % value and press the Enter key.                  |
|  | SD LOSS OF FIELD →<br>#% #KVAR  | Displays the corrected loss of field shutdown % value.  |
|  | TIME DELAY →<br>?SEC            | Displays the loss of field shutdown time delay. When required, use the numeric keys to enter the desired time delay value and press the Enter key.                    |
|  | TIME DELAY →<br>#SEC            | Displays the corrected loss of field shutdown time delay value.   |
|  | SD LOSS OF FIELD →<br>?% #KVAR  | Returns the user to the loss of field shutdown % value display.   |
|  | PR OVERCURRENT VR →<br>?% #AMPS | Displays the over current with voltage restraint (VR) % value. When required, use the numeric keys to enter the desired over current % value and press the Enter key. |
|  | PR OVERCURRENT VR →<br>#% #AMPS | Displays the corrected over current % value.  |
|  | TIME DELAY →<br>?SEC            | Displays the over current time delay. When required, use the numeric keys to enter the desired time delay value and press the Enter key.                              |
|  | TIME DELAY →<br>#SEC            | Displays the corrected over current time delay value.   |
|  | PR OVERCURRENT VR →<br>?% #AMPS | Returns the user to the over current % value display.   |

## Menu 15—Protective Relays, continued

### Menu 15 Displays with Key Entries

| Key Entry   | Display                          | Description   |
|---|----------------------------------|---|
|    | SD OVER CURRENT VR →<br>?% #AMPS | Displays the over current shutdown with voltage restraint (VR) % value. When required, use the numeric keys to enter the desired over current shutdown % value and press the Enter key. |
|    | SD OVER CURRENT VR →<br>#% #AMPS | Displays the corrected over current shutdown % value.   |
|    | TIME DELAY →<br>?SEC             | Displays the over current shutdown time delay. When required, use the numeric keys to enter the desired time delay value and press the Enter key.                                       |
|    | TIME DELAY →<br>#SEC             | Displays the corrected over current shutdown time delay value.  |
|    | SD OVER CURRENT VR →<br>?% #AMPS | Returns the user to the over current shutdown % value display.  |
|    | SYNC VOLTAGE MATCH →<br>? VAC    | Displays the synchronization matching voltage value. When required, use the numeric keys to enter the desired synchronization matching voltage value and press the Enter key.           |
|    | SYNC VOLTAGE MATCH →<br># VAC    | Displays the corrected synchronization matching voltage value.  |
|    | SYNC FREQ MATCH →<br>? HZ        | Displays the synchronization matching frequency value. When required, use the numeric keys to enter the desired synchronization matching frequency value and press the Enter key.       |
|   | SYNC FREQ MATCH →<br># HZ        | Displays the corrected synchronization matching frequency value.  |
|  | SYNC PHASE MATCH →<br>? DEG      | Displays the synchronization matching phase value. When required, use the numeric keys to enter the desired synchronization matching phase value and press the Enter key.               |
|  | SYNC FREQ MATCH →<br># DEG       | Displays the corrected synchronization matching phase value.  |
|  | TIME DELAY →<br>?SEC             | Displays the synchronization time delay. When required, use the numeric keys to enter the desired time delay value and press the Enter key.   |
|  | TIME DELAY →<br>#SEC             | Displays the corrected synchronization time delay value.  |
|  | SYNC VOLTAGE MATCH →<br>? VAC    | Returns the user to the synchronization matching voltage value display.   |

## 2.9.16 Menu 18—Battery Chargers

|   |
|---|
| <b>⚠ WARNING</b>  |
|    |
| <p><b>Explosion.</b><br/> <b>Can cause severe injury or death.</b><br/> <b>Relays in the battery charger cause arcs or sparks.</b></p> <p>Locate the battery in a well-ventilated area. Isolate the battery charger from explosive fumes.</p> |

**Battery gases. Explosion can cause severe injury or death.** Incorrect use of the equalize charge state may lead to hazardous situations. Equalization is **ONLY** applicable for flooded lead acid (FLA) type batteries and will damage gel, absorbed glass mat (AGM), or nickel-cadmium (NiCad) type batteries. In the controller menu or SiteTech™ settings, verify that the battery topology is set correctly for the battery type used. Do not smoke or permit flames, sparks, or other sources of ignition to occur near a battery at any time.

Menu 18 provides battery charger information and parameter settings for GM87448, 10 amp battery charger. Use this menu to view battery charger metering information, charge state and identify the battery charger software version as well as to configure the battery charger parameters.

**Note:** This menu is only available for controller firmware version 3.4.3 and above.

Refer to the Battery Charger Operation Manual for charger settings, operation instructions, and safety information.

**Note:** Incorrect charger output system voltage may cause irreversible damage to the battery and abnormal out gassing. Ensure that the battery charger parameters match the battery manufacturer's specifications before using. In the controller user interface settings, verify that the battery topology and system voltage is set correctly for the battery type that is used.

**Note:** The battery charger menus are designed to work with charger GM87448. Unless connected to charger GM87448 through CAN communication, the battery charger menus, although visible, have no effect on the battery charger.












## Menu 18—Battery Chargers

### Menu 18 Displays with Key Entries

| Key Entry  | Display   | Description   |
|------------|---|---|
| RESET MENU | ENTER MENU NO. 1-15   | Input a menu number.  |
| 1 8 NO     | MAIN MENU NUMBER 18   | Press the Enter key.  |
| ENTER      | MENU 18<br>BATTERY CHARGERS   | Displays the menu number and name.  |
| MENU ↓     | BATTERY CHARGER 1 → BATTERY CHARGER 2 →   | Allows the selection of the battery charger.  |
| MENU ↓     | BATTERY CHARGER METERING → BATTERY CHARGER BASIC CONFIG → BATTERY CHARGER ADVANCED CONFIG |   |
| MENU ↓     | OUTPUT VOLTAGE #<br>OUTPUT CURRENT #  | Displays the battery charger output voltage and output current.   |
| MENU ↓     | CHARGER STATE #   | Displays the charging state that the battery charger has entered such as recovery, bulk, absorption, float, equalize. |
| MENU ↓     | SFWR VER #  | Displays the battery charger firmware version.  |
| MENU ↓     | REDUCED OUTPUT Y/N<br>TEMP COMP ACTIVE Y/N  | Displays whether reduced output and temperature compensation are enabled.   |
| MENU ↓     | BATTERY CHARGER 1   | Returns the user to the Battery Charger 1 or 2 heading.   |

## Menu 18—Battery Chargers

### Menu 18 Displays with Key Entries

| Key Entry   | Display  | Description  |
|---|--|--|
|    | BATTERY CHARGER 1  | Returns the user to the battery charger selection menu.  |
|    | BATTERY CHARGER METERING   | Returns the user to the Battery Charger Metering menu.   |
|    | BATTERY CHARGER BASIC CONFIG   | Displays the Battery Charger Basic Configuration menu.   |
|    | 1-BATTERY TOPOLOGY →<br>(User Defined) Y/N   | Displays the user-defined battery topology. Press the Down arrow key if the correct battery topology is displayed. If the desired battery topology is not displayed, press the Right arrow key until the desired battery topology appears. |
|    | BATTERY TOPOLOGIES<br>Default Y/N<br>FLA/VRLA N/Y<br>AGM N/Y<br>Gel N/Y<br>NiCad N/Y | Entering YES selects the battery topology shown. <b>Note:</b> Selecting one battery topology deselects any previously selected choice.   |
|    | BATTERY TOPOLOGY →<br>(User Defined) YES   | Press the Enter key.   |
|    | BATTERY TOPOLOGY →<br>(User Defined) YES   | Confirms the entry.  |
|   | CHARGER SYSTEM<br>VOLTAGE → (user Defined) Y/N                                       | Displays the user-defined system voltage. Press the Down arrow key if the correct system voltage is displayed. If the desired system voltage is not displayed, press the Right arrow key until the desired system voltage appears.         |
|  | SYSTEM VOLTAGES<br>12V Y/N<br>24V N/Y  | Entering YES selects the stem voltage shown. <b>Note:</b> Selecting one system voltage deselects any previously selected choice.   |
|  | BATTERY TOPOLOGY →<br>(User Defined) YES   | Press the Enter key.   |
|  | BATTERY TOPOLOGY →<br>(User Defined) YES   | Confirms the entry.  |

# Menu 18—Battery Chargers, Continued

## Menu 18 Displays with Key Entries

| Key Entry                                   | Display                           | Description  |
|---|-----------------------------------|--|
| MENU<br>▼                                   | AUTOMATIC EQUALIZE<br>ENABLED Y/N | Enable equalization charge state. <b>Note:</b> Equalization is ONLY applicable for flooded lead acid (FLA or VRLA in the menu) type batteries and will damage gel, absorbed glass mat (AGM), or nickel-cadmium (NiCad) type batteries. |
| 7<br>YES                                    | AUTOMATIC EQUALIZE NO             | Entering YES activates the Equalize selection.   |
| ENTER<br>↵                                  | AUTOMATIC EQUALIZE YES            | Press the Enter key.   |
| ENTER<br>↵                                  | AUTOMATIC EQUALIZE YES            | Confirms the entry.  |
|   | <b>OR</b>                         |  |
| 8<br>NO                                     | AUTOMATIC EQUALIZE YES            | Entering NO deactivates the Equalize selection.  |
| ENTER<br>↵                                  | AUTOMATIC EQUALIZE NO             | Press the Enter key.   |
| ENTER<br>↵                                  | AUTOMATIC EQUALIZE NO             | Confirms the entry.  |
| <hr style="border-top: 1px dashed black;"/> |                                   |  |
| MENU<br>▼                                   | TEMP COMPENSATION<br>ENABLED Y/N  | Entering YES activates the Temperature Compensation selection.   |
| 7<br>YES                                    | TEMP COMPENSATION NO              | Press the Enter key.   |
| ENTER<br>↵                                  | TEMP COMPENSATION YES             | Press the Enter key.   |
| ENTER<br>↵                                  | TEMP COMPENSATION YES             | Confirms the entry.  |
|   | <b>OR</b>                         |  |
| 8<br>NO                                     | TEMP COMPENSATION YES             | Entering NO deactivates the Temperature Compensation selection.  |
| ENTER<br>↵                                  | TEMP COMPENSATION NO              | Press the Enter key.   |
| ENTER<br>↵                                  | TEMP COMPENSATION NO              | Confirms the entry.  |
| <hr style="border-top: 1px dashed black;"/> |                                   |  |
| MENU<br>▼                                   | ABSORPTION TERMINATION<br>????A   | Use the key pad to enter the limit to determine when the absorption charge state completes.  |
| ENTER<br>↵                                  | ABSORPTION TERMINATION<br>#.###A  | Confirms the entry.  |
| MENU<br>▼                                   | BATTERY CHARGER 1                 | Returns the user to the Battery Charger 1 heading.   |

# Menu 18—Battery Chargers, Continued

## Menu 18 Displays with Key Entries

| Key Entry  | Display                              | Description  |
|------------|--------------------------------------|--|
| MENU<br>↓  | BATTERY CHARGER 1                    | Returns the user to the battery charger selection menu.  |
| MENU<br>→  | BATTERY CHARGER METERING             | Returns the user to the Battery Charger Metering menu.   |
| MENU<br>→  | BATTERY CHARGER BASIC CONFIGURATION  | Displays the Battery Charger Basic Configuration menu.   |
| MENU<br>↓  | BATTERY CHARGER ADVANCED CONFIG      | Displays the Battery Charger Advanced Configuration menu.  |
| MENU<br>↓  | CUSTOMER CHARGING PROFILE ENABLE Y/N | Enables a customized battery charger profile. Note: ONLY adjust parameters outside default to manufacturer recommended values. Maladjustment will result in reduced battery performance and potential harm to the battery. |
|            | CUSTOMER CHARGING NO                 | Entering YES activates the Customer Charging selection.  |
| 7<br>YES   | CUSTOMER CHARGING YES                | Press the Enter key.   |
| ENTER<br>↵ | CUSTOMER CHARGING YES                | Confirms the entry.  |
|            | <b>OR</b>                            |  |
|            | CUSTOMER CHARGING YES                | Entering NO deactivates the Customer Charging selection.   |
| 8<br>NO    | CUSTOMER CHARGING NO                 | Press the Enter key.   |
| ENTER<br>↵ | CUSTOMER CHARGING NO                 | Confirms the entry.  |
| <hr/>      |                                      |  |
| MENU<br>↓  | BULK VOLTAGE ????VDC                 | Use the keypad to enter the target bulk voltage setpoint.  |
| ENTER<br>↵ | BULK VOLTAGE<br>####VDC              | Confirms the entry.  |
| <hr/>      |                                      |  |
| MENU<br>↓  | ABSORPTION VOLTAGE<br>???VDC         | Use the keypad to enter the target absorption voltage setpoint.  |
| ENTER<br>↵ | ABSORPTION VOLTAGE<br>####VDC        | Confirms the entry.  |
| <hr/>      |                                      |  |
| MENU<br>↓  | FLOAT VOLTAGE<br>???VDC              | Use the keypad to enter the target float voltage setpoint.   |
| ENTER<br>↵ | FLOAT VOLTAGE<br>####VDC             | Confirms the entry.  |
| <hr/>      |                                      |  |



# Menu 18—Battery Chargers, Continued

## Menu 18 Displays with Key Entries

| Key Entry  | Display                                | Description  |
|------------|--|--|
| MENU<br>▼  | MANUAL EQUALIZE ACTIVE<br>Y/N          | Manual Equalize triggers a single equalize cycle on the next charge cycle. The equalize cycle occurs between the absorption and float cycle. |
| 7<br>YES   | MANUAL EQUALIZE ACTIVE<br>NO           | Entering YES activates the Manual Equalize selection.  |
| ENTER<br>↵ | MANUAL EQUALIZE ACTIVE<br>YES          | Press the Enter key.   |
| ENTER<br>↵ | MANUAL EQUALIZE ACTIVE<br>YES          | Confirms the entry.  |
|            | <b>OR</b>                              |  |
| 8<br>NO    | MANUAL EQUALIZE ACTIVE<br>YES          | Entering NO deactivates the Manual Equalize selection.   |
| ENTER<br>↵ | MANUAL EQUALIZE ACTIVE<br>NO           | Press the Enter key.   |
| ENTER<br>↵ | MANUAL EQUALIZE ACTIVE<br>NO           | Confirms the entry.  |
| MENU<br>▼  | TEMPERATURE COMP SLOPE<br>-??mV/C      | Allows fine adjustment of the amount of temperature compensation to follow an optimal manufacturer's recommendation.                         |
| ENTER<br>↵ | TEMPERATURE COMP SLOPE<br>-##mV/C      | Confirms the entry.  |
| MENU<br>▼  | EQUALIZE VOLTAGE<br>?.??VDC            | Use the keypad to enter the target equalize voltage setpoint. Note: Automatic Equalize must be set to enabled.                               |
| ENTER<br>↵ | EQUALIZE VOLTAGE<br>#.###VDC           | Confirms the entry.  |
| MENU<br>▼  | MAX ABSORPTION TIME<br>??MIN           | Use the keypad to set the maximum amount of time the battery attempts to complete the absorption cycle.                                      |
| ENTER<br>↵ | MAX ABSORPTION TIME<br>###MIN          | Confirms the entry.  |
| MENU<br>▼  | MAX BULK TIME<br>??MIN                 | Use the keypad to set the maximum amount of time the battery attempts to complete the bulk cycle.  |
| ENTER<br>↵ | MAX BULK TIME<br>###MIN                | Confirms the entry.  |
| MENU<br>▼  | BULK STATE RETURN<br>VOLTAGE<br>?.??V  | Use the keypad to enter the measured battery terminal voltage at which the charger will initiate a charge cycle at bulk.                     |
| ENTER<br>↵ | BULK STATE RETURN<br>VOLTAGE<br>#.###V | Confirms the entry.  |
| MENU<br>▼  | BATTERY CHARGER1                       | Returns the user to the Battery Charger 1 heading.   |

## 2.9.17 Menu 20—Factory Setup

Menu 20 provides generator set, alternator, controller, and engine identification information. The user can use this menu to determine the generator set operating days and identify the controller software (code) version. The factory setup menu information is locked by the manufacturer. The temperature sensor setup applies to non-ECM engines only.

**Note:** This menu is for monitoring only; no adjustments or user settings can be entered.










**Note:** For Version 2.69 and lower, enter the numeric serial number from the generator set nameplate. For Version 2.70 and higher, confirm that the alphanumeric number shown on the display matches the serial number shown on the generator set nameplate. If the serial numbers match, press the YES key and then press ENTER. If the serial numbers do not match, the wrong personality parameter file is installed. Refer to the Program Loader documentation for instructions on reloading the personality parameter file.

**Note:** For Version 3.01 and higher, the engine type is displayed for engines with an ECM. The correct engine type is not displayed until the engine has run.

**Note:** For Version 3.01 and higher, the Low Coolant Temp Warning can be disabled on units with non-ECM engines that are not required to meet NFPA 110. As with older version of firmware on ECM engines, the LCTW may be disabled by selecting NO for the respective Warning Enabled input. Refer to section 2.9.7 for disabling NFPA defaults and refer to section 2.9.9 for configuration of digital inputs.

## Menu 20—Factory Setup

### Menu 20 Displays with Key Entries

| Key Entry   | Display   | Description  |
|---|---|--|
|    | <input type="text" value="ENTER MENU NO. 1-15"/>                    | Input a menu number.                                     |
|   | <input type="text" value="MAIN MENU NUMBER 20"/>                    | Press the Enter key.                                     |
|    | <input type="text" value="MENU 20&lt;br/&gt;FACTORY SETUP"/>        | Displays the menu number and name.                       |
|    | <input type="text" value="FINAL ASSEMBLY DATE&lt;br/&gt;DD/MM/YY"/> | Displays the final assembly date at the factory.         |
|    | <input type="text" value="FINAL ASSEMBLY&lt;br/&gt;CLOCK NO #"/>    | Displays the final assembly clock number at the factory. |
|    | <input type="text" value="OPERATING DAYS #"/>                       | Displays the generator set operating days.               |
|    | <input type="text" value="MODEL NO #"/>                             | Displays the generator set model number.                 |
|    | <input type="text" value="SPEC NO #"/>                              | Displays the generator set specification number.         |

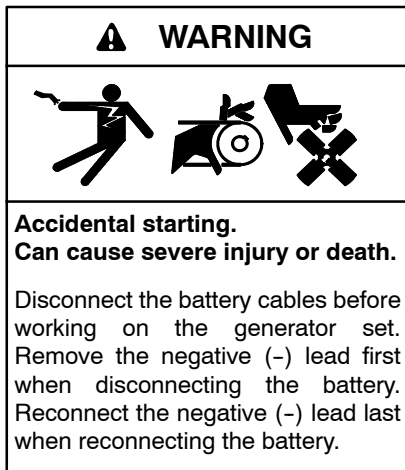
## Menu 20—Factory Setup, continued

### Menu 20 Displays with Key Entries

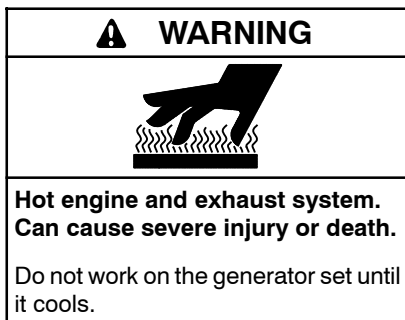
| Key Entry  | Display                              | Description  |
|------------|--------------------------------------|--|
| MENU<br>▼  | GENSET SERIAL NO #                   | Displays the generator set serial number.  |
| MENU<br>▼  | ALTERNATOR PART NO #                 | Displays the alternator part number.   |
| MENU<br>▼  | ENGINE PART NO #                     | Displays the engine part number.   |
| MENU<br>▼  | TEMP SENSOR YES<br>GM31045-X         | TEMP SENSOR NO<br>GM16787 → TEMP SENSOR NO<br>GM17362  |
| MENU<br>▼  | DISABLE LOW COOLANT TEMP WARNING Y/N | Press YES to disable the Low Coolant Temp Warning. Value is only accepted when the warning is not active and NFPA 110 Defaults are not selected. |
| 7<br>YES   | DISABLE LOW COOLANT TEMP WARNING Y/N | Press the Enter key.   |
| MENU<br>▼  | SERIAL NO CONFIRM →                  | Displays the generator set serial number confirmation display.   |
| MENU<br>▶  | CONFIRM SERIAL? Y/N<br>#####         | Press YES, if the display matches the generator set nameplate serial number. Refer to the Menu 20 notes if the serial numbers do not match.      |
| 7<br>YES   | CONFIRM SERIAL? YES<br>#####         | Press the Enter key.   |
| ENTER<br>◀ | SERIAL NO CONFIRM →                  | Returns user to the Serial No. Confirm display.  |
| MENU<br>▼  | CONTROLLER SERIAL NO #               | Displays the controller serial number.   |
| MENU<br>▼  | CODE VERSION #<br>COPYRIGHT XXXX     | Displays the controller software (code) version.   |
| MENU<br>▼  | SETUP LOCKED YES                     | Displays the setup locked by the manufacturer.   |
| MENU<br>▼  | ENGINE TYPE<br>?????????             | Displays the engine type.  |

## Section 3 Scheduled Maintenance

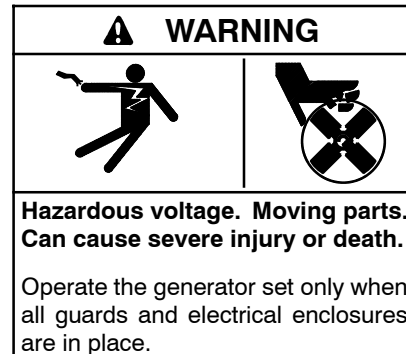
Under normal operating conditions, the generator set's alternator requires no routine service. Consult Section 2.1, Prestart Checklist, for a list of routine checks.



**Disabling the generator set. Accidental starting can cause severe injury or death.** Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.



**Servicing the exhaust system. Hot parts can cause severe injury or death.** Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.



**Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death.** Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

### 3.1 Alternator Service

When operating the generator set under dusty or dirty conditions, use dry compressed air to blow dust out of the alternator while the generator set is running. Direct the stream of air through openings in the generator set end bracket.

### 3.2 Engine Service

Perform engine service at the intervals specified in the engine manufacturer's service literature. Contact an authorized service distributor/dealer to obtain service literature.

**Note:** Have maintenance work, including battery service, performed by appropriately skilled and suitably trained maintenance personnel familiar with generator set operation and service.

### 3.3 Service Schedule

| System—Component   | Action           |       |        |       |      | Interval                                 |
|--|------------------|-------|--------|-------|------|--|
|  | Visually Inspect | Check | Change | Clean | Test |  |
| <b>Fuel System</b>   |                  |       |        |       |      |  |
| Day tank level   | X                | X     |        |       |      | Weekly                                   |
| Flexible lines and connections   | X                |       | R      |       |      | Weekly                                   |
| Fuel level switch  | X                |       |        |       | X    | Weekly                                   |
| Main tank supply level   |                  | X     |        |       |      | Weekly                                   |
| Solenoid valve operation   | X                |       |        |       | X    | Weekly                                   |
| Transfer pump operation  | X                |       |        |       | X    | Weekly                                   |
| Water in system, remove  |                  | •     |        | •     |      | Weekly                                   |
| Filter(s)  |                  |       | •      |       |      | Quarterly                                |
| Gasoline supply  |                  |       | R      |       |      | Six Months                               |
| Fuel piping  | X                |       |        |       |      | Yearly                                   |
| Tank vents and return lines for obstructions   |                  | X     |        |       |      | Yearly                                   |
| <b>Lubrication System</b>  |                  |       |        |       |      |  |
| Oil level  | •                | •     |        |       |      | Weekly                                   |
| Crankcase breather   | •                |       | •      |       |      | Quarterly                                |
| Change oil   |                  |       | •      |       |      | First 50 Hrs., Then<br>Every 250 Hrs.    |
| Replace filter(s)*   |                  |       | •      |       |      |  |
| <b>Cooling System</b>  |                  |       |        |       |      |  |
| Radiator fan bolt torque (1500-2800REOZDC, 2500-2800REOZDB, and 3000/3250REOZD with unit-mounted radiator)   |                  | X     |        |       |      | Initially 8 Hrs., Then<br>Every 100 Hrs. |
| Air cleaner to room/enclosure  |                  | X     |        |       |      | Weekly                                   |
| Block heater operation   |                  | X     |        |       |      | Weekly                                   |
| Coolant level  | •                | •     |        |       |      | Weekly                                   |
| Flexible hoses and connectors  | X                | X     |        |       |      | Weekly                                   |
| Water pump(s)  | •                |       |        |       |      | Weekly                                   |
| Fan and alternator belts   | •                | •     | R      |       |      | Monthly                                  |
| Coolant temperature protection level   |                  |       |        |       | •    | Six Months                               |
| Lubricate fan bearings (1350 kW and larger)  | X                | X     |        |       |      | 200 Hrs. or Six Months                   |
| Air ducts, louvers   |                  | X     |        | X     |      | Yearly                                   |
| Coolant  |                  |       | •      |       |      | Yearly                                   |
| Heat exchanger   |                  |       |        | X     |      | Yearly                                   |
| Louver motors and controls   | X                |       |        | X     | X    | Yearly                                   |
| Radiator exterior  |                  |       |        | X     |      | Yearly                                   |
| Water supply to heat exchanger   |                  | X     |        |       |      | Yearly                                   |
| <b>Exhaust System</b>  |                  |       |        |       |      |  |
| Drain condensate trap  |                  | X     |        |       |      | Weekly                                   |
| Leakage  | X                | X     |        |       |      | Weekly                                   |
| Insulation, fire hazards   | X                |       |        |       |      | Quarterly                                |
| Flexible connector(s)  | X                |       |        |       |      | Six Months                               |
| Excessive back pressure  |                  |       |        |       | X    | Yearly                                   |
| Hangers and supports   | X                |       |        |       |      | Yearly                                   |
| <b>DC Electrical System</b>  |                  |       |        |       |      |  |
| Battery charger operation, charge rate   | X                |       |        |       |      | Monthly                                  |
| Battery electrolyte level  |                  | X     |        |       |      | Monthly                                  |
| Battery specific gravity, charge state   |                  |       |        |       | X    | Monthly                                  |
| Recharge after engine start  |                  | X     |        |       |      | Monthly                                  |
| Remove corrosion, clean and dry battery and rack   | X                |       |        | X     |      | Monthly                                  |
| Clean and tighten battery terminals  | X                | X     |        |       |      | Quarterly                                |
| Tighten DC electrical connections  |                  | X     |        |       |      | Six Months                               |
| <ul style="list-style-type: none"> <li>• Follow procedures and frequencies indicated in the engine manufacturer's maintenance manual. If not indicated, follow this service schedule. Some items may not apply to all generator sets.</li> <li>R Replace as necessary.</li> <li>X Action</li> <li>* Service more frequently if operated in dusty areas.</li> </ul> |                  |       |        |       |      |  |

## Service Schedule, continued

| System—Component   | Action           |       |        |       |      | Interval               |
|--|------------------|-------|--------|-------|------|------------------------|
|  | Visually Inspect | Check | Change | Clean | Test |                        |
| <b>AC Electrical System</b>  |                  |       |        |       |      |                        |
| Controller lamp test   | X                |       |        |       | R    | Weekly                 |
| General Inspection   | X                |       |        |       |      | Weekly                 |
| Circuit breakers, fuses†   | X                | X     | R      | X     | X    | Monthly                |
| Wire abrasions where subject to motion   | X                | X     |        |       |      | Quarterly              |
| Safety and alarm operation   |                  | X     |        |       | X    | Six Months             |
| Tighten control and power wiring connections   |                  | X     |        |       |      | Yearly                 |
| Transfer switch main contacts†   | X                |       |        | X     |      | Yearly                 |
| Voltage-sensing device/relay adjustment†   |                  | •     |        |       | •    | Yearly                 |
| Wire-cable insulation breakdown  | X                |       |        |       | X    | 3 Years or<br>500 Hrs. |
| <b>Engine and Mounting</b>   |                  |       |        |       |      |                        |
| General inspection   | •                |       |        |       |      | Weekly                 |
| Governor operation, lubricate moving parts   | •                | •     |        |       |      | Monthly                |
| Air cleaner service  |                  | •     | •      |       |      | Six Months             |
| Choke, carburetor adjustment   |                  | •     |        |       |      | Six Months             |
| Governor oil (mechanical governor only)  |                  | •     |        |       |      | Yearly                 |
| Ignition components  | •                |       |        | •     |      | Yearly                 |
| Injector pump and injector flow rate, pressure, spray pattern  |                  | •     |        |       | •    | Yearly                 |
| Valve clearance  |                  | •     |        |       |      | 3 Years or<br>500 Hrs. |
| Bolt torque  |                  | •     |        |       | •    | 3 Years or<br>500 Hrs. |
| <b>Remote Control System, etc.</b>   |                  |       |        |       |      |                        |
| Compartment condition  | X                |       |        | X     |      | Weekly                 |
| Remote control   |                  |       |        |       | X    | Monthly                |
| Run generator set  |                  |       |        |       | X    | Monthly                |
| <b>Alternator</b>  |                  |       |        |       |      |                        |
| General inspection   | X                |       |        |       |      | Weekly                 |
| Rotor and stator   | X                |       |        | X     |      | Yearly                 |
| Bearing condition  | X                | X     | R      |       |      | Yearly                 |
| Exciter  | X                | X     |        | X     |      | Yearly                 |
| Voltage regulator  | X                | X     |        | X     |      | Yearly                 |
| Measure and record resistance readings of windings with insulation tester (Megger®, with SCR assembly or rectifier disconnected)   |                  |       |        |       | X    | Yearly                 |
| Blow dust out of alternator*   | X                |       |        | •     |      | 2 Years or<br>300 Hrs. |
| <b>General Condition of Equipment</b>  |                  |       |        |       |      |                        |
| Any condition of vibration, leakage, noise, temperature, or deterioration  | X                | X     |        | X     |      | Weekly                 |
| Ensure that system is set for automatic operation  | X                |       |        |       |      | Weekly                 |
| Interior of equipment room or outdoor weather housing  | X                |       |        | X     |      | Weekly                 |
| <ul style="list-style-type: none"> <li>• Follow procedures and frequencies indicated in the engine manufacturer's maintenance manual.</li> <li>If not indicated, follow this service schedule. Some items may not apply to all generator sets.</li> <li>R Replace as necessary.</li> <li>X Action.</li> <li>* Service more frequently if operated in dusty areas.</li> <li>† Do not break manufacturer's seals or internally inspect these devices.</li> </ul> |                  |       |        |       |      |                        |

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### 3.4 Alternator Bearing Service

Have an authorized service distributor/dealer perform service.

#### 3.4.1 20–300 kW Models

Replace the end bracket bearing every 10,000 hours of operation in standby and prime power applications. Service the bearing more frequently if the annual inspection indicates excessive rotor end play or bearing damage. Replace the tolerance ring, if equipped, following end bracket removal. The sealed end bracket bearing requires no additional lubrication.

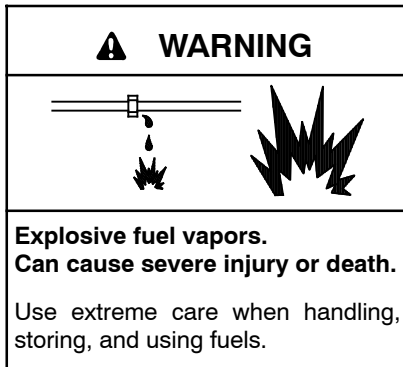
#### 3.4.2 300–2250 kW Models with Single-Bearing Alternator

The alternator bearing requires lubrication at intervals specified in the generator set technical manual. Use Chevron SRI or equivalent antifriction, high-quality grease with a lubrication temperature range of  $-30^{\circ}\text{C}$  to  $175^{\circ}\text{C}$  ( $-22^{\circ}\text{F}$  to  $350^{\circ}\text{F}$ ).

#### 3.4.3 1250 kW and Larger Models with Two-Bearing Alternator

Refer to the generator set service manual for bearing maintenance information.

### 3.5 Diesel Fuel Systems



**The fuel system. Explosive fuel vapors can cause severe injury or death.** Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

**Draining the fuel system. Explosive fuel vapors can cause severe injury or death.** Spilled fuel can cause an explosion. Use a container to catch fuel when draining the fuel system. Wipe up spilled fuel after draining the system.

#### 3.5.1 Bleeding Air from Fuel System

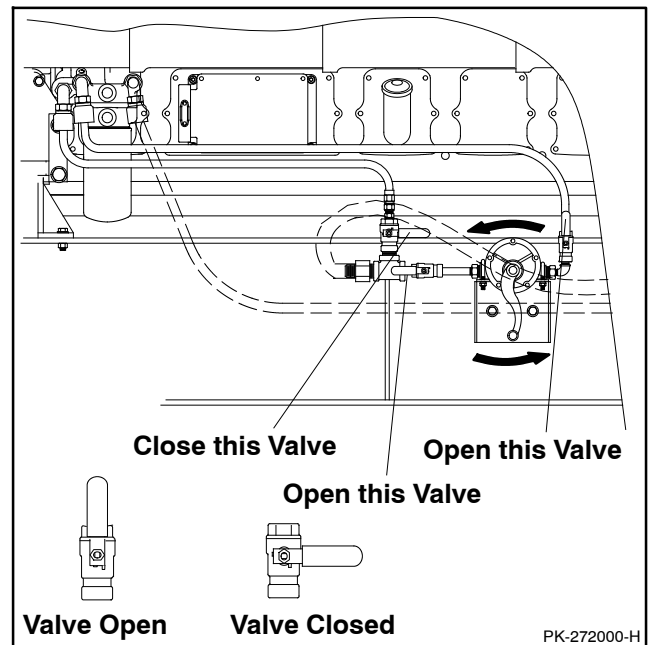
Bleed air from the fuel system after fuel system maintenance, such as replacing the fuel filter(s). Use the hand prime pump kit, when equipped. The hand prime fuel pump eliminates the need for cranking the engine to bleed air from the fuel system.

**Note:** Bleed air from the fuel system according to the engine manufacturer's instructions. Trapped air in the fuel system causes difficult starting and/or erratic engine operation.

**Note:** Correct any fuel leaks encountered during the priming procedure.

1. Place the fuel valves in the fuel system prime position. Close the fuel valve located between the pipe tee and the engine. Open the fuel valves on each side of the fuel prime pump. See Figure 3-1.

**Note:** The illustration shows a generator set without a fuel/water separator. The valve location and position for a generator set equipped with a fuel/water separator is similar.



**Figure 3-1** Hand Prime Pump with Valve Positions for Fuel Priming (generator set without a fuel/water separator shown), Typical

2. Loosen the bleed screw at the engine. Refer to the engine operation manual for location of the bleed screw(s). The bleed screw allows air to be expelled from the fuel system when the hand prime pump is operated.
3. Rotate the hand prime pump handle counterclockwise until fuel flows from the bleed screw. Stop pumping.
4. Tighten the bleed screw. Wipe up any fuel leakage.
5. Place the fuel valves in the normal operation position. Open the fuel valve located between the pipe tee and the engine. Close the fuel valves on each side of the fuel prime pump.

### 3.5.2 Subbase Fuel Day Tank Electronic Control Module (ECM)

With an electronic control module (ECM), the optional subbase diesel fuel tank functions as a day tank. Following are operating information and features of the ECM. See Figure 3-2 for the ECM front panel layout.

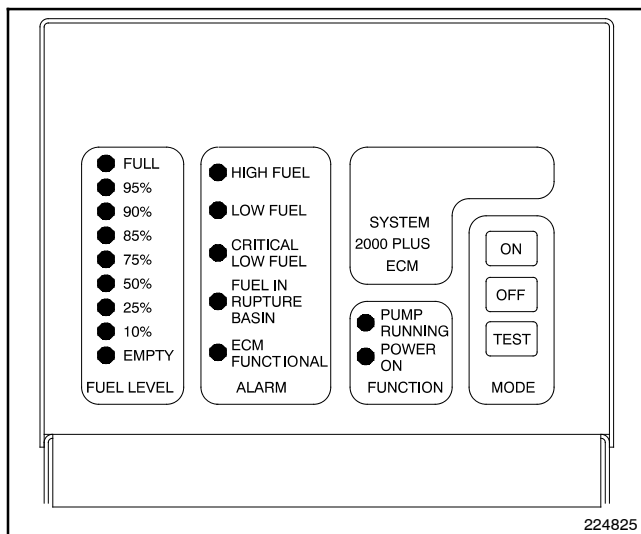


Figure 3-2 ECM Front Panel Layout

**Servicing the day tank. Hazardous voltage can cause severe injury or death.** Service the day tank electrical control module (ECM) as prescribed in the equipment manual. Disconnect the power to the day tank before servicing. Press the day tank ECM OFF pushbutton to disconnect the power. Notice that line voltage is still present within the ECM when the POWER ON light is lit. Ensure that the generator set and day tank are electrically grounded. Do not operate the day tank when standing in water or on wet ground because these conditions increase the risk of electrocution.

### ECM General Function

The ECM controls a pump/motor that maintains the day tank fuel level. The ECM motor relay is connected to the pump/motor. The ECM starts the pump when the fuel level drops to 87% of full and stops the pump when the day tank is full.

### ECM Function Indicator LEDs

Two LEDs on the front panel indicate ECM operation. See Figure 3-2 for the locations of the LEDs. Figure 3-3 describes the LED functions.

| Function     | Description  |
|--------------|--|
| Power On     | LED lights to indicate that power is applied to the ECM. |
| Pump Running | LED lights when the pump starts.                         |

Figure 3-3 ECM Function Indicator LEDs

### Level Sensor

An electronic analog float gauge located below the ECM on the mounting bracket determines the day tank fuel level. Nine LEDs on the ECM indicate the day tank fuel level from full to empty.

### ECM Mode

The ECM has three pushbutton switches for normal operation and one internal test button. See Figure 3-4.

| Pushbutton    | Description   |
|---------------|---|
| Off           | Pushbutton disables the ECM for routine maintenance to the tank system.   |
| On            | Pushbutton activates the ECM after the OFF pushbutton is depressed. On power-up after a power outage, the ECM automatically turns on.   |
| Test          | Pushbutton lights front panel LEDs for 3 seconds and activates the pump/motor for as long as the pushbutton is depressed. The alarm relays maintain their original positions. |
| Internal test | Pushbutton (located inside the ECM) tests each alarm LED and remote annunciation relay in sequential order (high fuel to ECM functional).                                     |

Figure 3-4 ECM Pushbuttons



## ECM Alarms

The ECM has five standard alarm conditions indicated locally by LEDs and remotely by relays. Figure 3-5 describes the five alarm conditions. Make controller connections to the normally open and normally closed relay contacts provided.

| Alarm                               | Description   |
|-------------------------------------|---|
| High fuel                           | Alarm activates at 106% of normal fuel level.   |
| Low fuel                            | Alarm activates at 62% of normal fuel level. The alarm provides time to respond to a potential problem before a low fuel shutdown occurs.                                 |
| Critical low fuel (engine shutdown) | Alarm activates at 6% of normal fuel level to warn the operator to shut down the generator set before fuel runs out.  |
| Fuel in rupture basin, if equipped  | Alarm activates when the ECM detects fuel in the rupture basin.   |
| ECM functional                      | Alarm activates to indicate a problem with the ECM operation.<br><b>Note:</b> The ECM functional alarm relay activates a user-installed alarm when the relay deenergizes. |

Figure 3-5 ECM Alarms

### 3.5.3 Subbase Inner Fuel Tank Alarm

This kit provides for both audible and visual alarms from a location remote from the generator set if a leak is detected in the inner fuel tank of the double-wall subbase fuel tanks. See Figure 3-6. If the inner tank is leaking, a sensor installed in the outer tank sends an electrical signal to the alarm plate when the sensor becomes immersed in the fuel collecting in the outer tank. If a leak is detected, the alarm horn will sound and the fault lamp will light. The alarm horn is quieted by moving the alarm switch to the SILENCE position; the alarm lamp remains lit until the fault is corrected. See Figure 3-7 for troubleshooting information.

#### Resetting Procedure

Use the following procedure to reset the alarm after a fault alarm.

1. Move the alarm switch to the SILENCE position to stop the alarm horn. The lamp will remain lit.
2. Disconnect the generator set from the load with the line circuit breaker or the automatic transfer switch.
3. Repair or replace the inner fuel tank.
4. Move the generator set master switch to the OFF/RESET position and then to the RUN position for startup. The alarm horn sounds and the lamp goes out.

5. Reconnect the generator set to the load via the line circuit breaker or the automatic transfer switch.
6. Move the generator set master switch to the AUTO position for startup by remote transfer switch or remote start/stop switch. Move the alarm switch to the NORMAL position.

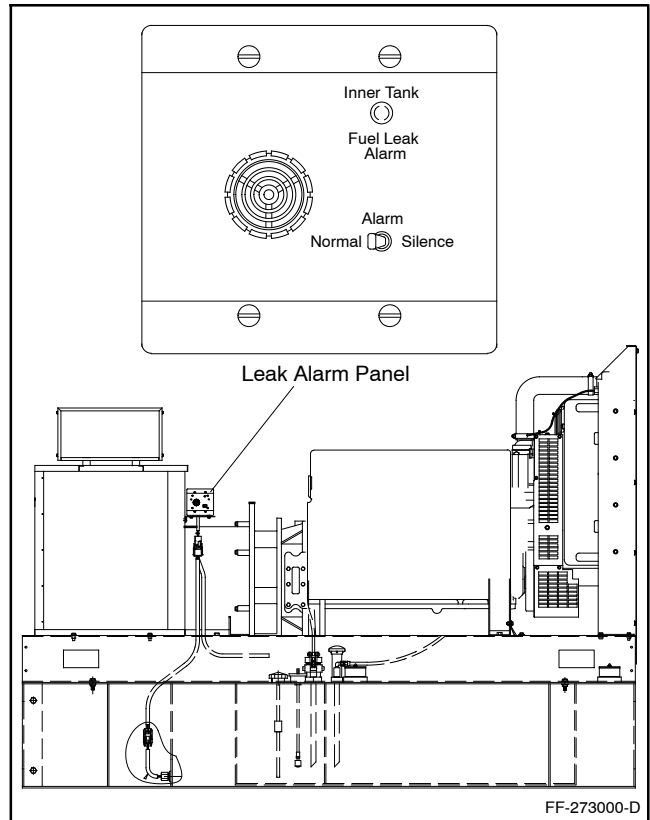


Figure 3-6 Inner Fuel Tank Leak Alarm (20–300 kW Model Shown)

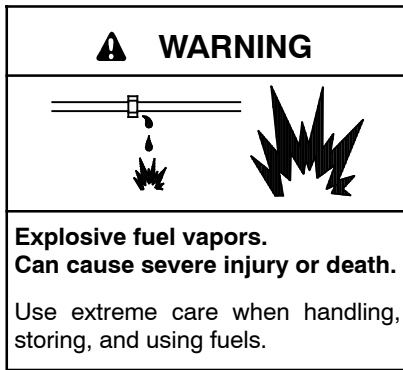
| Switch Position |        | Observation   |
|-----------------|--------|---|
| Alarm           | Float  |   |
| Normal          | Open   | The alarm horn and the lamp are not energized.  |
| Normal          | Closed | The alarm horn and lamp activate when a fuel leak occurs. If the alarm switch is moved to the silence position, the lamp stays on until the fuel leak fault is corrected. |
| Silence         | Open   | The alarm horn sounds to alert the user that the alarm horn switch is not in the normal position and that the alarm horn will not sound should a fuel leak occur.         |

Figure 3-7 Inner Fuel Tank Leak Alarm Troubleshooting

## 3.6 Gaseous Fuel Systems

Gaseous fuel systems apply to REZG\_/RZG\_/ERES\_ (GM/PSI Powered) and REZX\_/RZX\_ (Doosan Powered) generator set models.

This section describes natural gas and liquified petroleum gas (LPG) fuel systems that are not covered in the engine operation manual or engine service manual.



**The fuel system. Explosive fuel vapors can cause severe injury or death.** Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

**Explosive fuel vapors can cause severe injury or death.** Take additional precautions when using the following fuels:

**Propane (LPG)**—Adequate ventilation is mandatory. Because propane is heavier than air, install propane gas detectors low in a room. Inspect the detectors per the manufacturer's instructions.

**Natural Gas**—Adequate ventilation is mandatory. Because natural gas rises, install natural gas detectors high in a room. Inspect the detectors per the manufacturer's instructions.

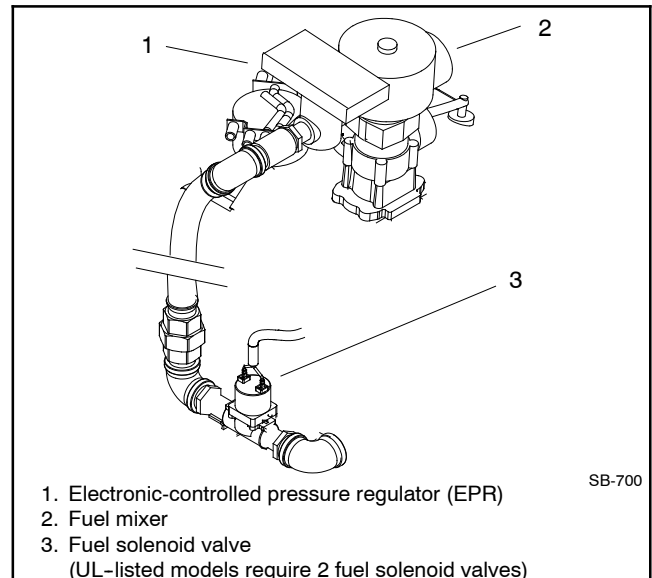
### 3.6.1 Gaseous Fuel System Concept (Single Fuel)

The gaseous fuel system uses a fuel solenoid valve to control the fuel flow to the electronic-controlled pressure regulator (EPR). The generator set-mounted EPR reduces the fuel pressure as fuel passes to the fuel mixer. See Figure 3-8.

The fuel mixer controls the ratio of fuel to air under varying load and speed conditions. Because the fuel mixer receives fuel in a gaseous state, it does not have to vaporize the fuel.

### 3.6.2 LPG Liquid Withdrawal Fuel System Concept

With the LPG liquid withdrawal fuel system, pressurized liquid LPG fuel passes from the tank to a vaporizer. The vaporizer converts the liquid fuel to gas before sending it to the fuel EPR. The system also includes a fuel solenoid valve that shuts off the fuel flow when the engine stops. Contact an authorized service distributor/dealer for availability.



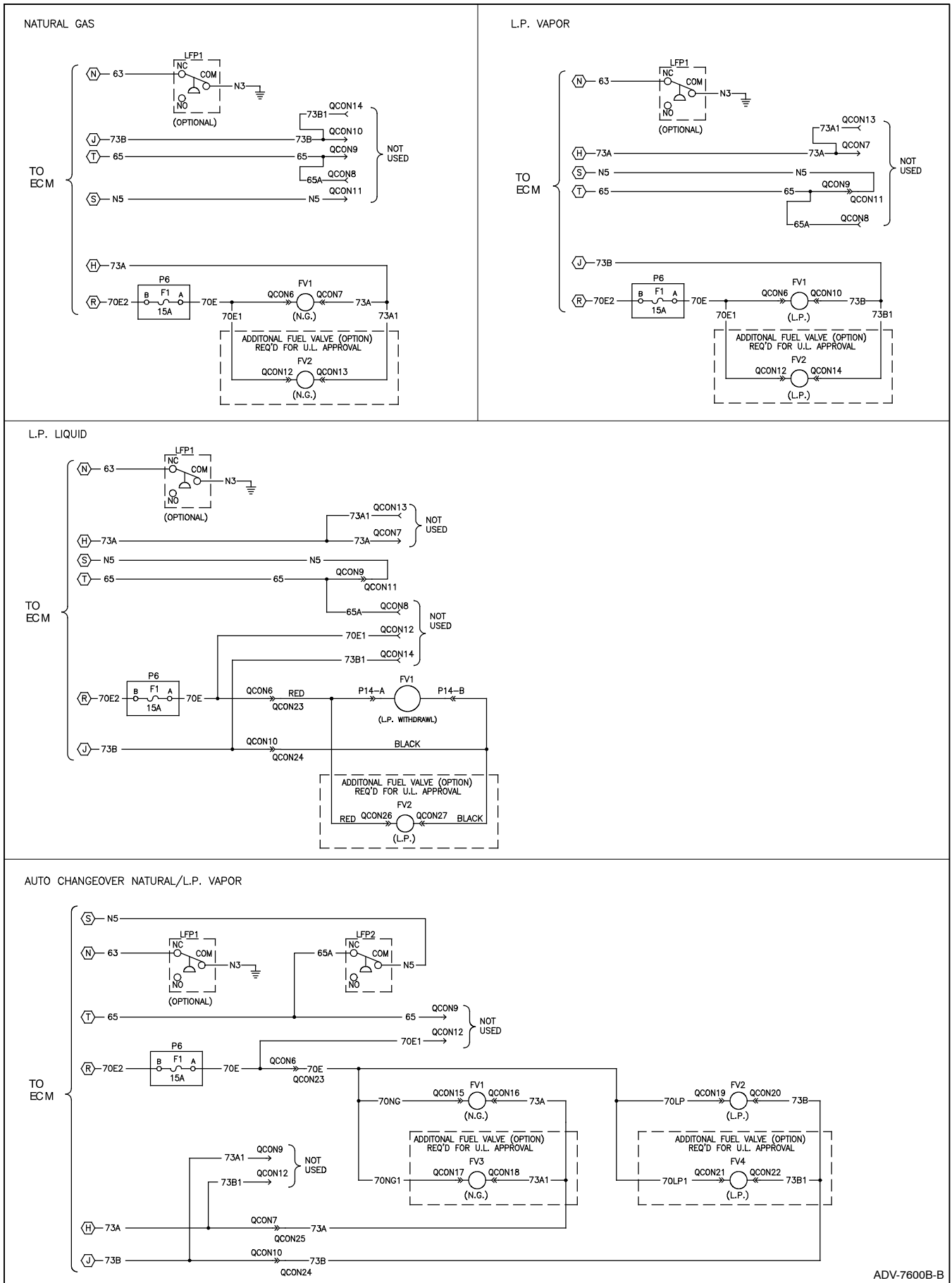
**Figure 3-8** Fuel Regulator and Valve, Typical

### 3.6.3 Natural Gas and LPG Conversion

Most models operate on either natural gas or LPG fuel by performing the fuel conversion procedure. A hang tag on the fuel regulator may provide additional conversion setup information. Fuel conversion may decrease generator set output. Refer to the respective generator set spec sheet for ratings based on fuel selection. Changing fuel does not alter the emissions compliance of the generator set engine. Consult your local generator set distributor/dealer for additional information.

**Note:** If a gas-fueled model has the fuel type changed (LPG to natural gas or natural gas to LPG), order a new nameplate from an authorized distributor/dealer with the updated ratings and attach to the generator set.

To change the fuel type, change the electrical connections between the fuel system and the engine ECM. The engine ECM has fuel tables and spark advance curves programmed for both natural gas and LPG. The information shown in Figure 3-9 and Figure 3-10 generally apply to all models and all fuels. Be sure to review the respective wiring diagram for your specific model for possible special applications.



ADV-7600B-B

**Figure 3-9** Gaseous Fuel Connections Wiring Diagram

| Eng. ECM | Natural Gas                                | LPG Vapor                         | LPG Liquid | Auto Changeover                 |
|----------|--|-----------------------------------|------------|---------------------------------|
| 73A      | QCON-7 (NG fuel solenoid valve)            | not used                          |            | QCON-7 (NG fuel solenoid valve) |
| N5       | not used                                   | 65                                | 65         | LFP2-COM                        |
| 73B      | not used                                   | QCON-10 (LPG fuel solenoid valve) |            |                                 |
| 65       | not used                                   | N5                                | N5         | not used                        |
| 63       | LFP1-NC low fuel pressure sensor (if used) |                                   |            |                                 |
| 70E2     | P6-B (15 amp fuse)                         |                                   |            |                                 |

**Figure 3-10** Gaseous Fuel Electrical Connections

### Natural Gas Operation

- Disconnect lead 65 from lead N5.
- Disconnect lead 73B from the fuel solenoid valve.
- Connect lead 73A to the fuel solenoid valve.

### LPG Vapor Operation

- Disconnect lead 73A from the fuel solenoid valve.
- Connect lead 73B to the fuel solenoid valve (LPG vapor).
- Connect lead 65 to lead N5 (ground).

### LPG Liquid Withdrawal Operation

- Disconnect lead 73A from the fuel solenoid valve.
- Connect lead 73B to the fuel solenoid valve (LPG liquid withdrawal).
- Connect lead 65 to lead N5 (ground).

### Auto Changeover Natural Gas/LPG Vapor Operation

- Disconnect lead 65 from N5.
- Connect lead N5 to LFP2 relay common terminal.
- Connect lead 73A to the fuel solenoid valve (natural gas).
- Connect lead 73B to the fuel solenoid valve (LPG vapor).

## 3.6.4 Fuel System Changeover Kits (Dual Fuel)

### Automatic Changeover

A changeover fuel system kit provides automatic changeover from natural gas to LPG vapor. The primary and backup fuels each have a fuel solenoid valve. The primary fuel is natural gas; the backup fuel is LPG vapor. Before starting, both fuel solenoid valves are closed. When the generator set starts, the primary fuel solenoid valve opens. The primary fuel line has a pressure switch in series with a relay connected to the start/run circuit.

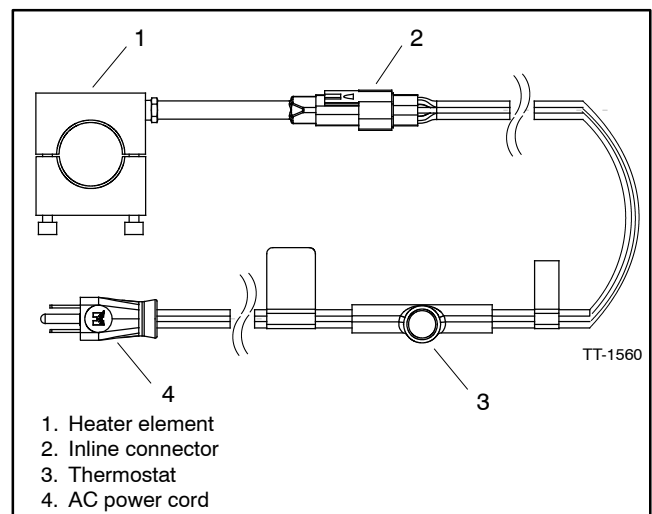
When the primary fuel pressure drops below 0.6 kPa (1.4 oz./in.<sup>2</sup>) or 6.4 cm (2.5 in.) water column, a relay opens the backup fuel solenoid valve and closes the primary fuel solenoid valve. When the primary fuel pressure rises above 0.6 kPa (1.4 oz./in.<sup>2</sup>) or 6.4 cm (2.5 in.) water column, the generator set uses the primary fuel. Contact an authorized service distributor/dealer for kit availability.

Emissions certified models use a single electronic-controlled pressure regulator (EPR) for both fuels. A tee fitting connects both fuels together upstream of the EPR. During operation when using the secondary fuel, it is normal for a small amount of secondary fuel to seep back through the primary fuel solenoid valve. To counter this situation, one of two methods is used depending upon the generator set model: (1) a second solenoid valve (identical to the primary fuel solenoid valve) is installed in a reverse configuration on the primary fuel side or (2) a small vent line is installed between the primary fuel inlet and the air intake through a fuel solenoid valve.

## 3.6.5 Crankcase Ventilation (CCV) Heater Kit GM78171-KP1

Applies to 125/150 kW, 8.1 L GM- and 8.8 L PSI-powered generator set models. Consult your local generator set distributor/dealer for additional information.

The crankcase ventilation (CCV) heater kit provides a controlled heating source to the crankcase ventilation system preventing freezing water buildup during cold weather. The thermostat turns on at 4°C (40°F) and turns off at 16°C (60°F) reducing energy consumption. See Figure 3-11.



**Figure 3-11** Crankcase Ventilation Heater Kit

### 3.7 Air Cleaner Restriction Indicator (if equipped)

The air cleaner restriction gauge mounted on the air cleaner(s) helps determine the air cleaner change interval.

The air cleaner restriction gauge monitors air flow and continuously displays restriction readings indicated as vacuum (see Figure 3-12). Increased restriction indicates a clogged air cleaner element.

As maximum allowable restriction is reached, the gauge window turns red indicating the air cleaner element needs replacement. To reset the gauge, push the gauge top down and release.

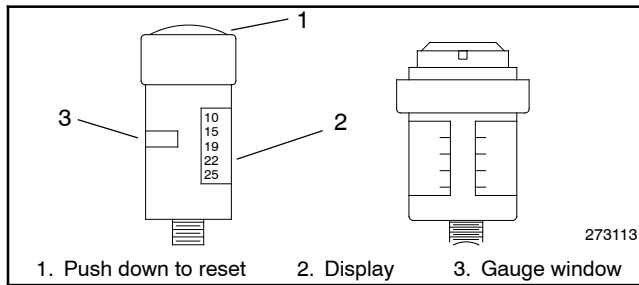




Figure 3-12 Restriction Indicators (styles vary)

### 3.8 Cooling System

The cooling system maintenance information applies to radiator-cooled models and city-water-cooled (heat exchanger) models. The cooling systems function similarly even though they use different components. Radiator-cooled models have a radiator with a pressure cap and coolant recovery tank. City-water-cooled models have a heat exchanger and an expansion/surge tank with a pressure cap.

**Note:** The 20–40 kW Deutz engine-powered generator sets are oil-cooled and, therefore, do not have a water cooling system.

|  |
|--|
|  <b>WARNING</b>                               |
|   |
| <b>Hot coolant and steam.<br/>Can cause severe injury or death.</b>  |
| Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure. |

Allow the engine to cool. Release pressure from the cooling system before removing the pressure cap. To release pressure, cover the pressure cap with a thick cloth and then slowly turn the cap counterclockwise to the first stop. Remove the cap after pressure has been completely released and the engine has cooled. Check the coolant level at the tank if the generator set has a coolant recovery tank.

**Note: Engine damage.** Bleed the air from the cooling system to prevent overheating and subsequent engine damage.

**Note: Block heater damage.** The block heater will fail if the energized heater element is not immersed in coolant. Fill the cooling system before turning on the block heater. Run the engine until it is warm, and refill the radiator to purge the air from the system before energizing the block heater.

#### 3.8.1 Coolant Level Check

Check the coolant level in the coolant recovery tank. Maintain the coolant level between the high and low marks.

**Note:** Periodically check the coolant level by removing the pressure cap. Do not rely solely on the level in the coolant recovery tank. Add fresh coolant until the level is just below the overflow tube opening of the filler neck.

#### 3.8.2 Cooling System Component Inspection

To prevent generator set shutdown or damage caused by overheating:

- Keep the cooling air inlets clean and unobstructed.
- Inspect the radiator's exterior for obstructions. Remove dirt and foreign material using a soft brush or cloth to avoid damaging the radiator fins.
- Check the hoses and connections for leaks. Replace any cracked, frayed, or spongy hoses.
- Check the condition and tension of the radiator fan and water pump belt(s). Follow the belt tension procedure in this manual and/or the engine operation manual.
- Check the pressure cap seal and replace a cracked or deteriorated cap. Remove dirt and other debris from the pressure cap and filler neck. The pressure cap raises the boiling point of the coolant, enabling higher operating temperatures. Replace a leaking pressure cap with one rated for the same pressure. The pressure cap rating usually appears on the pressure cap.

### 3.8.3 Procedure to Drain Cooling System

For optimum protection, drain, flush, and refill the cooling system at the intervals listed in the service schedule.

**Note:** Dispose of all waste materials (oil, fuel, coolant, filters, and gaskets) in an environmentally safe manner.

1. Deenergize the block heater, if equipped.
2. Remove the pressure cap to allow the entire system to drain and prevent air pockets from restricting coolant flow through the engine block.
3. Open the radiator and/or engine block coolant drain valve(s) and allow the system to drain.
4. If the inside of the radiator has mineral deposits or the used coolant contains dirt or grease, refer to Section 3.8.4, Procedure to Flush and Clean the Cooling System. If the cooling system does not have mineral deposits, go to Section 3.8.5, Procedure to Refill the Cooling System.

### 3.8.4 Procedure to Flush and Clean Cooling System

Use the instructions in the engine operation manual when available to flush and clean the cooling system. Otherwise, use the following procedure and the cooling system cleaner manufacturer's instructions.

1. Flush the cooling system with clean water.
2. If the inside of the radiator still has mineral deposits, use a radiator cleaner to remove the remaining deposits following the manufacturer's instructions.
3. Drain, clean, and flush the coolant recovery tank.

### 3.8.5 Procedure to Refill Cooling System

See the generator set spec sheet for coolant capacity.

**Note:** Do not add coolant to a hot engine. Adding coolant to a hot engine can cause the cylinder block or cylinder head to crack. Wait until the engine has cooled.

1. Remove the pressure cap.

2. Close the radiator and/or engine block coolant drain valve(s) and tighten the cooling system hose clamps.
  3. Open the air-bleed petcocks, if equipped. Close the air-bleed petcocks when coolant begins to flow from them.
  4. Add coolant additives or water pump lubricants according to the engine manufacturer's recommendations in the engine operation manual.
  5. Fill the cooling system with a coolant/antifreeze mixture based on the engine manufacturer's recommendation.
  6. Replace the pressure cap.
  7. Fill the coolant recovery tank to the low mark.
  8. Operate generator set until the thermostat opens when the upper cooling system hose warms.
  9. Stop the engine and allow it to cool.
  10. Check and repair any coolant leaks.
  11. Remove the pressure cap.
  12. Add coolant to bring the coolant level to just below the overflow tube opening of the filler neck.
  13. Replace the pressure cap.
  14. Maintain the coolant level in the coolant recovery tank between the high and low marks.
- Note:** Air pockets often form in the engine water jacket when the coolant system is refilled. Check the coolant level in the coolant recovery tank after each generator set operation and add coolant as necessary until the coolant level stabilizes. Then check the coolant at the interval specified in the service schedule.
15. Reenergize the block heater, if equipped.

## 3.9 Radiator Fan Bolt Retorque

*Adapted from Service Bulletin SB-683.*

Check the radiator fan bolts after approximately 8 hours of operation and then recheck after each 100 hours of operation. This scheduled service is required on 1500-

2250REOZDC, 2500–2800REOZDB, and 3000/3250REOZD unit-mounted radiator models using a 2743 mm (108 in.) diameter fan.

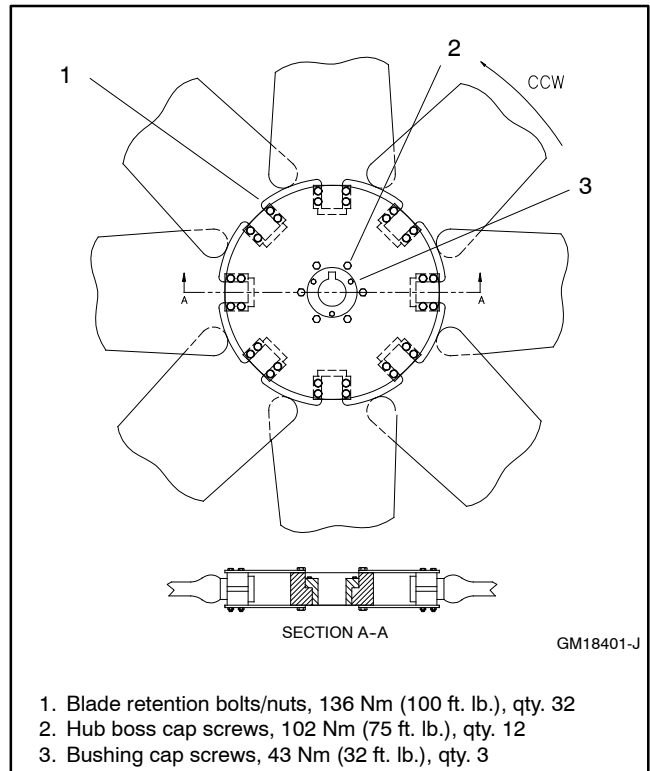
Perform the scheduled service steps in the order shown.

### Required Tools

- Socket wrench sets American Standard and Metric sizes
- Torque wrench, up to 203 Nm (150 ft. lb.)

### Procedure

1. Place the generator set master switch in the OFF/RESET position.
2. Disconnect the power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery(ies), negative (-) lead first.
4. Remove the fan guards, screens, and covers as necessary to access the radiator fan hardware.
5. Inspect the blades for cracks or other damage. Verify that all hardware is present. Replace as needed.
6. Retorque the (32 qty.) blade retention bolts/nuts to 136 Nm (100 ft. lb.). See Figure 3-13.
7. Retorque the (12 qty.) hub boss cap screws to 102 Nm (75 ft. lb.). There are six screws on each side of the fan.
8. Retorque the (3 qty.) bushing cap screws to 43 Nm (32 ft. lb.).
9. Replace the fan guards, screens, and covers that were removed to access the radiator fan hardware.
10. Check that the generator set master switch is in the OFF position.
11. Reconnect the generator set engine starting battery, negative (-) lead last.
12. Reconnect power to the battery charger, if equipped.
13. Place the generator set master switch to the RUN position to start the generator set. Refer to the respective generator set operation manual as needed.

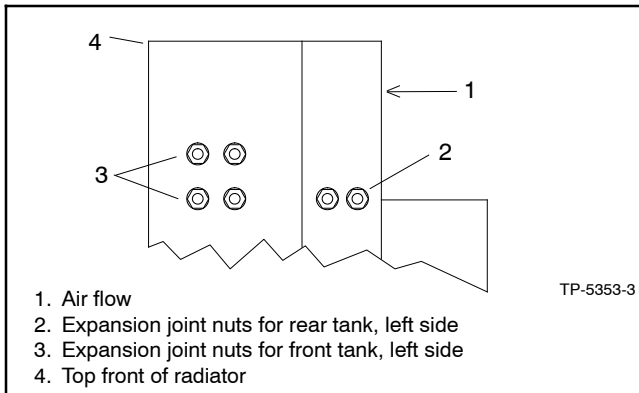


**Figure 3-13** Fan Hardware Location and Torque

14. Listen and observe the fan operation.
15. **Immediately shut down the generator set if abnormal noise or fan assembly vibration is observed.** Correct the problem and go back to step 13.
16. After several minutes of generator set operation without abnormal noise or vibration, shut down the generator set by placing the generator set master switch to the OFF/RESET position.

## 3.10 Radiator Expansion Joint Loosening—Initial Setup Only

Loosen the radiator expansion joint nuts on 1200–2000 kW generator sets that have radiators manufactured by Young Radiator Company. Expansion joints located on each side of the radiator permit differential thermal expansion of the radiator tank. The factory tightens the 12 expansion joint nuts before generator set shipment. Loosen the expansion joint nuts one full turn before running the generator set. See Figure 3-14.



**Figure 3-14** Expansion Joint Nuts, Top Left Side of Radiator, Typical

### 3.11 Radiator Fan Bearing Lubrication

The following procedure applies only to 1200 kW and larger generator sets. Lubricate the radiator fan shaft and idler shaft bearings at every engine oil change to avoid bearing damage. Lubricate the bearings every 200 hours of operation when the generator set runs in ambient temperatures below 29°C (85°F) or when the generator set runs in a dusty and/or humid environment.

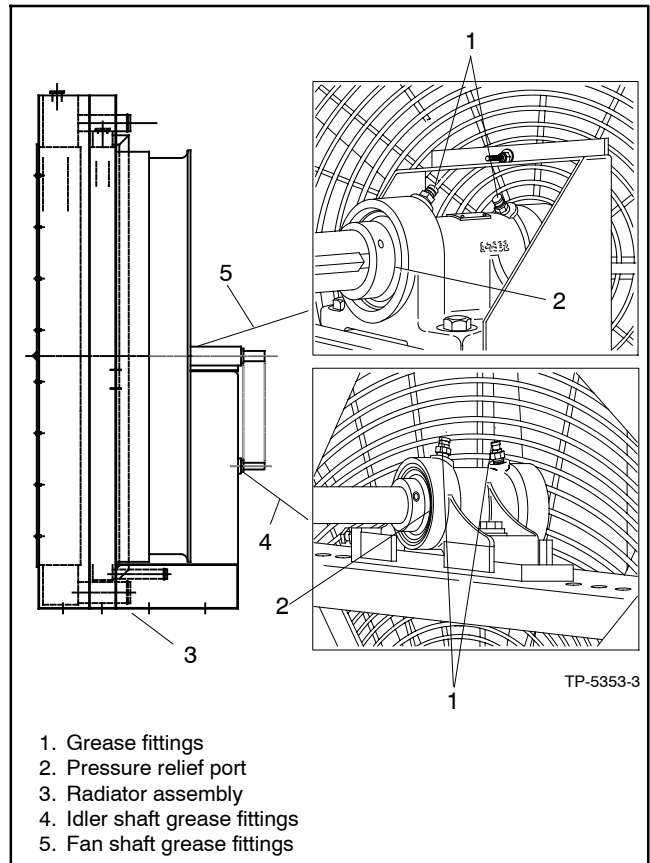
#### Lubrication and Drive Belt Adjustment Procedure

Lubricate the fan shaft and idler shaft bearings with a lithium-complex base, multi-purpose grease with antirust, antifoam, and extreme-pressure additives having a minimum dropping point of 204°C (400°F). Use Mobil Mobilith AW2 NLGI Grade 2 or equivalent.

1. Place the generator set master switch in the OFF/RESET position.
2. Disconnect the generator set engine starting battery(ies), negative (-) lead first, and disconnect power to the battery charger.
3. Remove the belt guards to expose the fan shaft and idler shaft bearings.
4. Inject grease into the two bearings on the fan shaft block and the two bearings on the idler shaft block using a grease gun until a 3–6 mm (0.13–0.25 in.) grease column shows at the bearing pressure relief port. See Figure 3-15.

**Note:** The fan shaft and idler shaft bearings have pressure relief ports to prevent bearing damage caused by overlubrication.

5. Remove excess grease from the bearing pressure relief ports.



**Figure 3-15** Radiator Fan Bearings and Pressure Relief Ports, Typical

6. Inspect the fan drive belt and replace if it is damaged or worn. Check the fan belt tension using a poly V-belt tension gauge and adjust the tension, if necessary. See Figure 3-16.
7. Reinstall the belt guards using the original hardware.

| Generator Set Model | New Belt, N (lbf.)     | Used Belt*, N (lbf.)   |
|---------------------|------------------------|------------------------|
| 1200-2250 kW        | 2450-2890<br>(550-650) | 1650-1910<br>(370-430) |

\* A belt is considered used after 50 hours of service.

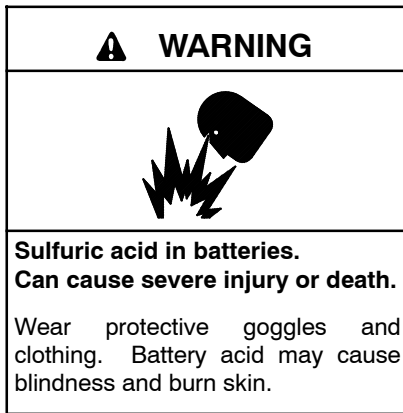
**Figure 3-16** Poly V-Belt Tension Specifications

8. Reconnect the generator set engine starting battery(ies), negative (-) lead last.
9. Test run the generator set for a few minutes and listen for belt noise (squeal) indicating a slipping belt. Stop the generator set.

If the belt slips after the belt tension procedure, clean the pulley surfaces and repeat the belt tension procedure. If slippage continues, replace the fan belt.



## 3.12 Battery



**Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death.** Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.

**Battery acid cleanup. Battery acid can cause severe injury or death.** Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled battery acid and continue to add the neutralizing solution to the spilled battery acid until all evidence of a chemical reaction (foaming) has ceased. Flush the resulting liquid with water and dry the area.

**Battery gases. Explosion can cause severe injury or death.** Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove all jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

**Battery short circuits. Explosion can cause severe injury or death.** Short circuits can cause bodily injury and/or equipment damage. Disconnect the battery before generator set installation or maintenance. Remove all jewelry before servicing the equipment. Use tools with insulated handles. Remove the negative (-) lead first when disconnecting the

battery. Reconnect the negative (-) lead last when reconnecting the battery. Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together.

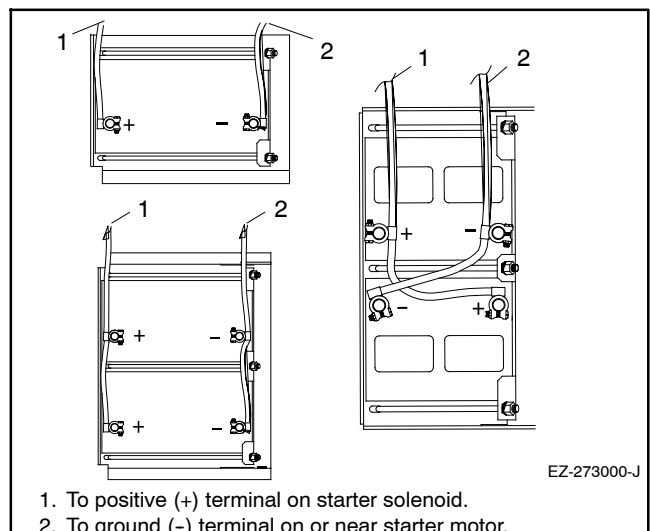
Refer to this section for general battery information and maintenance. All generator set models use a negative ground with a 12-volt or 24-volt engine electrical system. Consult the generator set nameplate for the engine electrical system voltage. Consult the generator set spec sheet for battery capacity recommendations for replacement purposes. The wiring diagrams provide battery connection information. See Figure 3-17, Figure 3-18, and Figure 3-19 for typical battery connections, including multiple battery configurations.

### 3.12.1 Clean Battery

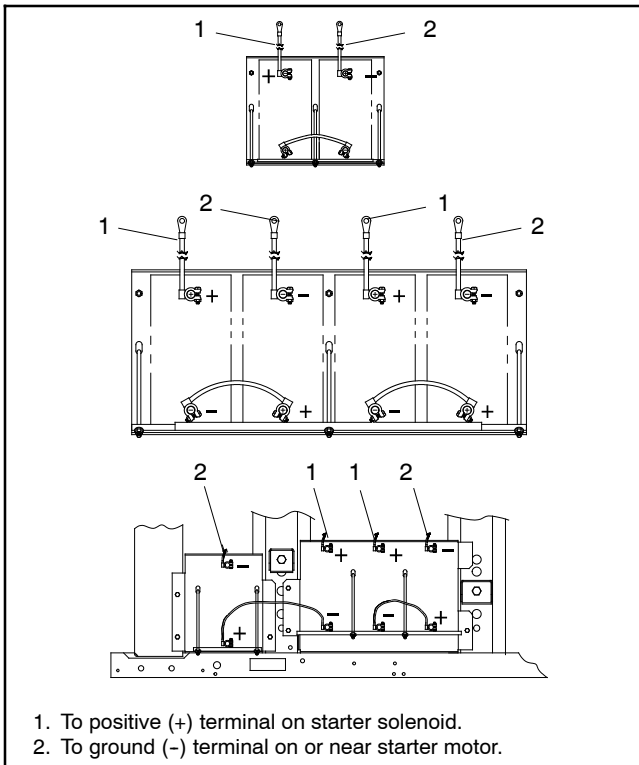
Clean the battery and cables and tighten the battery terminals according to the service schedule recommendations. Clean the battery by wiping it with a damp cloth. Keep the electrical connections dry and tight.

If corrosion exists, disconnect the cables from the battery and remove the corrosion with a wire brush. Clean the battery and cables with a solution of baking soda and water. Do not allow the cleaning solution to enter battery cells. Flush the battery and cables with clean water and wipe the battery with a dry cloth.

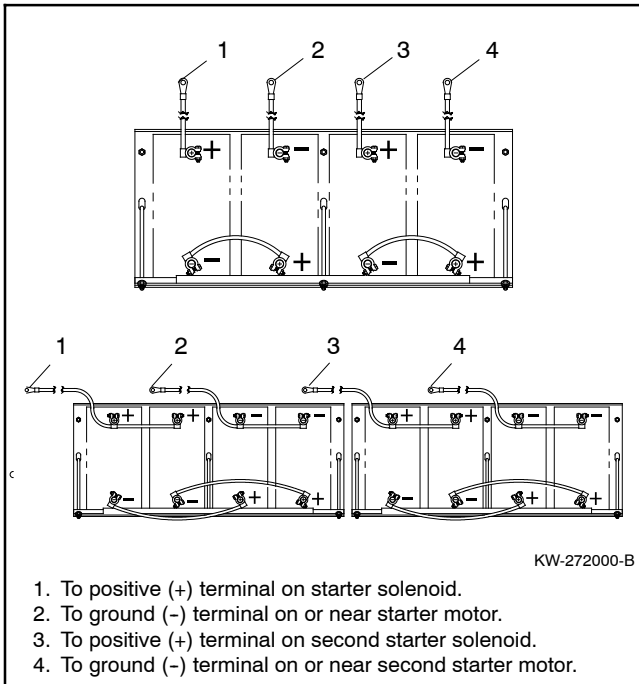
After reconnecting the battery cables, coat the terminals with petroleum jelly, silicon grease, or other nonconductive grease.



**Figure 3-17** 12-Volt Engine Electrical System Single Starter Motor Typical Battery Connection



**Figure 3-18** 24-Volt Engine Electrical System Single Starter Motor Typical Battery Connection

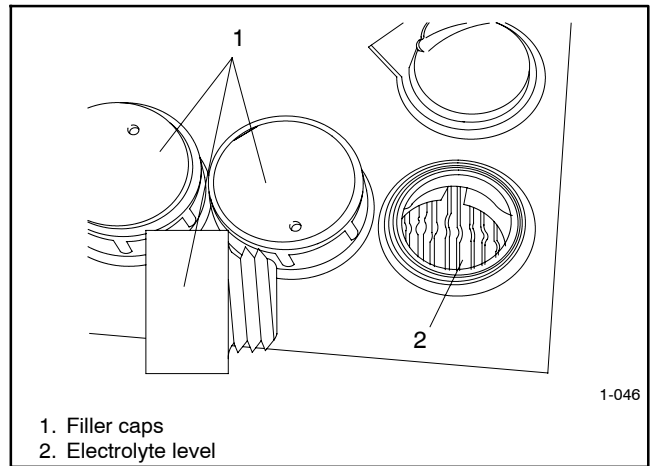


**Figure 3-19** 24-Volt Engine Electrical System Dual Starter Motors Typical Battery Connections

### 3.12.2 Electrolyte Level Inspection

Check the electrolyte level and specific gravity of batteries that have filler caps. Maintenance-free batteries do not require electrolyte level checking or specific gravity testing.

Check the electrolyte level at the specified interval. Remove the filler caps and verify that the electrolyte level reaches the bottom of each filler hole. See Figure 3-20. Refill as necessary with distilled water or clean tap water. Do not add fresh electrolyte. Tighten the filler caps. After adding water during freezing temperatures, run the generator set 20–30 minutes to mix the electrolyte and the water to prevent battery damage from freezing.



**Figure 3-20** Battery Electrolyte Level Inspection

### 3.12.3 Specific Gravity Check

Use a battery hydrometer to check the specific gravity of the electrolyte in each battery cell of batteries with filler caps. Holding the hydrometer vertically, read the number on the glass bulb at the top of the electrolyte level or the number adjacent to the pointer. If the hydrometer used does not have a correction table, consult Figure 3-21. Determine the specific gravity and electrolyte temperature of the battery cells. Locate the temperature in Figure 3-21 and correct the specific gravity by the amount shown. The battery is fully charged if the specific gravity is 1.260 at an electrolyte temperature of 26.7°C (80°F). Maintain the specific gravities between cells within ±0.01 of each other. Charge the battery if the specific gravity is below 1.215 at an electrolyte temperature of 26.7°C (80°F).

**Note:** Some battery testers have four or five beads in a test tube. Draw electrolyte into the tube as with the battery hydrometer described in this section or use the manufacturer's instructions. Use Figure 3-22 to interpret typical test results.

### 3.12.4 Charge Battery

Use a battery charger to maintain a fully charged battery when the generator set is used in a standby application. The engine battery-charging alternator charges the battery while the generator set is running.

**Note:** If the generator set is in a temporary prime power application in which the generator set has periods of inactivity, the controller circuitry may drain the battery. If there is no power source for a battery charger, place the controller in the prime power mode, if equipped, or disconnect the battery from the generator set.

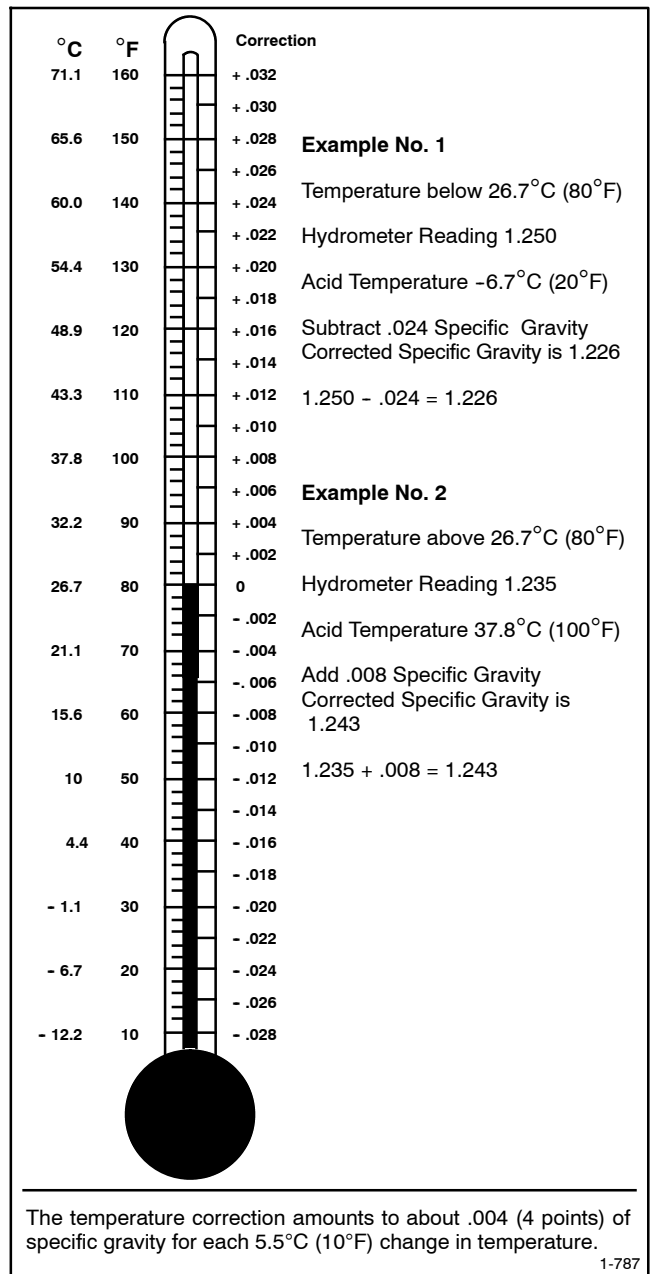


Figure 3-21 Specific Gravity Temperature Correction

| Number of Floating Beads | Battery Condition |
|--------------------------|-------------------|
| 5                        | Overcharged       |
| 4                        | Fully charged     |
| 3                        | A good charge     |
| 1 or 2                   | A low charge      |
| 0                        | A dead battery    |

Figure 3-22 Bead-Type Test Interpretation

### 3.13 Detroit Diesel Engine Control Systems

Some generator sets equipped with Detroit Diesel engines use a DDEC/MDEC/ADEC system. Access the DDEC control box inside the generator set junction box to retrieve codes when performing routine maintenance or troubleshooting the engine.

**Note:** DDC/MTU engines with MDEC/ADEC use the 550 controller to display all engine fault code numbers. The engine operation manual provides the fault code description.

Use the following data for informational purposes only. Consult the engine literature for complete information regarding DDEC/MDEC/ADEC operation and troubleshooting. See List of Related Materials in the Introduction section. Contact an authorized service distributor/dealer for service or diagnostic equipment.

#### 3.13.1 Features

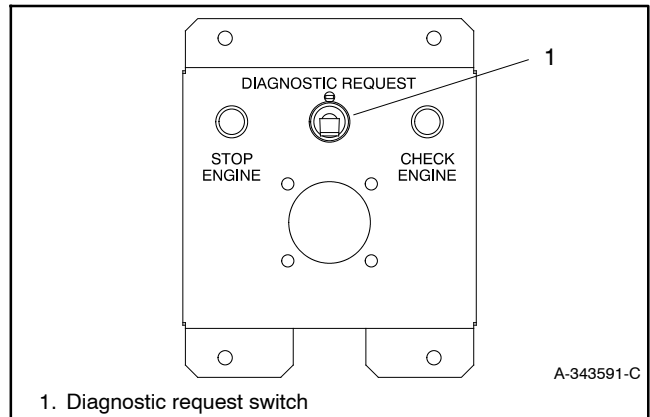
The engine control system optimizes control of critical engine functions and protects against serious engine damage resulting from conditions such as the following:

- Low coolant level
- Low coolant pressure
- High coolant temperature
- Low oil pressure
- High oil temperature

The major components of the DDEC/MDEC/ADEC system include the electronic control module (ECM) and engine sensors. The DDEC control box is located in the generator set junction box.

#### 3.13.2 DDEC Engine Diagnostics

The DDEC engine protection system monitors engine sensors and electronic components and recognizes system malfunctions. Critical faults light the check engine (CEL) and stop engine (SEL) lamps on the control box. ECM memory software logs malfunction codes. Consult the engine operation manual or engine service manual to identify the stored failure code. See Figure 3-23 for the DDEC control box features.



**Figure 3-23** DDEC Control Box

Access the stored codes in one of three ways:

- Place the switch in the DIAGNOSTIC REQUEST position. The CEL or SEL flashes to identify the failure.
- Use a hand-held diagnostic data reader (DDR). Place the switch in the DIAGNOSTIC DATA READER position. Plug the DDR into the control box. The DDR displays the stored failure codes.
- Use a personal computer software package available from the manufacturer with a translator to access stored codes. Follow the instructions provided with the software.

#### Code Types

**Active code.** A code flashing on the SEL lamp indicates a fault currently exists.

**Inactive code.** A code flashing on the CEL lamp indicates a previous fault occurrence. The ECM memory stores inactive codes with time/date identification and the following information:

- First occurrence of each diagnostic code in engine operating hours.
- Last occurrence of each diagnostic code in engine operating hours.
- Total time in seconds that the diagnostic code was active.

### 3.14 Engine Control Systems

Some generator sets use an engine control system. Access the control box inside the generator set junction box to retrieve codes when performing routine maintenance or troubleshooting engine.

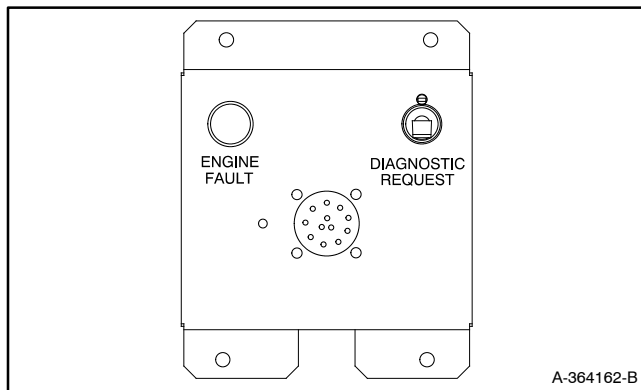
Use the following data for general informational purposes only. See the Engine Service Manual for complete information regarding operation and troubleshooting. Contact an authorized service distributor/dealer for service or diagnostic equipment.

#### Engine Control Features

Engine control is an advanced-technology, electronic engine control system. The system optimizes control of critical engine functions and provides protection against serious engine damage.

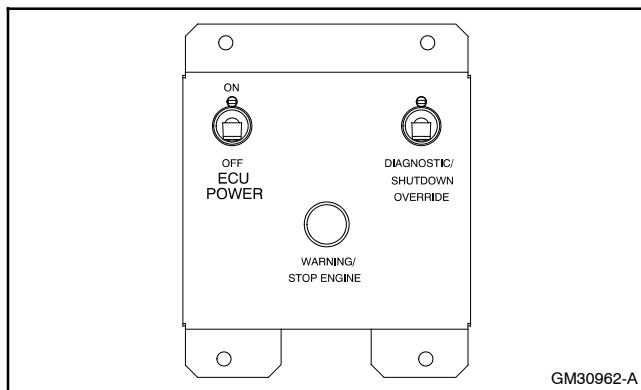
The major components include the engine control module, engine sensors, and control box located in the generator set junction box.

See Figure 3-24 for the Deutz control box features.



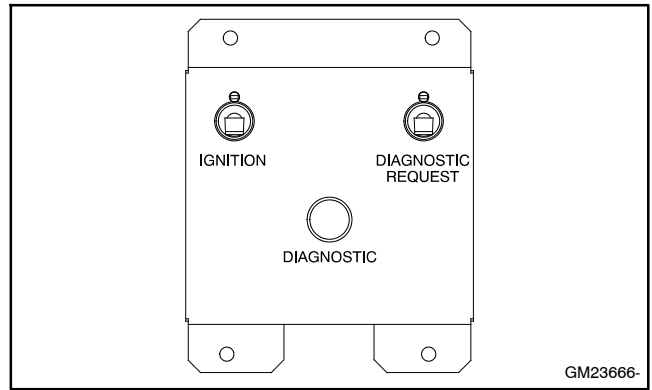
**Figure 3-24** Deutz Engine Control Box

See Figure 3-25 for the John Deere engine control box features.



**Figure 3-25** John Deere Engine Control Box

See Figure 3-26 for the Kohler-branded D300, D350, D400, D450, and D500 engine control box features.



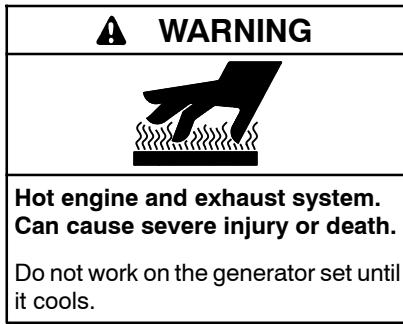
**Figure 3-26** Kohler-Branded Engine Control Box

### 3.15 Storage Procedure

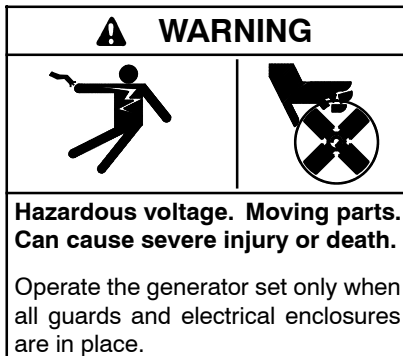
Perform the following storage procedure before taking a generator set out of service for three months or longer. Follow the engine manufacturer's recommendations, if available, for fuel system and internal engine component storage.

|   |
|---|
| <b>⚠ WARNING</b>  |
|   |
| <p><b>Accidental starting.</b><br/> <b>Can cause severe injury or death.</b></p> <p>Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.</p> |

**Disabling the generator set. Accidental starting can cause severe injury or death.** Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.



**Servicing the exhaust system. Hot parts can cause severe injury or death.** Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.



**Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death.** Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

### 3.15.1 Lubricating System

Prepare the engine lubricating system for storage as follows:

1. Run the generator set for a minimum of 30 minutes to bring it to normal operating temperature.
2. Stop the generator set.
3. With the engine still warm, drain the oil from the crankcase.
4. Remove and replace the oil filter.
5. Refill the crankcase with oil suited to the climate.
6. Run the generator set for two minutes to distribute the clean oil.
7. Stop the generator set.
8. Check the oil level and adjust, if needed.

### 3.15.2 Cooling System

Prepare the cooling system for storage as follows:

1. Check the coolant freeze protection using a coolant tester.
2. Add or replace coolant as necessary to ensure adequate freezing protection. Use the guidelines included in the engine operation manual.
3. Run the generator set for 30 minutes to redistribute added coolant.

### 3.15.3 Fuel System

Prepare the fuel system for storage as follows:

#### Diesel-Fueled Engines

1. Fill the fuel tank with the specified diesel fuel.
2. Condition the fuel system with compatible additives to control microbial growth.
3. Change the fuel filter/separator and bleed the fuel system. See the engine owner's manual.

#### Gas-Fueled Engines

1. Start the generator set.
2. With the generator set running, shut off the gas supply.
3. Run the generator set until the engine stops.
4. Place the generator set master switch in the OFF/RESET position.

### 3.15.4 Internal Engine Components (Gaseous-Fueled Engines)

If you have access to a fogging agent or SAE 10 oil prepare the pistons and cylinders for storage as follows:

1. While the engine is running, spray a fogging agent or SAE 10 engine oil into the air intake for about two minutes until the engine stops.
2. Place the generator set master switch in the OFF/RESET position.

If a fogging agent is not available perform the following:

1. Remove the spark plugs.

2. Pour 15 cc (0.5 oz.) of engine oil into each spark plug hole.

**Ignition System Damage.** Refer to the engine operation manual for ignition system precautions before cranking the engine while the spark plug wires are disconnected.

3. Toggle the generator set master switch to crank the engine two or three revolutions to lubricate the cylinders.
4. Reinstall the spark plugs and torque them to specifications.

### 3.15.5 Exterior

1. Clean the exterior surface of the generator set.
2. Seal all engine openings except for the air intake with nonabsorbent adhesive tape.
3. To prevent impurities from entering the air intake and to allow moisture to escape from the engine, secure a cloth over the air intake.
4. Mask electrical connections.
5. Spread a light film of oil over unpainted metallic surfaces to inhibit rust and corrosion.

### 3.15.6 Battery

Perform battery storage after all other storage procedures.

1. Place the generator set master switch in the OFF/RESET position.
2. Disconnect the battery(ies), negative (-) lead first.
3. Clean the battery. Refer to Section 3.12.1 for the battery cleaning procedure.
4. Place the battery in a cool, dry location.
5. Connect the battery to a battery charger or charge it monthly with a trickle battery charger. Refer to the battery charger manufacturer's recommendations.

Maintain a full charge to extend battery life.

## Section 4 General Troubleshooting

---

This section contains generator set troubleshooting, diagnostic, and repair information.

**Note:** The controller clock must be set each time the engine battery(ies) are disconnected. The controller clock determines exercise run time and event records. See Menu 6—Time and Date, for setup.

Use the following charts to diagnose and correct common problems. First check for simple causes such as a dead engine starting battery or an open circuit breaker. The charts include a list of common problems, possible causes of the problem, recommended corrective actions, and references to detailed information or repair procedures.

Maintain a record of repairs and adjustments performed on the equipment. If the procedures in this manual do not explain how to correct the problem, contact an authorized distributor/dealer. Use the record to help describe the problem and repairs or adjustments made to the equipment.

**Battle Switch/Fault Shutdown Override Switch.** The *battle* switch function forces the system to ignore normal fault shutdowns such as low oil pressure and high engine temperature. The battle switch does not override the emergency stop, overspeed, and overfrequency shutdowns. When the battle switch function is enabled, the generator set continues to run regardless of shutdown signals where potential engine/alternator damage can occur.

When this input is enabled, the yellow warning lamp illuminates and stored warning/shutdown events that are ignored continue to log in Menu 5—Event History.

See Section 2.9.9, Menu 9—Input Setup, for information on how to enable the battle switch feature.

**Cooldown Temperature Override Function.** This function provides the ability to bypass the generator set temperature based cooldown and force the unit to wait for the engine cooldown time delay.

If the generator set is shutting down before the full cooldown time expires, inspect the Cooldown Temperature Override setting. Set the override to YES to force the unit to run in cooldown for the entire cooldown delay.

If the generator set is not shutting down when coolant temperature falls below the cooled down threshold, inspect the Cooldown Temperature Override setting. Set the override to NO enabling smart temperature based cooldown.

See Section 2.9.8, Menu 8—Time Delays, for information on how to enable the cooldown temperature override feature.

Appendix G, DEC 550 Controller Fault Displays, provides additional information regarding warning and shutdown faults and their related sensors or controller logic protection for each engine family.



## 4.1 General Troubleshooting Chart

| Trouble Symptoms  |                           |             |                          |                |             |           |                  |                       |                             | Probable Causes | Recommended Actions   | Section or Publication Reference*  |                                 |
|---|---------------------------|-------------|--------------------------|----------------|-------------|-----------|------------------|-----------------------|-----------------------------|-----------------|---|--|---------------------------------|
| Does not crank  | Cranks but does not start | Starts hard | No or low output voltage | Stops suddenly | Lacks power | Overheats | Low oil pressure | High fuel consumption | Excessive or abnormal noise |                 |   |  | Displays error message/locks up |
| <b>Alternator</b>   |                           |             |                          |                |             |           |                  |                       |                             |                 |   |  |                                 |
|   |                           |             | x                        |                |             |           |                  |                       |                             |                 | AC output circuit breaker open  | Reset the breaker and check for AC voltage at the generator set side of the circuit breaker.                     | —                               |
| x   |                           |             |                          |                |             |           |                  |                       |                             |                 | Transfer switch test switch in the OFF position   | Move the transfer switch test switch to the AUTO position.   | ATS O/M                         |
|   |                           |             | x                        |                |             |           |                  |                       |                             |                 | Transfer switch fails to transfer load  | Move the ATS test switch to the AUTO position. Troubleshoot the transfer circuit and time delays.                | ATS O/M, S/M                    |
|   |                           |             | x                        |                |             |           |                  |                       |                             |                 | Wiring, terminals, or pin in the exciter field open   | Check for continuity.  | Gen. S/M, W/D                   |
|   |                           |             | x                        |                |             |           |                  |                       |                             |                 | Main field (rotor) inoperative (open or grounded)   | Test and/or replace the rotor.†  | Gen. S/M                        |
|   |                           |             | x                        |                |             |           |                  |                       |                             |                 | Stator inoperative (open or grounded)   | Test and/or replace the stator.†   | Gen. S/M                        |
|   |                           |             |                          |                |             |           |                  |                       | x                           |                 | Vibration excessive   | Tighten loose components.†   | —                               |
|   |                           |             | x                        |                |             |           |                  |                       |                             |                 | Voltage regulator digital settings incorrect (digital controller only)                                    | Adjust the voltage regulator.  | Sec. 2.9.11, Menu 11            |
|   |                           |             | x                        |                |             |           |                  |                       |                             |                 | Light flicker caused by armature leads incorrectly connected to FRX activator board (FRX alternator only) | Check that AC1, AC2, and AC3 from exciter armature are correctly connected to the FRX activator board terminals. | Gen. S/M, W/D                   |
| <b>Electrical System (DC Circuits)</b>  |                           |             |                          |                |             |           |                  |                       |                             |                 |   |  |                                 |
| x   | x                         |             |                          |                |             |           |                  |                       |                             |                 | Battery connections loose, corroded, or incorrect   | Verify that the battery connections are correct, clean, and tight.   | Section 3                       |
| x   | x                         |             |                          |                |             |           |                  |                       |                             |                 | Battery weak or dead  | Recharge or replace the battery. The spec sheet provides recommended battery CCA rating.                         | Section 3, S/S                  |
| x   | x                         |             |                          |                |             |           |                  |                       |                             |                 | Starter/starter solenoid inoperative  | Replace the starter or starter solenoid.   | Eng. S/M                        |
| x   |                           |             |                          |                |             |           |                  |                       |                             |                 | Engine harness connector(s) not locked tight  | Disconnect the engine harness connector(s) then reconnect it to the controller.                                  | W/D                             |
|   |                           |             |                          |                |             |           |                  |                       |                             |                 | High water temperature switch inoperative   | Replace the inoperative switch.  | Gen. S/M or W/D                 |
|   |                           |             |                          |                |             |           |                  |                       |                             |                 | Fault shutdown  | Reset the fault switches and troubleshoot the controller.  | Section 2                       |
|   |                           |             |                          |                |             |           |                  |                       |                             |                 | High exhaust temperature switch inoperative   | Replace the inoperative switch.  | Gen. S/M or W/D                 |
| * Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual<br>† Have an authorized service distributor/dealer perform this service. |                           |             |                          |                |             |           |                  |                       |                             |                 |   |  |                                 |

| Trouble Symptoms   |                           |             |                          |                |             |           |                  |                       |                             | Probable Causes | Recommended Actions | Section or Publication Reference*                  |   |  |
|--|---------------------------|-------------|--------------------------|----------------|-------------|-----------|------------------|-----------------------|-----------------------------|-----------------|---------------------|--|---|--|
| Does not crank   | Cranks but does not start | Starts hard | No or low output voltage | Stops suddenly | Lacks power | Overheats | Low oil pressure | High fuel consumption | Excessive or abnormal noise |                 |                     |  | Displays error message/locks up   | Exercise run time and/or event records inoperative |
| <b>Controller</b>  |                           |             |                          |                |             |           |                  |                       |                             |                 |                     |  |   |  |
| x  | x                         |             |                          |                |             |           |                  |                       |                             |                 |                     | Controller circuit board(s) inoperative            | Replace the controller circuit board.   | Gen. S/M   |
|  |                           |             |                          | x              |             |           |                  |                       |                             |                 |                     | Controller fault                                   | Troubleshoot the controller.†   | Gen. S/M   |
| x  | x                         |             |                          | x              |             |           |                  |                       |                             |                 |                     | Controller fuse blown                              | Replace the blown controller fuse. If the fuse blows again, troubleshoot the controller.†   | Section 2, W/D                                     |
| x  |                           |             |                          |                |             |           |                  |                       |                             |                 |                     | Controller master switch inoperative               | Replace the controller master switch.   | —  |
| x  |                           |             |                          |                |             |           |                  |                       |                             |                 |                     | Controller master switch in the OFF/RESET position | Move the controller master switch to the RUN or AUTO position.  | Section 2  |
| x  |                           |             |                          |                |             |           |                  |                       |                             |                 |                     | Engine start circuit open                          | Move the controller master switch to the RUN position to test the generator set. Troubleshoot the auto start circuit and time delays. | Section 2, W/D, Gen. I/M, S/M, ATS O/M, S/M        |
|  |                           |             |                          | x              |             |           |                  |                       |                             |                 |                     | Voltage regulation inoperative                     | Replace the controller fuse, if the fuse blows again, troubleshoot the controller.  | Section Fuses, Gen. S/M                            |
|  |                           |             |                          |                |             |           |                  |                       |                             | x               |                     | Controller firmware error                          | Review the controller display troubleshooting chart.  | Section 4-2  |
|  |                           |             |                          |                |             |           |                  |                       |                             |                 | x                   | Controller clock not set                           | Reset time and date.  | Section 2.9.6, Menu 6                              |
| <b>Engine</b>  |                           |             |                          |                |             |           |                  |                       |                             |                 |                     |  |   |  |
| x  | x                         |             |                          |                | x           |           |                  | x                     |                             |                 |                     | Air cleaner clogged                                | Clean or replace the filter element.  | Eng. O/M   |
| x  | x                         |             |                          |                |             | x         |                  | x                     |                             |                 |                     | Compression weak                                   | Check the compression.†   | Eng. S/M   |
|  |                           |             |                          |                | x           |           |                  | x                     |                             |                 |                     | Engine overload                                    | Reduce the electrical load. See the generator set spec sheet for wattage specifications.  | S/S  |
|  |                           |             |                          |                |             |           |                  |                       | x                           |                 |                     | Exhaust system leak                                | Inspect the exhaust system. Replace the inoperative exhaust system components.†   | I/M  |
|  |                           |             |                          |                |             |           |                  |                       | x                           |                 |                     | Exhaust system not securely installed              | Inspect the exhaust system. Tighten the loose exhaust system components.†   | I/M  |
|  |                           |             |                          |                |             |           |                  |                       |                             |                 |                     | Governor inoperative                               | Adjust the governor.†   | Gen. S/M   |
|  |                           |             |                          |                |             |           |                  |                       | x                           |                 |                     | Valve clearance incorrect                          | Adjust the valves.†   | Eng. S/M   |
|  |                           |             |                          |                |             |           |                  |                       | x                           |                 |                     | Vibration excessive                                | Tighten all loose hardware.   | —  |
|  | x                         |             |                          |                |             |           |                  |                       |                             |                 |                     | Ignition system inoperative (gas/gasoline only)    | Check the ignition system (spark plugs, spark plug wires, etc.).  | Eng. O/M   |
| <p>* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual</p> <p>† Have an authorized service distributor/dealer perform this service.</p> |                           |             |                          |                |             |           |                  |                       |                             |                 |                     |  |   |  |

| Trouble Symptoms      |                           |             |                          |                |             |           |                  |                       |                             | Probable Causes | Recommended Actions | Section or Publication Reference*                                     |  |  |
|-----------------------|---------------------------|-------------|--------------------------|----------------|-------------|-----------|------------------|-----------------------|-----------------------------|-----------------|---------------------|---|--|--|
| Does not crank        | Cranks but does not start | Starts hard | No or low output voltage | Stops suddenly | Lacks power | Overheats | Low oil pressure | High fuel consumption | Excessive or abnormal noise |                 |                     |   | Displays error message/locks up  | Exercise run time and/or event records inoperative |
| <b>Cooling System</b> |                           |             |                          |                |             |           |                  |                       |                             |                 |                     |   |  |  |
|                       |                           |             |                          |                |             | X         |                  | X                     |                             |                 |                     | Air openings clogged  | Clean the air openings.  | —  |
|                       |                           |             |                          |                |             | X         |                  |                       |                             |                 |                     | Coolant level low   | Restore the coolant to normal operating level.                               | Section 3  |
|                       |                           |             |                          |                |             | X         |                  |                       |                             |                 |                     | Cooling water pump inoperative  | Tighten or replace the belt. Replace the water pump.                         | Eng. O/M or S/M                                    |
|                       |                           |             |                          | X              |             |           |                  |                       |                             |                 |                     | High temperature shutdown   | Allow the engine to cool down. Then troubleshoot the cooling system.         | Sec. 3, Eng. O/M                                   |
|                       |                           |             |                          | X              |             |           |                  |                       |                             |                 |                     | Low coolant level shutdown, if equipped                               | Restore the coolant to normal operating level.                               | Section 3  |
|                       |                           |             |                          |                |             | X         |                  |                       |                             |                 |                     | Thermostat inoperative  | Replace the thermostat.  | Eng. S/M   |
| <b>Fuel System</b>    |                           |             |                          |                |             |           |                  |                       |                             |                 |                     |   |  |  |
| X                     | X                         |             |                          |                | X           |           |                  |                       |                             |                 |                     | Air in fuel system (diesel only)                                      | Bleed the diesel fuel system.  | Eng. O/M   |
| X                     | X                         |             |                          |                |             |           |                  |                       |                             |                 |                     | Ether canister empty or system inoperative, if equipped (diesel only) | Replace or repair the ether starting system.                                 | Eng. O/M   |
| X                     |                           |             |                          | X              |             |           |                  |                       |                             |                 |                     | Fuel tank empty or fuel valve shut off                                | Add fuel and move the fuel valve to the ON position.                         | —  |
| X                     |                           |             |                          | X              |             |           |                  | X                     |                             |                 |                     | Fuel feed or injection pump inoperative (diesel only)                 | Rebuild or replace the injection pump.†                                      | Eng. S/M   |
| X                     | X                         |             |                          | X              |             |           |                  |                       |                             |                 |                     | Fuel or fuel injectors dirty or faulty (diesel only)                  | Clean, test, and/or replace the inoperative fuel injector.†                  | Eng. S/M   |
| X                     | X                         |             |                          | X              |             |           |                  |                       |                             |                 |                     | Fuel filter restriction   | Clean or replace the fuel filter.  | Eng. O/M   |
| X                     |                           |             |                          |                |             |           |                  |                       |                             |                 |                     | Fuel solenoid inoperative   | Troubleshoot the fuel solenoid.†   | Eng. S/M   |
| X                     |                           |             |                          | X              |             |           |                  |                       |                             |                 |                     | Fuel pressure insufficient (gas only)                                 | Check the fuel supply and valves.†   | S/S, Gen. O/M                                      |
| X                     | X                         |             |                          | X              |             |           |                  | X                     |                             |                 |                     | Fuel injection timing out of adjustment (diesel only)                 | Adjust the fuel injection timing.†   | Eng. S/M   |
| <b>Lube System</b>    |                           |             |                          |                |             |           |                  |                       |                             |                 |                     |   |  |  |
| X                     | X                         |             |                          |                |             |           | X                |                       | X                           |                 |                     | Crankcase oil type incorrect for ambient temperature                  | Change the oil. Use oil with a viscosity suitable for the operating climate. | Eng. O/M   |
|                       |                           |             |                          |                |             | X         |                  |                       | X                           |                 |                     | Oil level low   | Restore the oil level. Inspect the generator set for oil leaks.              | Eng. O/M   |
|                       |                           |             |                          | X              |             |           |                  |                       |                             |                 |                     | Low oil pressure shutdown   | Check the oil level.   | Eng. O/M   |

\* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual

† Have an authorized service distributor/dealer perform this service.

## 4.2 Controller Display and Voltage Regulation Troubleshooting Chart

| Trouble Symptoms  | Probable Causes  | Recommended Actions   | Section or Publication Reference*            |
|---|--|---|--|
| <b>Controller Display and Voltage Regulator</b>               |  |   |  |
| Display is black  | No/low battery charge  | Recharge/replace battery  | Section 3, Battery                           |
| Display shows single segment                                  | Low battery voltage  | Recharge battery  | Section 3, Battery                           |
| Display shows an error message                                | Controller firmware or keypad entry error                                    | Review the Request and Error Message Section  | Section 2.6.3                                |
| Display shows an EEPROM WRITE ERROR message                   | EEPROM fault caused by component failure, lightning strike, or voltage spike | Reinitialize the problem data block †   | Contact an Authorized Distributor/Dealer     |
| Display locks up  | No/low battery charge  | Recharge/replace battery  | Section 3, Battery                           |
| Output voltage ramps  | Defective exciter winding  | Troubleshoot alternator components †  | Generator Service Manual                     |
| Output voltage unstable                                       | Voltage regulation calibration incorrect                                     | Readjust voltage regulation †   | Menu 11, Voltage Regulator                   |
| Speed adjust does not function                                | Analog input A06 is supported with Doosan, GM, and Volvo engines only        | Check calibration values  | Menu 12, Calibration                         |
| Voltage adjust does not function for paralleling applications | Analog input A07 description does not match <i>Analog Volt Adjust</i>        | Change description to <i>Analog Volt Adjust</i> using Monitor III software or enable analog voltage adjust in Menu 11 | Monitor Software Manual, Menu 9, Input Setup |

\* Sec./Section—numbered section of this manual; ATS—Automatic Transfer Switch; Eng.—Engine; Gen.—Generator Set; I/M—Installation Manual; O/M—Operation Manual; S/M—Service Manual; S/S—Spec Sheet; W/D—Wiring Diagram Manual  
† Have an authorized service distributor/dealer perform this service.

# Notes

## Section 5 Generator Set Reconnection

### 5.1 Introduction

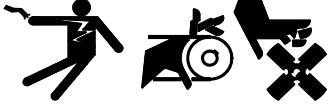
Use the following voltage reconnection procedure to change the voltage of 10- and 12-lead generator sets. Frequency changes require voltage regulator *and* governor adjustments. Refer to the respective spec sheet to determine if frequency is fixed or field-convertible. If frequency is adjustable, refer to the engine service manual and/or governor literature for conversion information.

Refer to the following procedure and the connection schematics. Follow the safety precautions at the front of this manual and in the procedure text and observe National Electrical Code (NEC) guidelines.

#### NOTICE

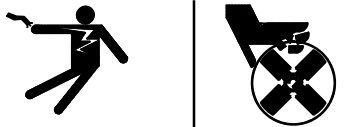
**Voltage reconnection.** Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.

**Note: Equipment damage.** Verify that the voltage ratings of the transfer switch, line circuit breakers, and other accessories match the selected line voltage.

|  |
|--|
| <b>⚠ WARNING</b>   |
|   |
| <b>Accidental starting.<br/>Can cause severe injury or death.</b><br>Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. |

**Disabling the generator set. Accidental starting can cause severe injury or death.** Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Turn the generator set master switch and switchgear engine control switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by an automatic transfer switch or a remote start/stop switch.

**Disabling the generator set. Accidental starting can cause severe injury or death.** Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

|   |
|---|
| <b>⚠ WARNING</b>  |
|    |
| <b>Hazardous voltage. Moving parts.<br/>Can cause severe injury or death.</b><br>Operate the generator set only when all guards and electrical enclosures are in place. |

**Grounding electrical equipment. Hazardous voltage can cause severe injury or death.** Electrocutation is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

**Short circuits. Hazardous voltage/current can cause severe injury or death.** Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

## 5.2 Voltage Reconnection Procedure

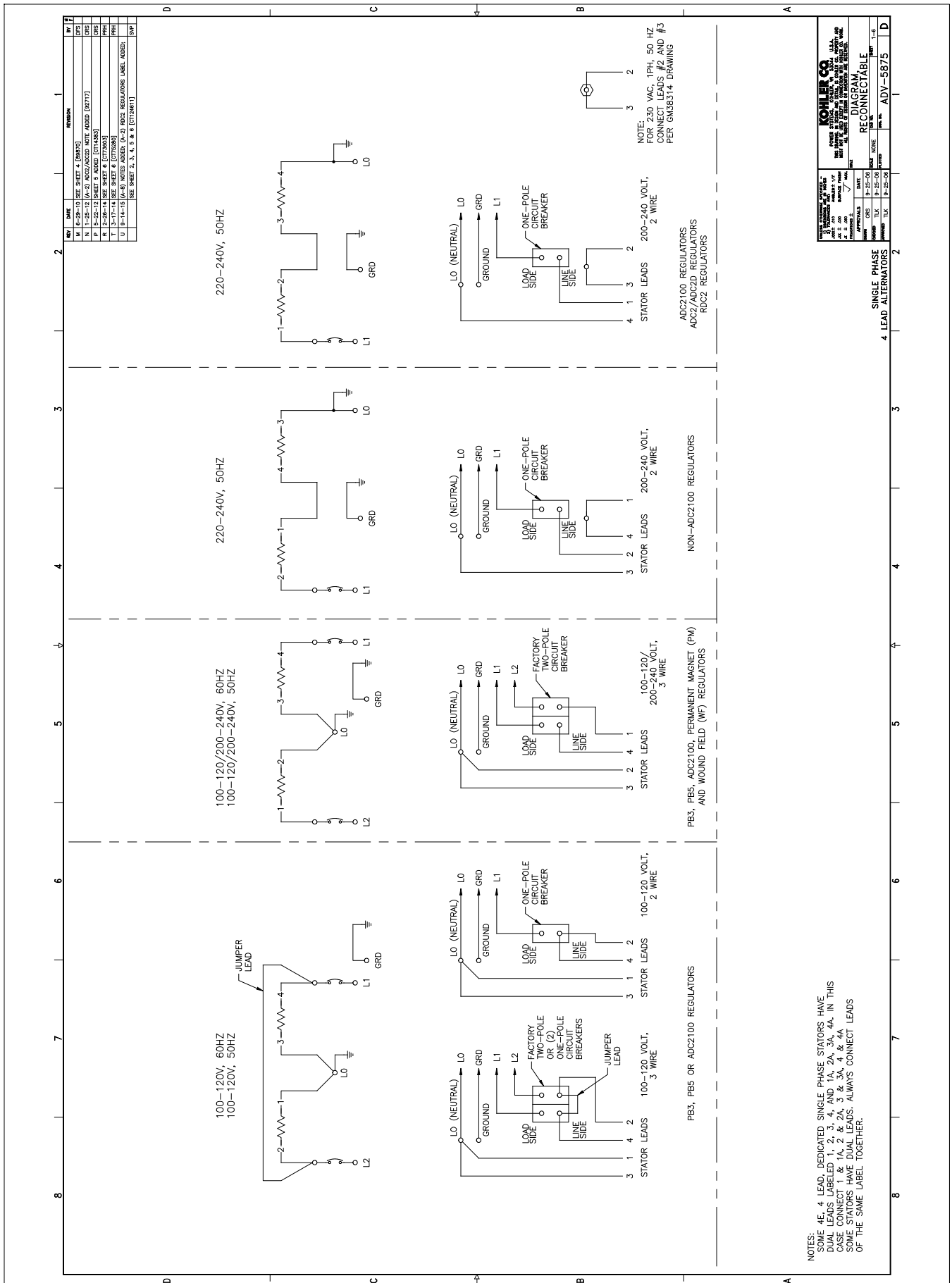
1. Place the generator set master switch in the OFF/RESET position.
2. Disconnect the generator set engine starting battery, negative (-) lead first. Disconnect power to the battery charger (if equipped).
3. Use Figure 5-1, Figure 5-2, Figure 5-3, or Figure 5-4 to determine the generator set voltage configuration. Note the original voltage and reconnect as needed. Route leads through current transformers (CTs) and connect them according to the diagram for the desired phase and voltage.

**Note:** Position current transformers CT1, CT2, and CT3 with the dot or HI side CT marking toward the generator set.

4. Reconnect the battery, negative lead last.
5. Go to Menu 14—Programming Mode and select the Program Mode—Local. See Section 2.9.14, Menu 14—Programming Mode, for the complete procedure.
6. Go to Menu 7—Generator System and update the voltage information. See Section 2.9.7, Menu 7—Generator System, for the complete procedure.
7. Go to Menu 12—Calibration and perform the calibration procedure. See Section 2.9.12, Menu 12—Calibration, for the complete procedure.

**Note:** There is a minimum current that must appear on the screen in Menu 12—Calibration before the user can enter the actual measured value. If the minimum value is not met, a RANGE ERROR code will occur when attempting to change the value. If the unit voltage is 10 kV (medium voltage) or if the unit is 100 kW or less, the minimum value is 25% of the rated current that is displayed in Menu 7—Generator System. If the unit is greater than 100 kW, the minimum value is 50 amps. If the value in Menu 12—Calibration does not meet the minimum criteria mentioned above, the user must increase the test load before the actual measured value can be entered.

8. Go to Menu 11—Voltage Regulator and perform the voltage regulator setup procedure. See Section 2.9.11, Menu 11—Voltage Regulator, for the complete procedure.
9. Move the generator set master switch to the RUN position to start the generator set. Check the digital display for correct voltages using Menu 1—Generator Monitoring.
10. Move the generator set master switch to the OFF/RESET position to stop the generator set after completing the voltage adjustments.
11. Replace the controller cover.
12. Place the generator set master switch in the AUTO or RUN position.



**Figure 5-1** 20-150 kW Permanent Magnet and Wound Field Single-Phase Alternators, ADV-5875U-1



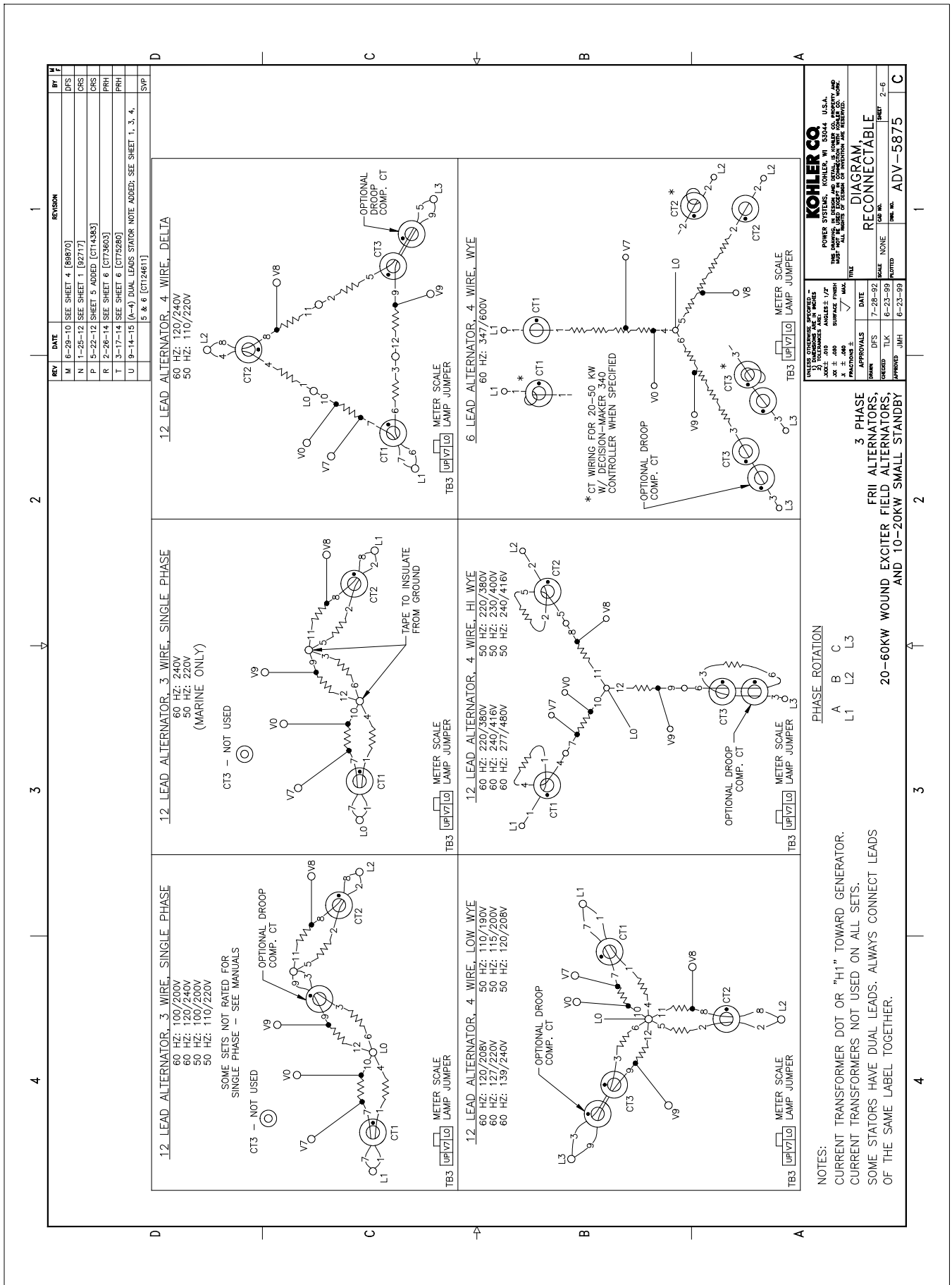


Figure 5-2 20-400 kW Permanent Magnet and 20-60 kW Wound Field Alternators, ADV-5875U-2

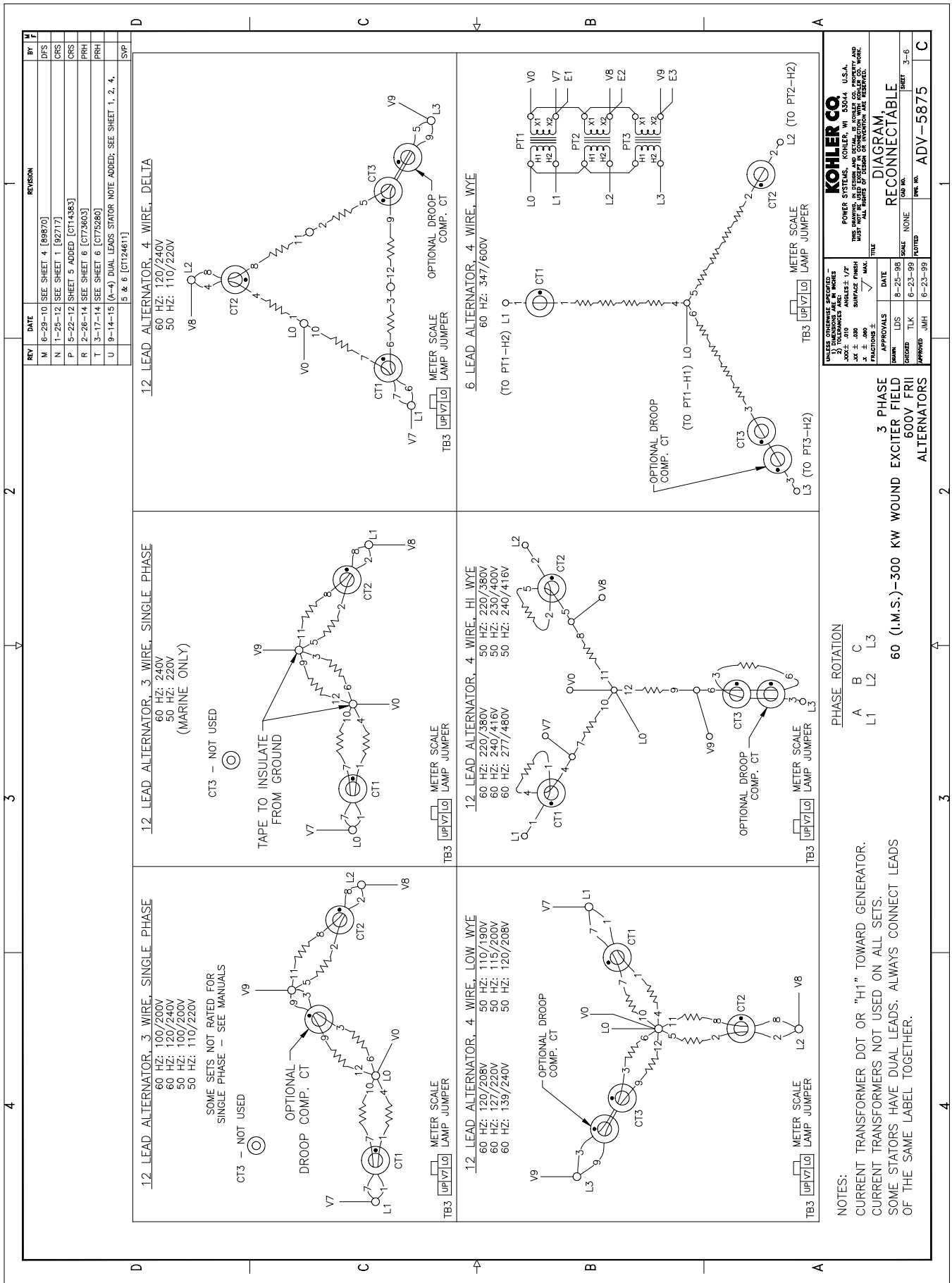


Figure 5-3 60 (with Oversize Alternator)-400 kW Wound Field Alternators, ADV-5875U-3

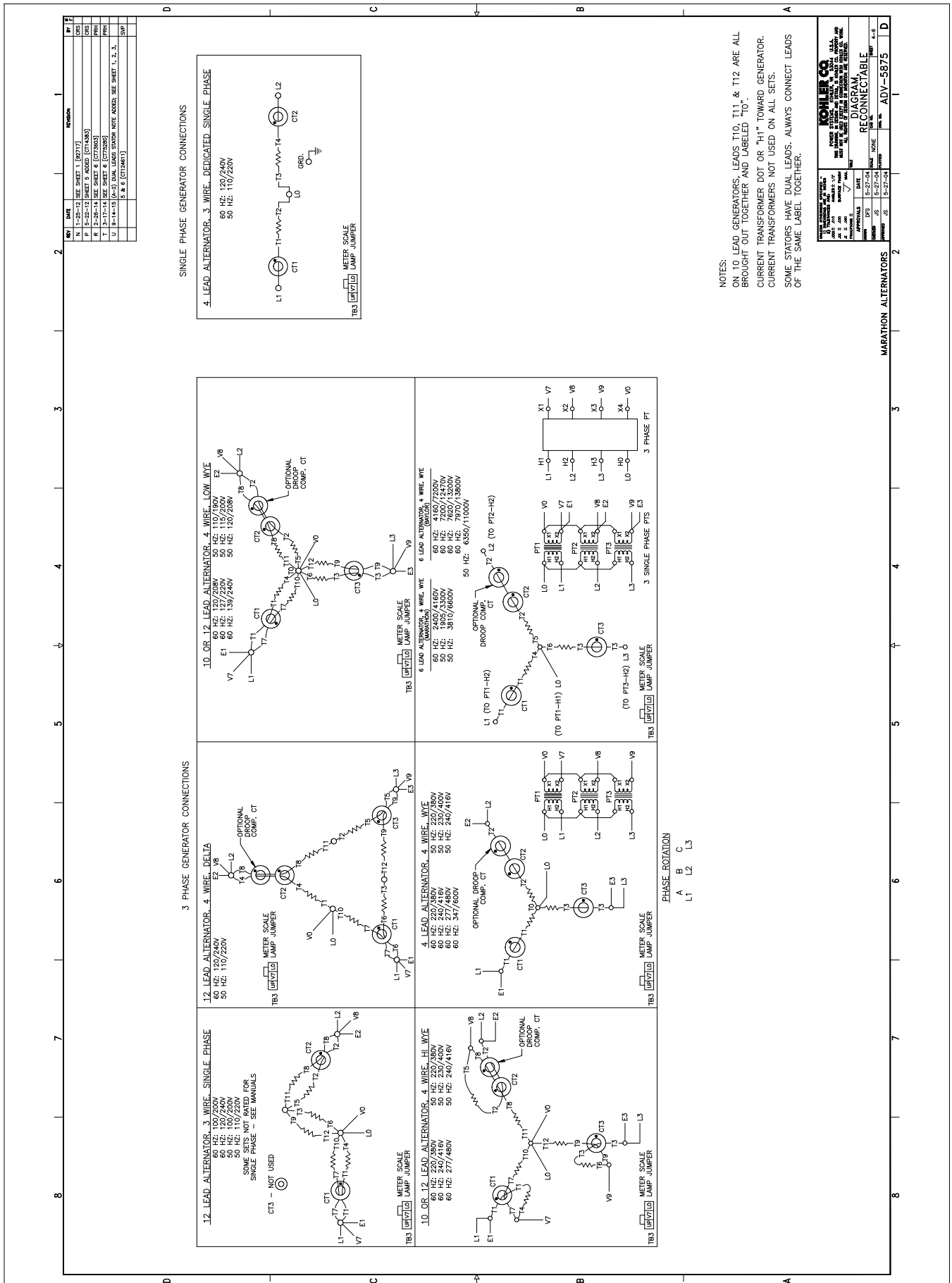


Figure 5-4 350 kW and Larger Pilot-Excited, Permanent Magnet Alternator, ADV-5875U-4

6.1 Accessories and Connections

Several accessories help finalize installation, add convenience to operation and service, and establish state and local code compliance.

Accessories vary with each generator set model and controller. Select factory-installed and/or shipped-loose accessories. See Figure 6-1 for a list of available kits. Obtain the most current accessory information from your local authorized service distributor/dealer.

This section illustrates several accessories available at print time of this publication. Accessory kits generally include installation instructions. See wiring diagrams manual for electrical connections not shown in this section. See the installation instructions and drawings supplied with kit for information on kit mounting location.

The instructions provided with the accessory kit supersede these instructions where there are differences. In general, run AC and DC wiring in separate conduit. Use shielded cable for all analog inputs. Observe all applicable national, state, and local electrical codes during accessory installation.

6.1.1 Audiovisual Alarm Kit

An audiovisual alarm warns the operator at a remote location of fault shutdowns and prealarm conditions. Audiovisual alarms include an alarm horn, an alarm silence switch, and common fault lamp. See Figure 6-2 and Figure 6-3. See Section 6.2, Accessory Connections, for terminal identification.

**Note:** Use the audiovisual alarm with a dry contact kit.

| Kit Description   |
|---|
| Audiovisual Alarm   |
| Common Failure Relay (Terminal 32A)   |
| Controller (Customer) Connection  |
| Battery Charger (with alarms)   |
| Ground Fault Annunciation   |
| Idle (Speed) Mode Feature   |
| Low Fuel (Level) Switch   |
| Low Fuel (Pressure) Switch  |
| Prime Power Switch  |
| Remote Emergency Stop   |
| Remote Reset Feature  |
| Remote Serial Annunciator (RSA III)   |
| Remote Speed Adjust Kit (ECM Models only)   |
| Remote Speed Adjustment Potentiometer (requires electronic governor), Non-ECM Models only |
| Run Relay   |
| Shunt-Trip Line Circuit Breaker and Shunt-Trip Wiring                                     |
| Single-Relay Dry Contact  |
| Ten-Relay Dry Contact   |
| Twenty-Relay Dry Contact  |
| Wireless Monitor  |

Figure 6-1 Optional Accessories

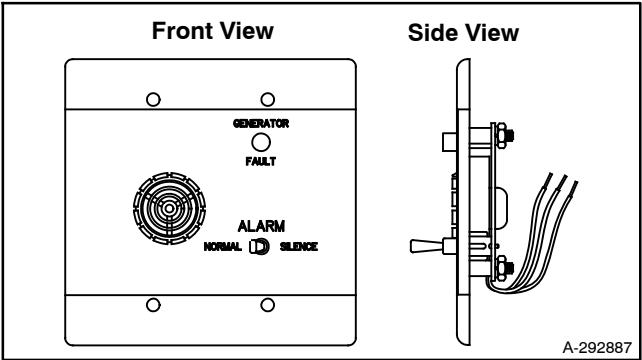


Figure 6-2 Audiovisual Alarm

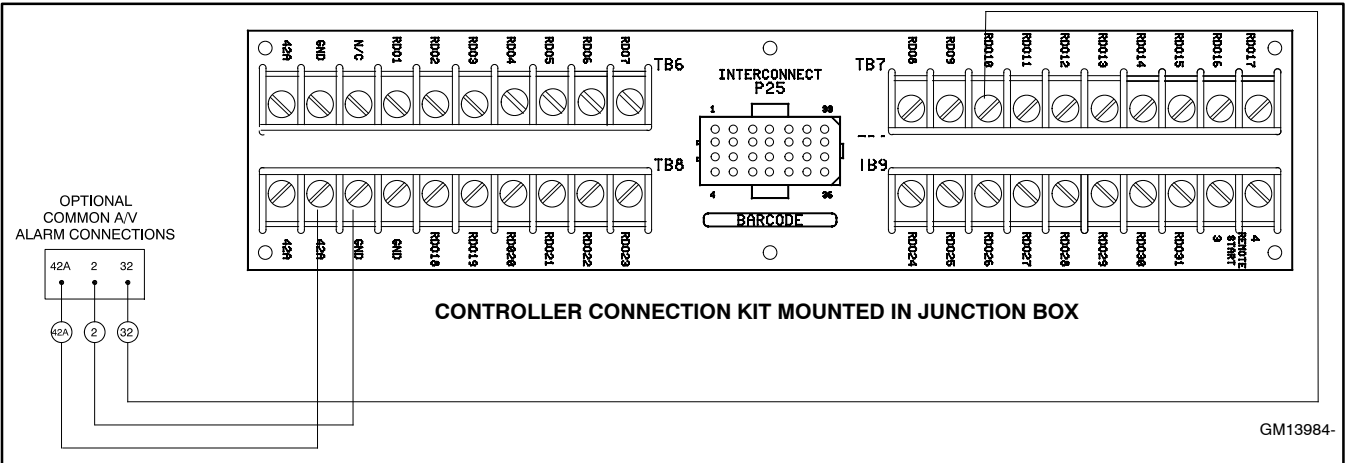


Figure 6-3 Audiovisual Alarm Connections

### 6.1.2 Common Failure Relay Kit

The common failure relay kit provides one set of contacts to trigger user-provided warning devices if a fault occurs. The common failure relay faults are user-defined. See Section 2, Operation, Menu 10—Output Setup, for status and faults available for this function.

Connect up to three common failure relay kits to the controller output. See Figure 6-4 and Figure 6-5. See Section 6.2, Accessory Connections, for terminal identification.

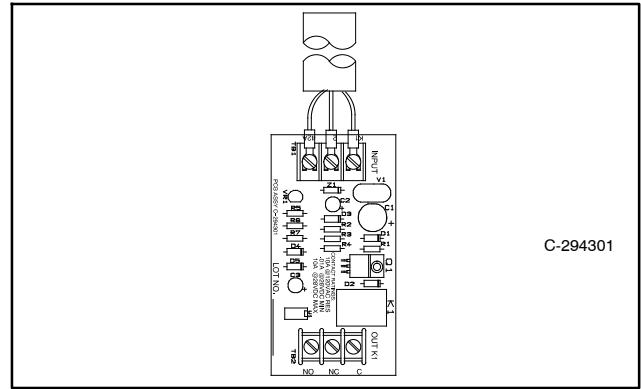


Figure 6-4 Common Failure Relay Kit

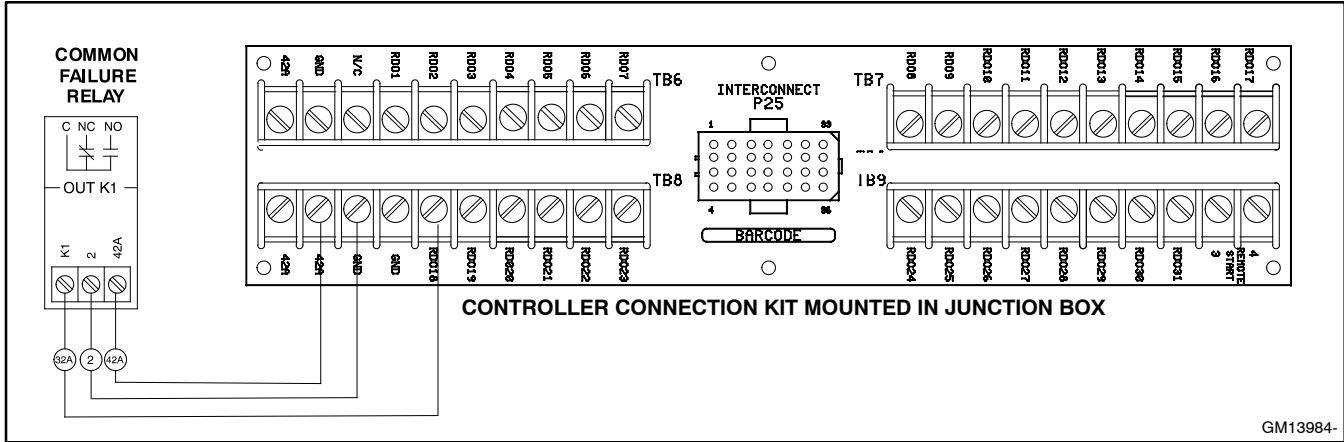


Figure 6-5 Common Failure Relay Kit Connections

### 6.1.3 Battery Charger Kit with Alarm Option

The battery charger with alarm option provides battery charging to the engine starting battery(ies) and connects to the controller for fault detection. Battery chargers for 12- or 24-volt models are available as a

generator set accessory. See Figure 6-6. See Section 6.2, Accessory Connections, for terminal identification.

**Note:** On charger GM87448, the Battery Charger Fault is communicated through CAN communication and the connection on TB4 is not used.

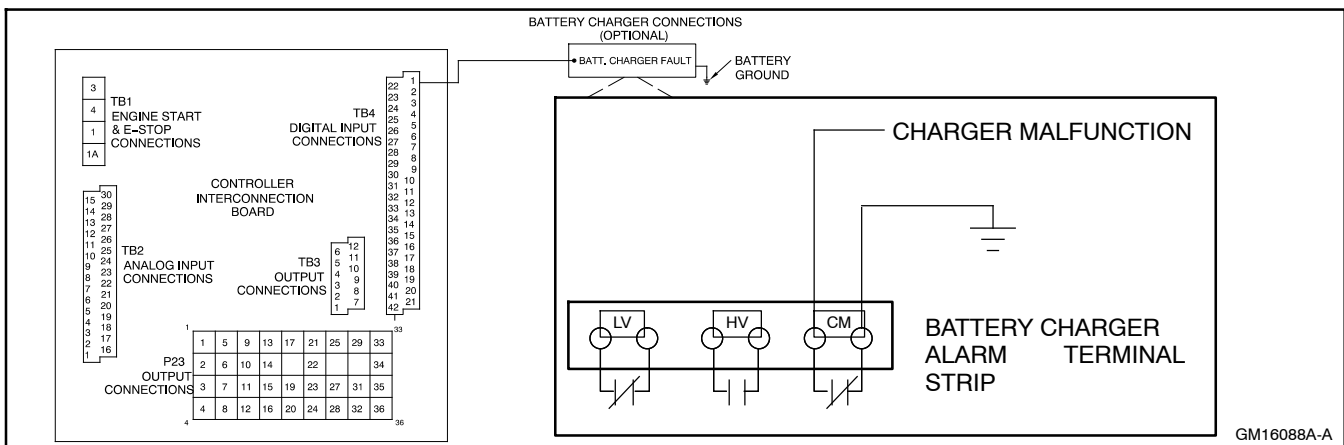


Figure 6-6 Battery Charger Connections

## 6.1.4 Controller (Customer) Connection Kit

The controller connection kit allows easy connection of controller accessories without accessing the controller terminal strip. The supplied wiring harness connects controller connector P23 and terminal strips TB1-3 and

TB1-4 to the controller connection kit connector P25 and terminal strips TB6, TB7, TB8, and TB9. Connect all accessories (except the emergency stop kit) to the controller connection kit terminal strips. See Figure 6-7. See Section 6.2, Accessory Connections, for terminal identification.

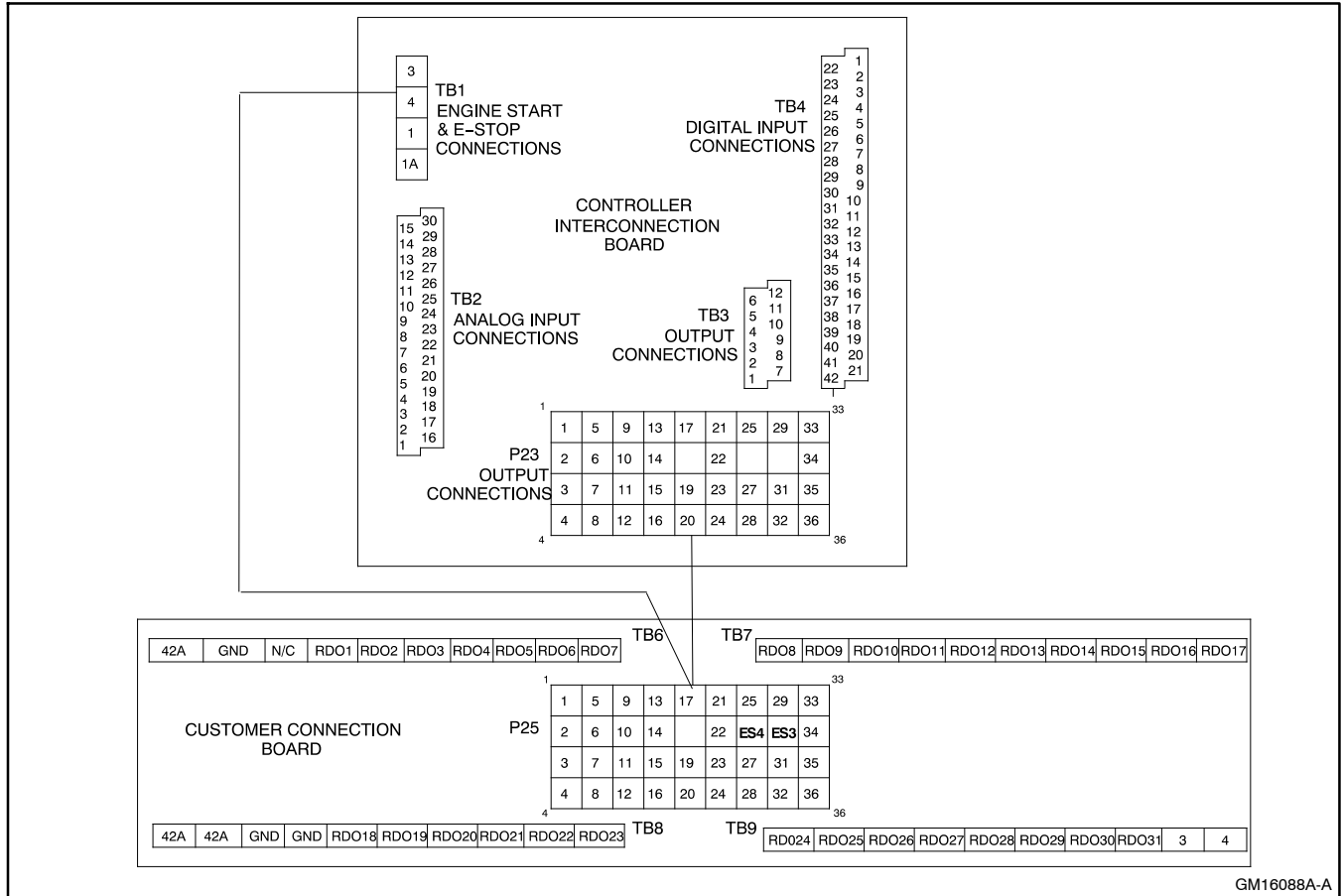
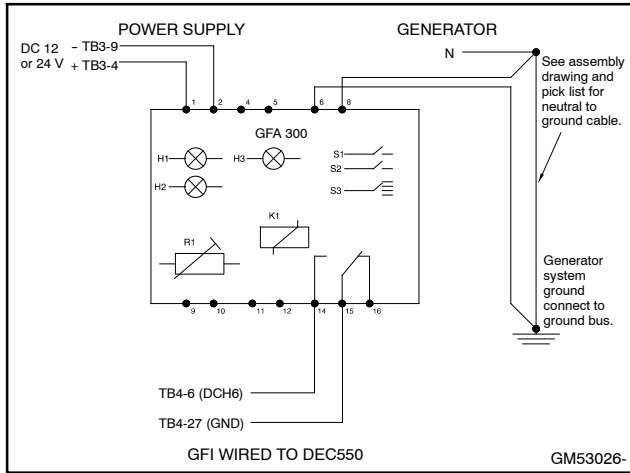


Figure 6-7 Controller (Customer) Connection Kit

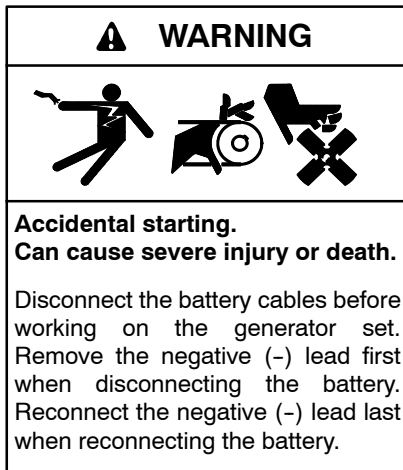
GM16088A-A

## 6.1.5 Ground Fault Annunciation

A relay contact for customer connection indicates a ground fault condition and is part of a ground fault alarm. See Figure 6-8 for electrical connections and the following procedure for controller setup. Use the instructions with the kit when provided to install and setup this accessory.



**Figure 6-8** Ground Fault Connections



**Disabling the generator set. Accidental starting can cause severe injury or death.** Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

## Ground Fault Controller Setup Procedure

1. Reconnect battery, if not already done.
2. Place the controller master switch to the AUTO position.
3. Press the Alarm Off key to silence the alarm horn, if necessary.
4. If the programming mode LED is not flashing, go to the step 5. If the programming mode LED is flashing, go to step 6.
5. Set Programming Mode to Local.

a. Press keys .

b. Press key until *Programming Mode-Local* is displayed.

c. Press the YES key .

d. When the *Enter Code* displays, press the factory default or the user password keys and . The programming mode LED should be flashing.

6. Set digital input #6 to ground fault.

a. Press . *Menu 9 Input Setup* should be displayed.

b. Press until *Digital Input 06 Warning* is displayed.





c. Press once to select this input.

d. Press until *Ground Fault* is displayed.

e. Press to define Digital Input #06 as ground fault. *Entry Accepted* is displayed.

f. Press to display *Digital Input #06 Inhibit Time*.











g. Press to enter the inhibit time. *Entry Accepted* is displayed and the inhibit time 0:00 is now displayed.

- h. Press  to display *Digital Input #06 Delay Time*.
- i. Press   to enter delay time. *Entry Accepted* is displayed. Default delay time is 5 sec.
- j. Press .

## 7. Verify Programming.

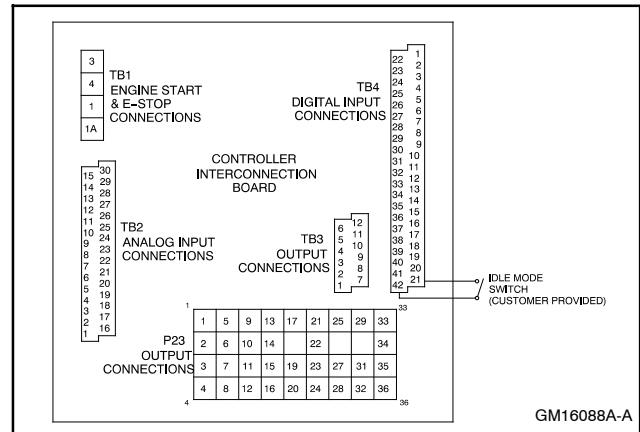
- Move handle of ground fault circuit breaker at generator set to simulate a ground fault.
- Verify that display shows *D06 Ground Fault*. The System Warning LED should be illuminated and the alarm horn should sound. If these indicators are not present, recheck steps 6a. through 6j.
- Return handle of ground fault circuit breaker to the non-ground fault position. *D06 Ground Fault* display should now be cleared.

## 8. Set Programming Mode to Off.

- Press    .
  - Press key  until *Programming Mode Off* is displayed.
  - Press the YES key  .
  - When the *Enter Code* displays, press the factory default   or the user password keys and . The programming mode LED should now be off.
- Place the controller master switch to the OFF/RESET position.
  - Disconnect the battery negative (-) lead to power down the generator set.
  - After 2-3 minutes, reconnect the battery negative (-) lead.
  - Reset the controller clock. See Menu 6—Time and Date.

## 6.1.6 Idle (Speed) Mode Feature

The idle (speed) mode feature provides the ability to start and run the engine at idle (reduced) speed for a selectable time period (0–10 minutes) during warm-up. See Figure 6-9 for user-supplied switch connection.



**Figure 6-9** Idle (Speed) Mode Switch

The controller will override the idle speed mode when the engine reaches the preprogrammed engine warm-up temperature before the idle mode times out.

The idle function also provides engine cooldown at idle speed. The controller overrides the idle speed mode when the engine reaches the preprogrammed engine cooldown temperature before the idle mode times out.

During the idle (speed) mode the controller continues to monitor critical engine parameters such as oil pressure, coolant temperature, and engine speed. The voltage regulator, thermal protection feature, and AC metering are disabled in the idle speed mode.

To start warm up, the master switch must be in the AUTO position. Activate the idle mode input by closing the contacts at the auxiliary digital input assigned to Idle Mode D21 by default). The generator set will run at idle speed until the engine coolant temperature reaches the pre-programmed warm-up temperature, at which point the engine will run at normal speed.

If the idle delay is set in infinite (9:99), the generator set will not transition to normal speed and it will continue to run at idle speed until the idle input is de-activated.

To stop the generator set that was started by activating the idle mode input (master switch in AUTO), simply deactivate the idle mode input by opening the contacts at this input.

If the Idle Delay is set for infinite operation (Idle delay = 9:99) the generator set will continue running at idle speed until the idle input is de-activated. When the idle mode contacts open, the generator set will immediately shut down.



If the Idle Delay is not set for infinite operation (Idle delay = 0–10 minutes), the generator set will transition to the Cooldown state when the idle input is de-activated. The generator set will run at idle speed until the engine coolant temperature falls below the pre-programmed cooldown threshold or until the programmable idle time delay expires, whichever occurs first. If the Cooldown Override parameter is set to TRUE, the coolant temperature will be ignored and the cooldown will continue for the entire idle delay.

If the remote start input is re-activated during the cooldown cycle, the cooldown will abort and normal generator set operation will resume.

If the idle delay is set to 0, the idle input will behave much like the remote start input.

**Note:** Idle operation is only available on generator set models equipped with an electronic ECM. Further, certain engines do not support idle operation. Consult the factory for more information.

### 6.1.7 Low Fuel (Level/Pressure) Switch

Some gaseous-fueled models offer a low fuel pressure switch. The low fuel pressure switch connects to the same terminal as the low fuel level switch on diesel- or gasoline-fueled models. See Figure 6-10 and Figure 6-11. See Section 6.2, Accessory Connections, for terminal identification.

**Note:** The main tank or the transfer/day tank includes the low fuel level switch. The fuel tank supplier typically provides the low fuel level switch.

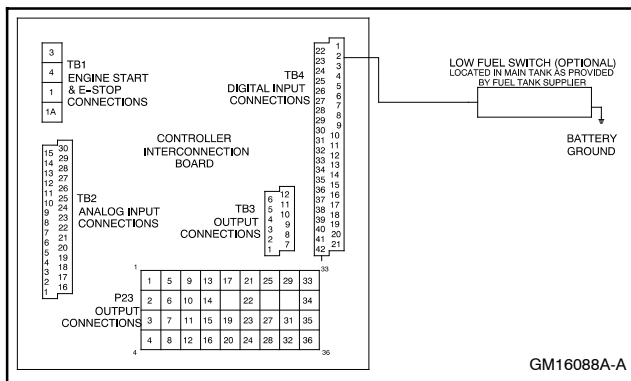


Figure 6-10 Low Fuel Switch (Level or Pressure)

| Switch Rating         | 12 volts DC minimum, 0.5 amp minimum |
|-----------------------|--------------------------------------|
| Wiring Recommendation |                                      |
| Gauge                 | mm (ft.)                             |
| 18-20                 | 30.5 (100)                           |
| 14                    | 153 (500)                            |
| 10                    | 305 (1000)                           |

Figure 6-11 Switch Rating & Wiring Recommendation

### 6.1.8 Prime Power Switch Kit

The prime power switch kit prevents battery drain during generator set nonoperation periods and when the generator set battery cannot be maintained by an AC battery charger. See Figure 6-12 for an illustration of the kit and Figure 6-13 for the electrical connections.

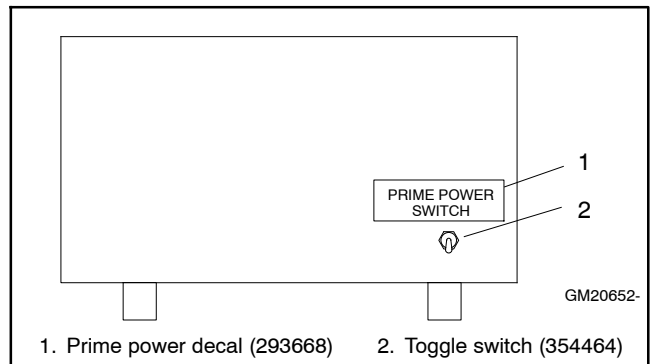


Figure 6-12 Prime Power Switch Installation Location

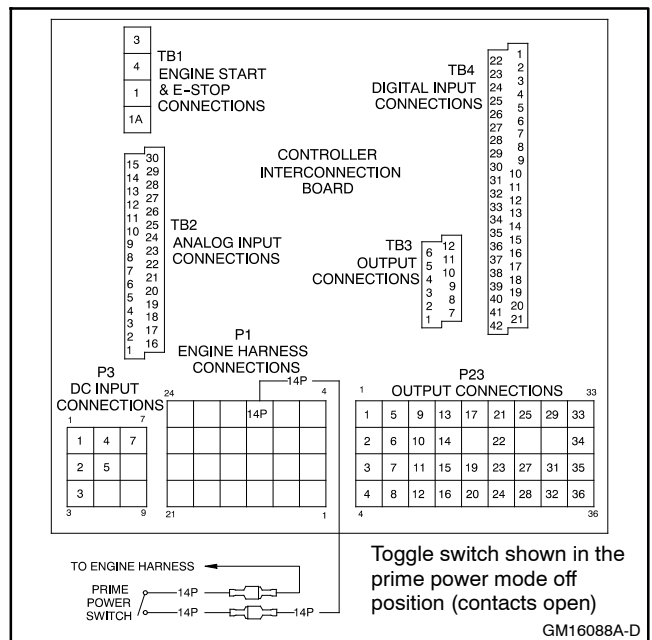


Figure 6-13 Prime Power Switch Connections

Stop the generator set using the stopping procedures in Section 2.4.2, Stopping, before placing the generator set in the prime power OFF mode. Move the prime power switch located on the back of the controller to the DOWN position. The controller including the digital display, LEDs, and alarm horn does not function when the generator set is in the prime power OFF mode.

Move the prime power switch located on the back of the controller to the UP position to place the generator set in the prime power ON mode. Reset the controller time and date before attempting to start the generator set.

### 6.1.9 Remote Emergency Stop Kit

The emergency stop kit allows immediate shutdown of the generator set from a remote location. See Figure 6-14 and Figure 6-15. If the emergency stop switch activates, the EMERGENCY STOP lamp lights and the unit shuts down. Before attempting to restart the generator set, reset the emergency stop switch (by replacing the glass piece) and reset the generator set by placing the master switch in the OFF/RESET position.

Use the single glass piece located inside the switch for replacement and order additional glass pieces as service parts. See Section 2.4.3, Emergency Stop Switch Reset Procedure. See Section 6.2, Accessory Connections, for terminal identifications.

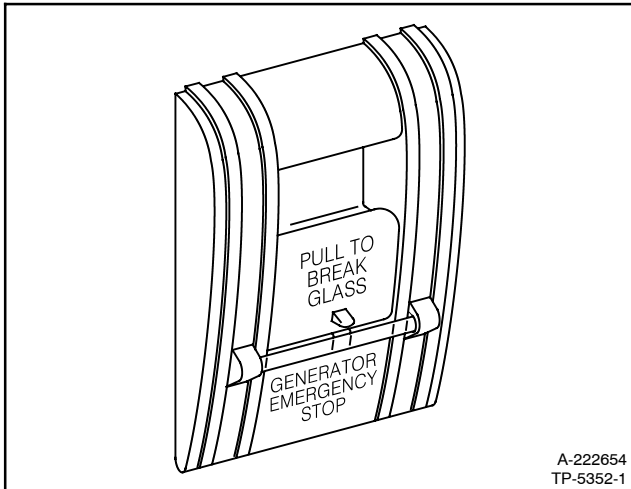


Figure 6-14 Emergency Stop Kit

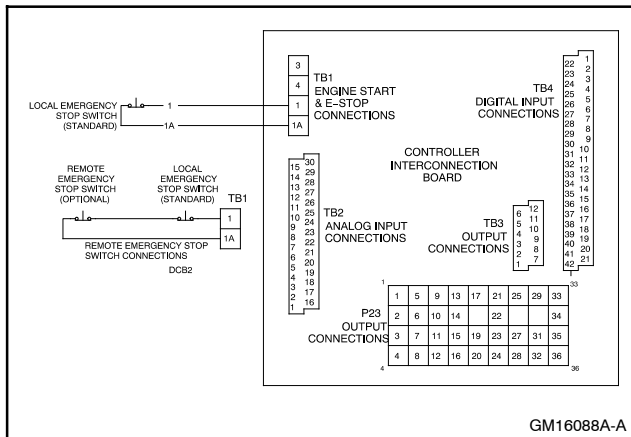


Figure 6-15 Remote Emergency Stop Kit Connections

### 6.1.10 Remote Reset Feature

The remote reset switch provides generator set resetting after a fault shutdown at a remote location. See Figure 6-16 and Figure 6-17 for user-supplied switch connection.

Press and hold the switch for 2-3 seconds and release to reset the generator set controller.

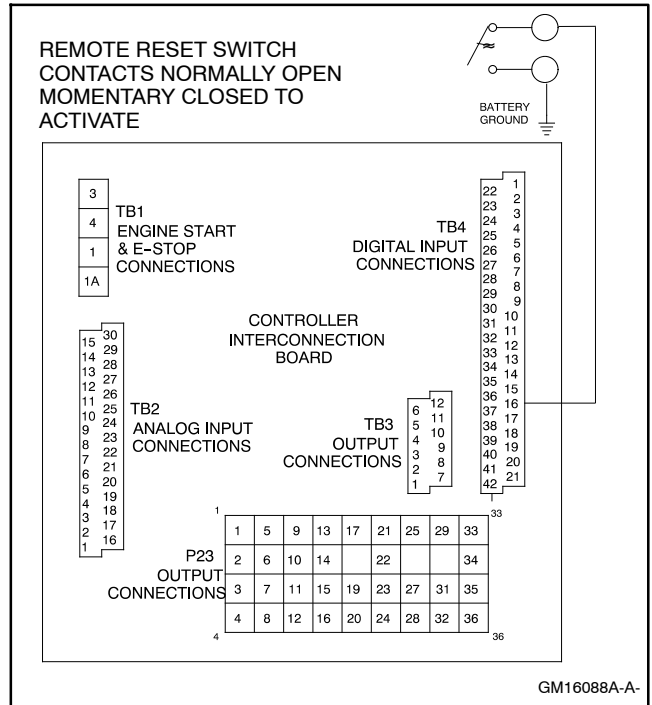


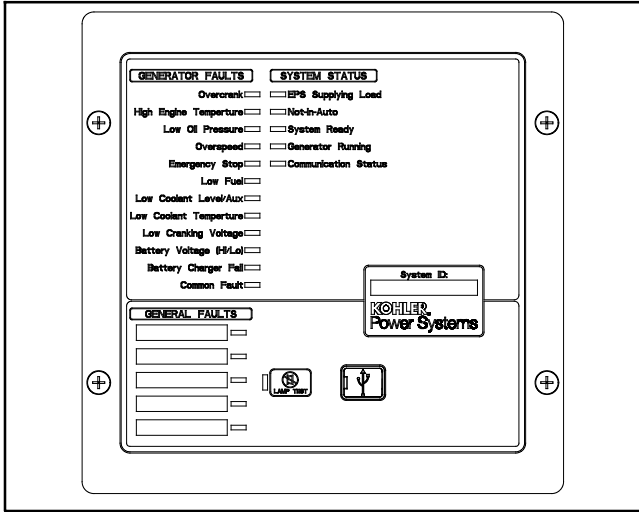
Figure 6-16 Remote Reset Switch Connections

| Switch Rating         | 12 volts DC minimum, 1 amp minimum |
|-----------------------|------------------------------------|
| Wiring Recommendation |                                    |
| Gauge                 | mm (ft.)                           |
| 18-20                 | 30.5 (100)                         |
| 14                    | 153 (500)                          |
| 10                    | 305 (1000)                         |

Figure 6-17 Switch Rating and Wiring Recommendations

### 6.1.11 Remote Serial Annunciator (RSA)

RSA III is an annunciator panel offered in several kit configurations to support Kohler power equipment. The RSA III is a remote serial annunciator (Figure 6-18, Figure 6-19, and Figure 6-20) that monitors the condition of the generator set and/or ATS from a remote location. The RSA III alerts the operator through visual and audible signals using LED indication and a horn. An alarm silence and lamp test switch are included.



**Figure 6-18** Remote Serial Annunciator (RSA III)

The RSA III meets NFPA 110, Level 1 applications that require remote controls and alarms be powered by a storage battery such as the engine starting battery. AC adaptor kit GM62466-KP1 is available when NFPA is not required.

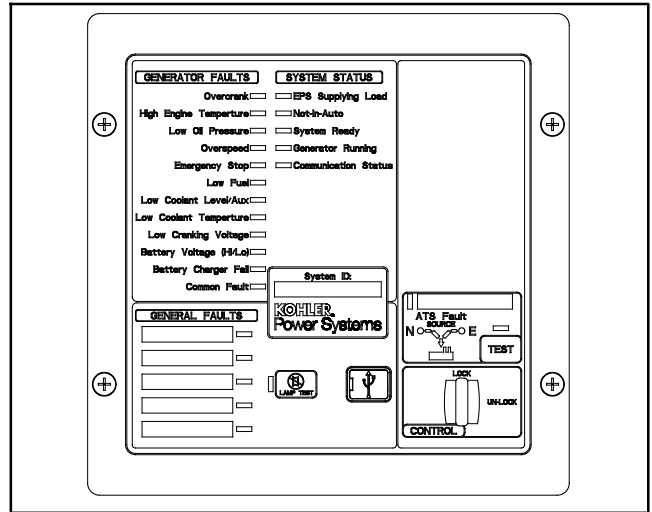
The front panel decals include areas that can be used to identify user-selected fault inputs and identify associated power system equipment.

An RSA III annunciator can be used for a single generator set or with a combination of a generator set and automatic transfer switch. In systems using more than a single RSA III, one must be designated as the master device to broadcast to additional RSA III annunciators, designated as slave devices. Up to five RSA III slave devices can be used with an RSA III master device. All RSA III annunciators are factory set as the master device, but can be changed to a slave device using a PC and SiteTech™ software that connects to the RSA III front panel via a universal serial bus (USB) connection.

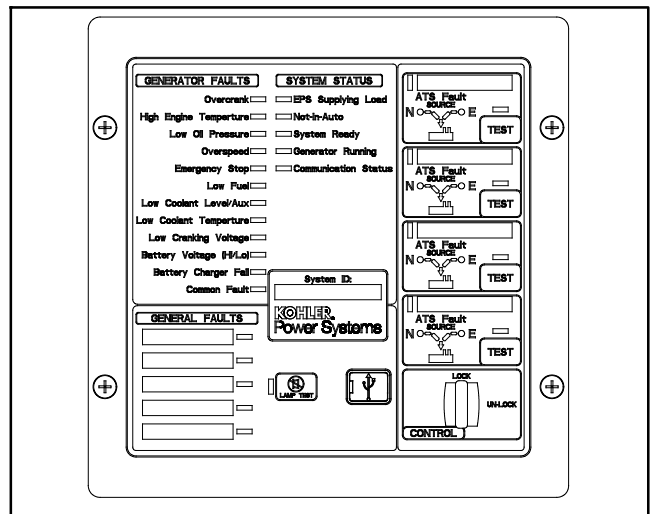
The RSA II and RSA 1000 can be connected with the RSA III provided that the master remote annunciator is an RSA III.

Refer to TT-1625 Remote Serial Annunciator (RSA III) Kits for operation and installation instructions.

See Section 6.2, Accessory Supply Connections, for terminal identifications.



**Figure 6-19** RSA III with Single ATS Control



**Figure 6-20** RSA III with Four ATS Controls

**A PC with SiteTech™ software is required to make the RSA III functional.** Use your SecurID to access KOHLERnet, click on the TechTools button, and follow the instructions to download the files. See SiteTech™ Software Settings and refer to TP-6701 SiteTech™ Software Operation Manual for more information.

The RSA III kits include components for surface mounting or flush mounting.

Figure 6-21 shows the status of the system ready LED, generator set running LED, communication status LED, common fault LED, common fault output, and horn for each fault or status condition.

If a fault occurs, the RSA III horn activates and the corresponding LED illuminates.

If the RSA III is used with an Ethernet communication network, order Modbus® Ethernet converter GM41143-KP2 and refer to TT-1405 Converters, Connections, and Controller Setup for Network Communication for system installation.

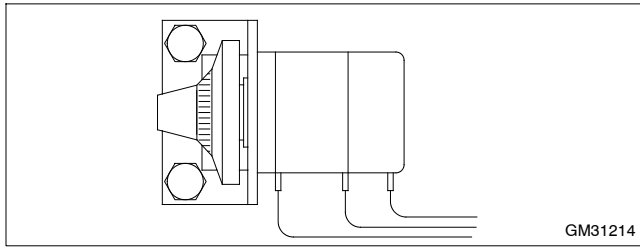
| Fault and Status Condition                              | Fault LED | System Monitoring LEDs and Functions |                       |                           |                  |                     |      |
|---|-----------|--------------------------------------|-----------------------|---------------------------|------------------|---------------------|------|
|   |           | System Ready LED                     | Generator Running LED | Communications Status LED | Common Fault LED | Common Fault Output | Horn |
| Overcrank (Shutdown)                                    | Red SF    | Red SF                               | Off                   | Green                     | Red SF           | On                  | On   |
| High Engine Temperature (Warning)                       | Yellow SF | Red SF                               | Green                 | Green                     | Red SF           | On                  | On   |
| High Engine Temperature (Shutdown)                      | Red SF    | Red SF                               | Off                   | Green                     | Red SF           | On                  | On   |
| Low Oil Pressure (Warning)                              | Yellow SF | Red SF                               | Green                 | Green                     | Red SF           | On                  | On   |
| Low Oil Pressure (Shutdown)                             | Red SF    | Red SF                               | Off                   | Green                     | Red SF           | On                  | On   |
| Overspeed (Shutdown)                                    | Red SF    | Red SF                               | Off                   | Green                     | Red SF           | On                  | On   |
| Emergency Stop  | Red SF    | Red SF                               | Off                   | Green                     | Off              | On                  | On   |
| Low Coolant Level/Aux (Shutdown)                        | Red SF    | Red SF                               | Off                   | Green                     | Red SF           | On                  | On   |
| Low Coolant Temperature                                 | Yellow SF | Red SF                               | Green or Off          | Green                     | Red SF           | On                  | On   |
| Low Fuel  | Yellow SF | Red SF                               | Green or Off          | Green                     | Red SF           | On                  | On   |
| Low Cranking Voltage                                    | Yellow SF | Red SF                               | Off                   | Green                     | Red SF           | On                  | On   |
| Battery Charger Fail                                    | Yellow SF | Green                                | Green or Off          | Green                     | Off              | On                  | On   |
| Battery Voltage (Hi)                                    | Yellow SF | Green                                | Green or Off          | Green                     | Off              | On                  | On   |
| Battery Voltage (Lo)                                    | Yellow SF | Green                                | Green or Off          | Green                     | Off              | Off                 | Off  |
| Common Fault (Warning)                                  | Yellow SF | Green                                | Green or Off          | Green                     | Red SF           | On                  | Off  |
| Common Fault (Shutdown)                                 | Red SF    | Green                                | Green or Off          | Green                     | Red SF           | On                  | On   |
| User Input #1 (Warning)                                 | Yellow SF | Green                                | Green or Off          | Green                     | Off              | Off                 | Off  |
| User Input #1 (Shutdown)                                | Red FF    | Green                                | Green or Off          | Green                     | Off              | On                  | On   |
| User Input #2 (Warning)                                 | Yellow SF | Green                                | Green or Off          | Green                     | Off              | Off                 | Off  |
| User Input #2 (Shutdown)                                | Red FF    | Green                                | Green or Off          | Green                     | Off              | On                  | On   |
| User Input #3 (Warning)                                 | Yellow SF | Green                                | Green or Off          | Green                     | Off              | Off                 | Off  |
| User Input #3 (Shutdown)                                | Red FF    | Green                                | Green or Off          | Green                     | Off              | On                  | On   |
| User Input #4 (Warning)                                 | Yellow SF | Green                                | Green or Off          | Green                     | Off              | Off                 | Off  |
| User Input #4 (Shutdown)                                | Red FF    | Green                                | Green or Off          | Green                     | Off              | On                  | On   |
| User Input #5 (Warning)                                 | Yellow SF | Green                                | Green or Off          | Green                     | Off              | Off                 | Off  |
| User Input #5 (Shutdown)                                | Red FF    | Green                                | Green or Off          | Green                     | Off              | On                  | On   |
| ATS Position N (RSA III with ATS only)                  | Green     | Green                                | Green or Off          | Green                     | Off              | Off                 | Off  |
| ATS Position E (RSA III with ATS only)                  | Red       | Red SF                               | Green or Off          | Green                     | Off              | Off                 | Off  |
| ATS Available N (RSA III with ATS only)                 | Green     | Green                                | Green or Off          | Green                     | Off              | Off                 | Off  |
| ATS Available E (RSA III with ATS only)                 | Red       | Red SF                               | Green or Off          | Green                     | Off              | Off                 | Off  |
| ATS Test (RSA III with ATS only, Test initiated at ATS) | Yellow    | Green                                | Green or Off          | Green                     | Off              | Off                 | On   |
| ATS Test (RSA III with ATS only, Test initiated at RSA) | Green     | Green                                | Green or Off          | Green                     | Off              | Off                 | On   |
| ATS Fault (RSA III with ATS only, No fault)             | Green     | Green                                | Green or Off          | Green                     | Off              | Off                 | On   |
| ATS Fault (RSA III with ATS only, With fault)           | Red FF    | Red SF                               | Green or Off          | Green                     | Off              | Off                 | On   |
| EPS Supplying Load                                      | Green     | Green                                | Green or Off          | Green                     | Off              | Off                 | Off  |
| Not-In-Auto   | Red FF    | Red SF                               | Off                   | Green                     | Red SF           | On                  | On   |
| Communication Status (Loss - Master)                    | Red FF    | Off                                  | Off                   | Red FF                    | Off              | On                  | On   |
| Communication Status (Loss - Slave)                     | Red SF    | Off                                  | Off                   | Red SF                    | Off              | On                  | On   |

*Note: SF = Slow Flash (once per second), FF = Fast Flash (five times per second)*

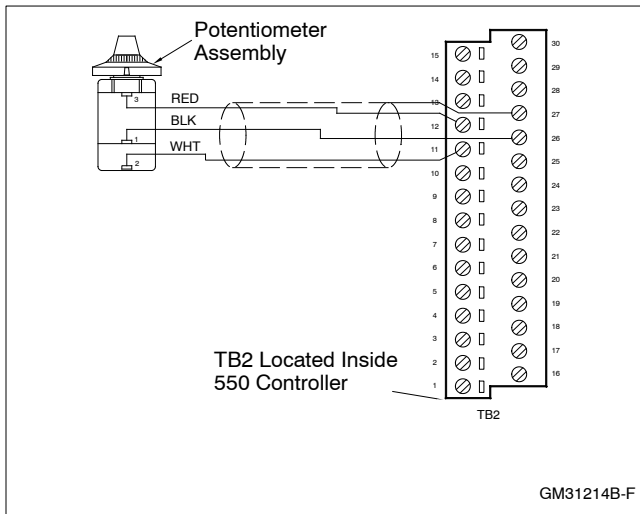
**Figure 6-21** System Monitoring LEDs and Functions

### 6.1.12 Remote Speed Adjust Kit (ECM Models)

This kit provides remote engine speed adjustments with an approximate range of  $\pm 5\%$  at 1800 rpm. See Figure 6-22 and Figure 6-23.



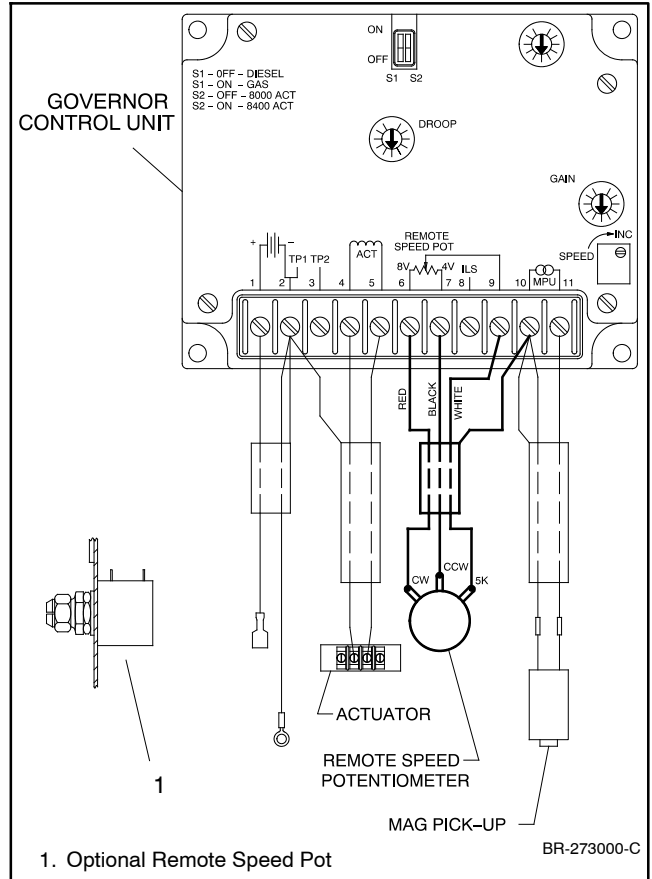
**Figure 6-22** Remote Speed Adjusting Control



**Figure 6-23** Speed Adjusting Control Wiring Diagram

### 6.1.13 Remote Speed Adjustment Potentiometer Kit (Non-ECM Models)

The remote speed adjustment potentiometer kit provides controller-mounted engine speed adjustment. The adjustment range is approximately  $\pm 5\%$ . Some applications locate this potentiometer with the switchgear. This kit requires an electronic governor on the generator set. See Figure 6-24. See Section 6.2, Accessory Connections, for terminal identifications.



**Figure 6-24** Remote Speed Adjustment Potentiometer Connection, Typical

### 6.1.14 Run Relay Kit

The run relay kit energizes only when the generator set runs. Use the run relay kit to control air intake and radiator louvers, alarms, and/or other signalling devices. See Figure 6-25 and Figure 6-26.

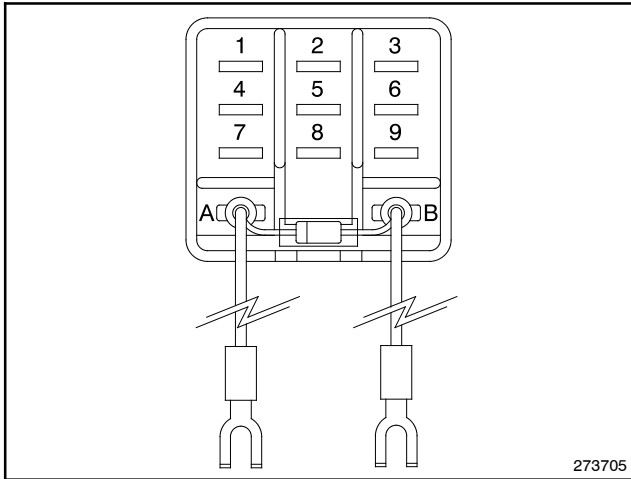


Figure 6-25 Run Relay Kit

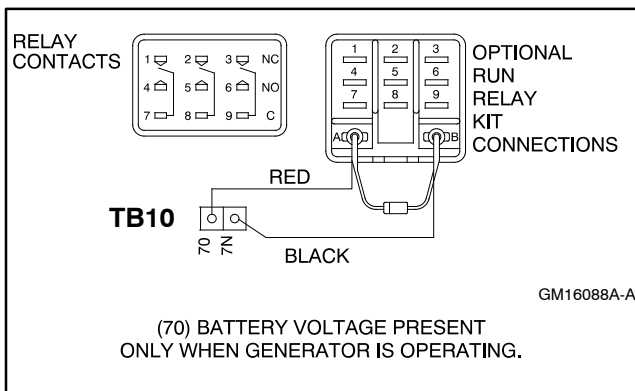


Figure 6-26 Run Relay Connections

### 6.1.15 Shunt-Trip Line Circuit Breaker

A shunt-trip line circuit breaker provides a 12- or 24-DC volt solenoid within the line circuit breaker case that can energize the trip mechanism. This feature allows the circuit breaker to be tripped by a customer-selected fault such as alternator overload, overspeed, overvoltage, or defined common fault. Connection requires a shunt-trip wiring kit and a dry contact kit. See Figure 6-27.

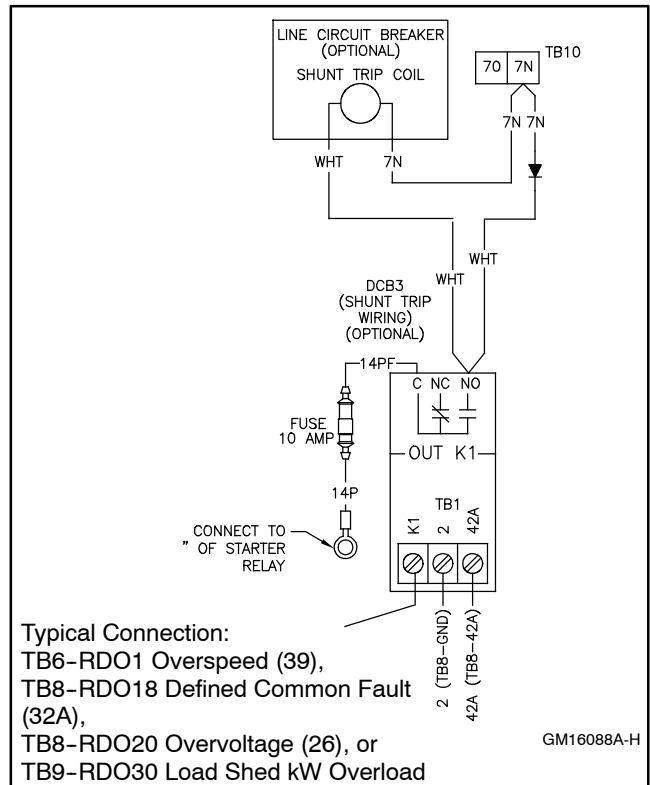


Figure 6-27 Shunt-Trip Line Circuit Breaker and Shunt-Trip Wiring Kit Connections

### 6.1.16 Single-Relay Dry Contact Kit

The single-relay dry contact kit provides normally open and normally closed contacts in a form C configuration to activate warning devices and other user-provided accessories allowing remote monitoring of the generator set. Typically, lamps, audible alarms, or other devices signal faults or status conditions. Connect any controller fault output to the single-relay dry contact kit.

A total of three dry contact kits may connect to a single controller output. See Figure 6-28 and Figure 6-29. See Section 6.2, Accessory Connections, for terminal identifications.

### 6.1.17 Ten-Relay Dry Contact Kit

The ten-relay dry contact kit provides normally open and normally closed contacts in a form C configuration to activate warning devices and other user-provided accessories allowing remote monitoring of the generator set. Connect any controller fault output to the ten-relay dry contact kit. Typically, lamps, audible alarms, or other devices signal the fault conditions.

Refer to Figure 6-30 for an internal view of the contact kit. See Figure 6-31 for electrical connections. See Section 6.2, Accessory Connections, for terminal identifications.

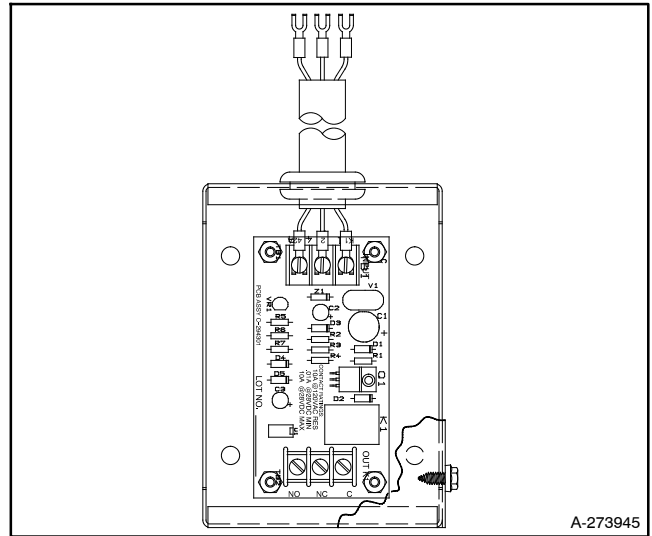


Figure 6-28 Single-Relay Dry Contact Kit, Typical

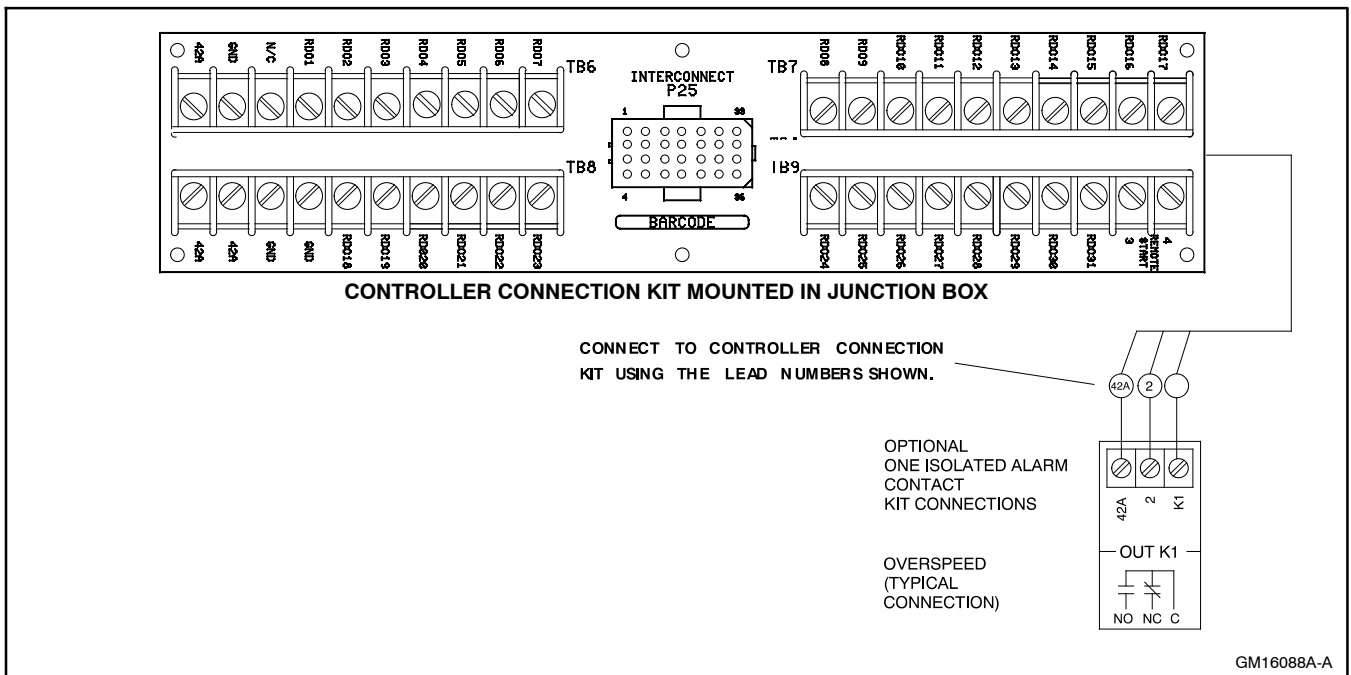


Figure 6-29 Single-Relay Dry Contact Kit Connections

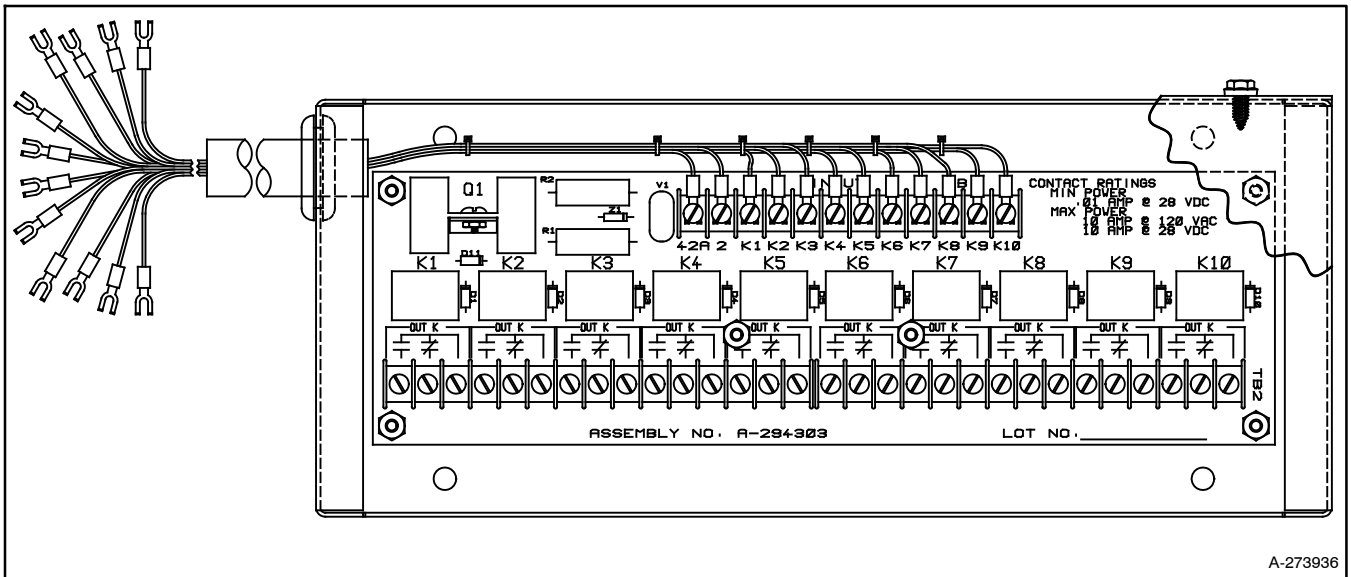


Figure 6-30 Ten-Relay Dry Contact Kit

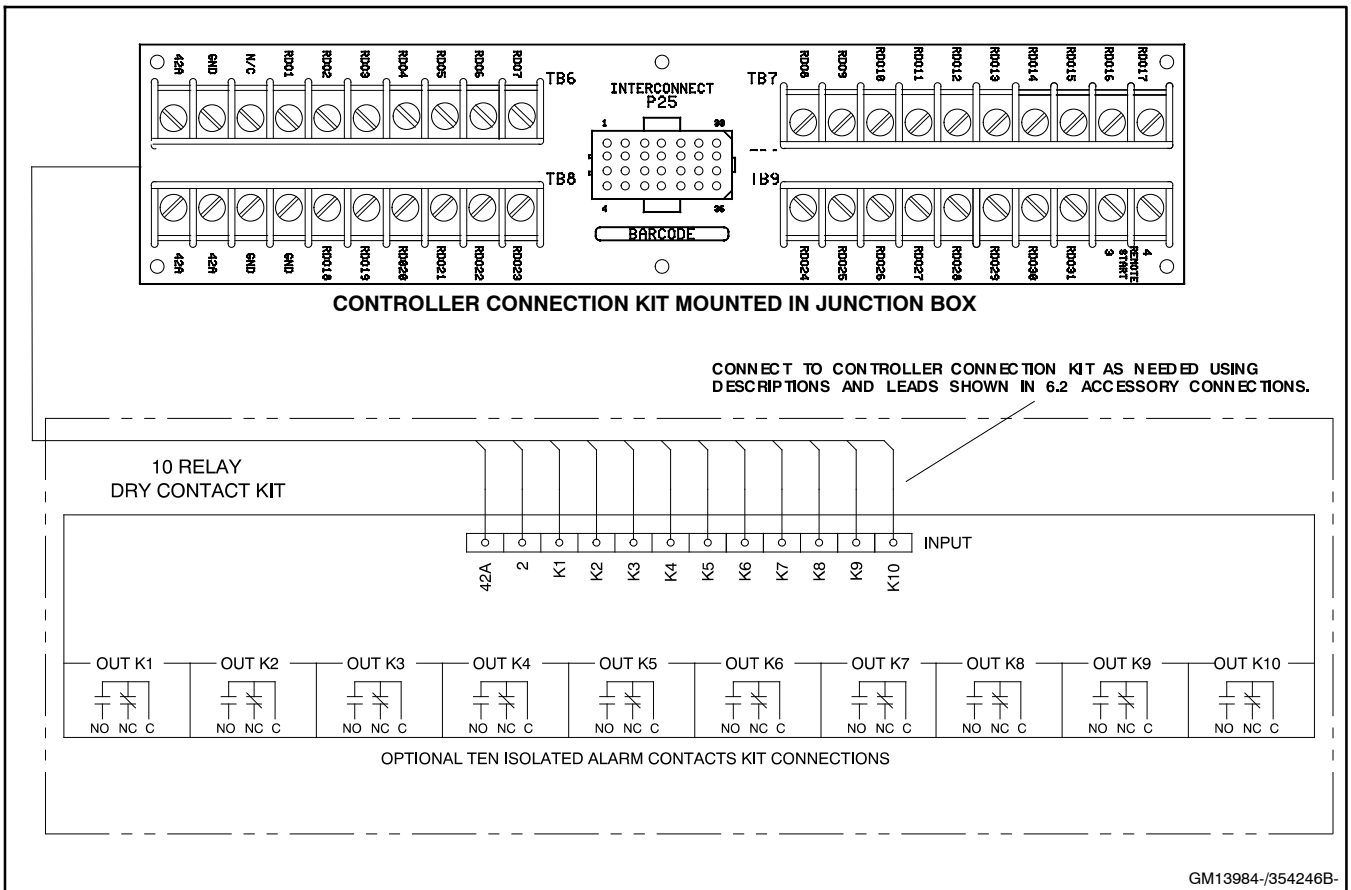


Figure 6-31 Ten-Relay Dry Contact Kit Connections



### 6.1.18 Twenty-Relay Dry Contact Kit

The twenty-relay dry contact kit provides normally open and normally closed contacts in a form C configuration to activate warning devices and other user-provided accessories allowing remote monitoring of the generator set. Typically, lamps, audible alarms, or other devices signal faults or status conditions. Connect any generator set fault output to the dry contact kit.

Refer to Figure 6-32 for an internal view of the contact kit. See Figure 6-33 for electrical connections. See Section 6.2, Accessory Connections, for terminal identifications.

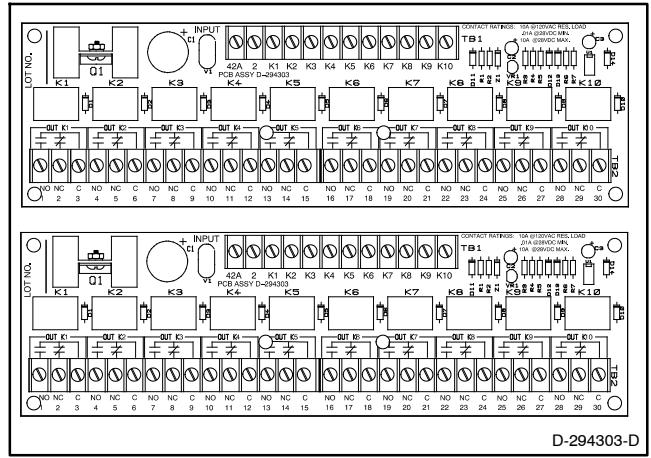


Figure 6-32 Twenty-Relay Dry Contact Kits

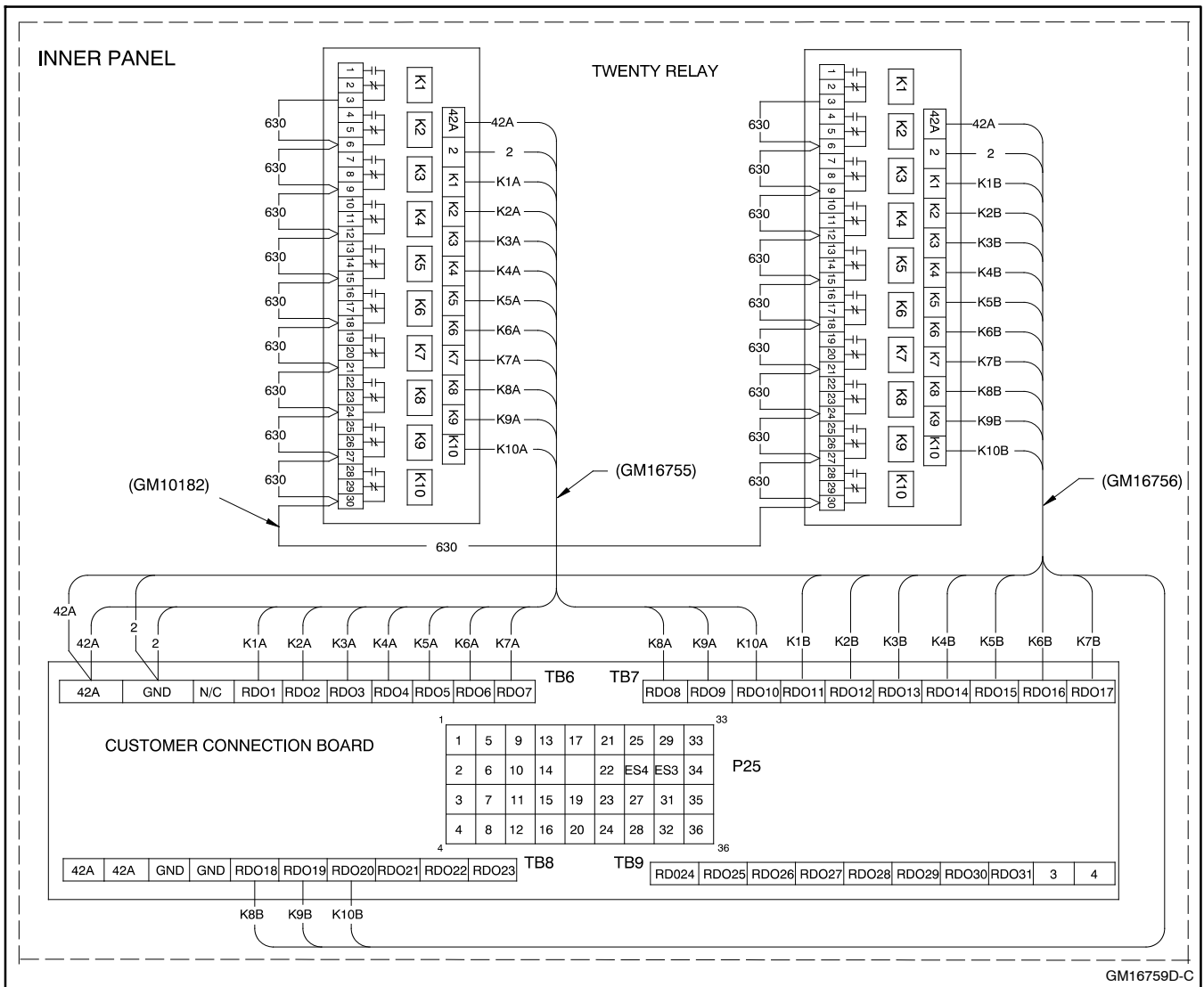
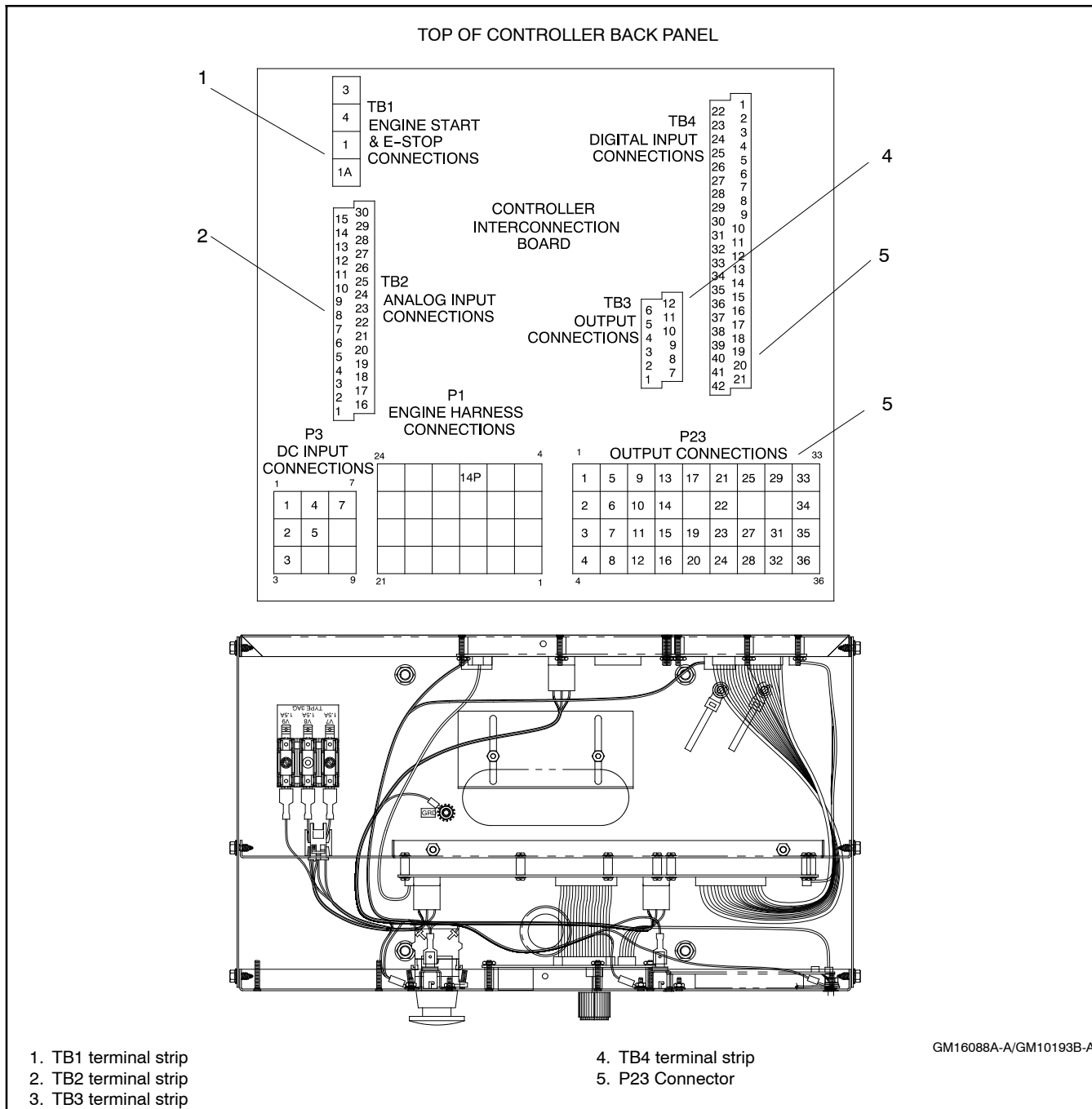


Figure 6-33 Twenty-Relay Dry Contact Relay Kit Connections

## 6.2 Accessory Connections

The 550 controller contains circuit boards equipped with terminal strip(s) for use in connecting a controller connection kit. Do not connect accessories directly to the controller terminal strip(s). Connect accessories to either a controller connection kit or a dry contact kit. Connect the dry contact kit(s) to the controller connection kit. Connect alarms, battery chargers, remote switches, and other accessories to the dry contact kit relay(s).

For specific information on accessory connections, refer to the accessory wiring diagrams in the wiring diagram manual and the instruction sheet accompanying the kit. See Figure 6-34 and Figure 6-35 for controller interconnection circuit board connections. See Figure 6-36 and Figure 6-37 for controller (customer) connection kit connections. See Figure 6-38, Figure 6-39, and Figure 6-40 for accessory connection wiring diagrams.



**Figure 6-34** Terminal Strips on Controller Interconnection Circuit Board (Controller Back Panel Folded Down)

**TB1 Terminal Strip—Engine Start and Emergency Stop Connections**

**Term. Description**

|    |                       |
|----|-----------------------|
| 1  | Emergency stop ground |
| 1A | Emergency stop        |
| 3  | Remote start          |
| 4  | Remote start          |

**TB2 Terminal Strip—Analog Input Connections**

**Term. Description**

|    |   |
|----|---|
| 1  | ACH1 (CTS) Signal (non-ECM including Waukesha)      |
| 2  | ACH1 (CTS) Supply (non-ECM including Waukesha)      |
| 3  | ACH2 (OPS) Signal (non-ECM including Waukesha)      |
| 4  | ACH2 (OPS) Supply (non-ECM including Waukesha)      |
| 5  | ACH3 Signal (air intake temp. for Waukesha)         |
| 6  | ACH3 Supply (air intake temp. for Waukesha)         |
| 7  | ACH4 Signal (oil temp. for Waukesha)                |
| 8  | ACH4 Supply (oil temp. for Waukesha)                |
| 9  | ACH5 Signal   |
| 10 | ACH5 Supply   |
| 11 | ACH6 Signal   |
| 12 | ACH6 Supply (VSG for Volvo, GM, Doosan, and KDI)    |
| 13 | ACH7 Signal (optional analog voltage adjust signal) |
| 14 | ACH7 Supply   |
| 15 | N/C   |
| 16 | ACH1 (CTS) Return (non-ECM)                         |
| 17 | ACH1 (CTS) Shield ground (non-ECM)                  |
| 18 | ACH2 (OPS or OPS2) Return (non-ECM)                 |
| 19 | ACH2 (OPS) Shield ground (non-ECM)                  |
| 20 | ACH3 (IAT or OPS1) Return                           |
| 21 | ACH3 Shield ground                                  |
| 22 | ACH4 (Oil Temp) Return                              |
| 23 | ACH4 Shield ground                                  |
| 24 | ACH5 Return   |
| 25 | ACH5 Shield ground                                  |
| 26 | ACH6 Return   |
| 27 | ACH6 Shield ground                                  |
| 28 | ACH7 Return   |
| 29 | ACH7 Shield ground                                  |
| 30 | N/C   |

**TB3 Terminal Strip—Accessory Power Output Connections**

**Term. Description**

|    |                                 |
|----|---------------------------------|
| 1  | +12 VDC (OEM use only)          |
| 2  | +12 VDC (OEM use only)          |
| 3  | +12 VDC (OEM use only)          |
| 4  | Fused battery (+) (42A) (5 amp) |
| 5  | Fused battery (+) (42A) (5 amp) |
| 6  | Fused battery (+) (42A) (5 amp) |
| 7  | Battery (-)                     |
| 8  | Battery (-)                     |
| 9  | Battery (-)                     |
| 10 | Battery (-)                     |
| 11 | Battery (-)                     |
| 12 | Panel lamp output               |

**TB4 Terminal Strip—Input Factory Connections**

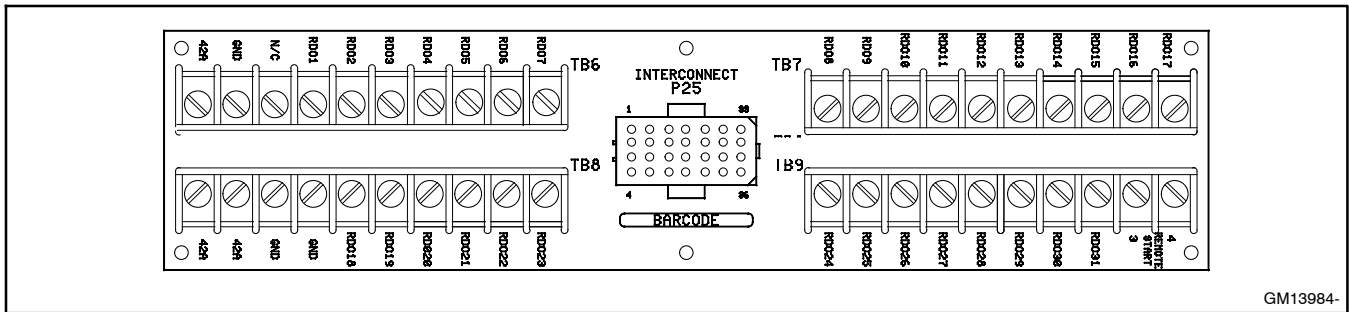
**Term. Description**

|    |   |
|----|---|
| 1  | DCH1 Battery charger fault  |
| 2  | DCH2 Low fuel   |
| 3  | DCH3 Low coolant temp. with ECM models or warning default with non-ECM models                     |
| 4  | DCH4 Field overvoltage with M4/M5/M7 alternators or warning default with non-M4/M5/M7 alternators |
| 5  | DCH5 Breaker Closed, Paralleling Applications   |
| 6  | DCH6 Enable Synch, Paralleling Applications   |
| 7  | DCH7 Warning  |
| 8  | DCH8 Warning  |
| 9  | DCH9 Warning  |
| 10 | DCH10 Warning   |
| 11 | DCH11 AFM Shutdown, Waukesha engine   |
| 12 | DCH12 Detonation Warning, Waukesha engine   |
| 13 | DCH13 Detonation Shutdown, Waukesha engine  |
| 14 | DCH14 Warning   |
| 15 | DCH15 Remote shutdown   |
| 16 | DCH16 Remote reset  |
| 17 | DCH17 VAR PF mode   |
| 18 | DCH18 Voltage lower   |
| 19 | DCH19 Voltage raise   |
| 20 | DCH20 Air damper  |
| 21 | DCH21 Idle mode functional with ECM-equipped engines only   |
| 22 | DCH1 Return   |
| 23 | DCH2 Return   |
| 24 | DCH3 Return   |
| 25 | DCH4 Return   |
| 26 | DCH5 Return   |
| 27 | DCH6 Return   |
| 28 | DCH7 Return   |
| 29 | DCH8 Return   |
| 30 | DCH9 Return   |
| 31 | DCH10 Return  |
| 32 | DCH11 Return  |
| 33 | DCH12 Return  |
| 34 | DCH13 Return  |
| 35 | DCH14 Return  |
| 36 | DCH15 Return  |
| 37 | DCH16 Return  |
| 38 | DCH17 Return  |
| 39 | DCH18 Return  |
| 40 | DCH19 Return  |
| 41 | DCH20 Return  |
| 42 | DCH21 Return  |

**Note:** TB4-1 through TB4-21 are user definable with factory defaults listed. Terminals TB4-3, TB4-4, TB4-14, and TB4-21 have different functions depending upon the generator set configuration. See comments above. See Menu 9—Input Setup for changing inputs.

**Note:** On charger GM87448, the Battery Charger Fault is communicated through CAN communication and the connection on TB4, DCH1, is not used.

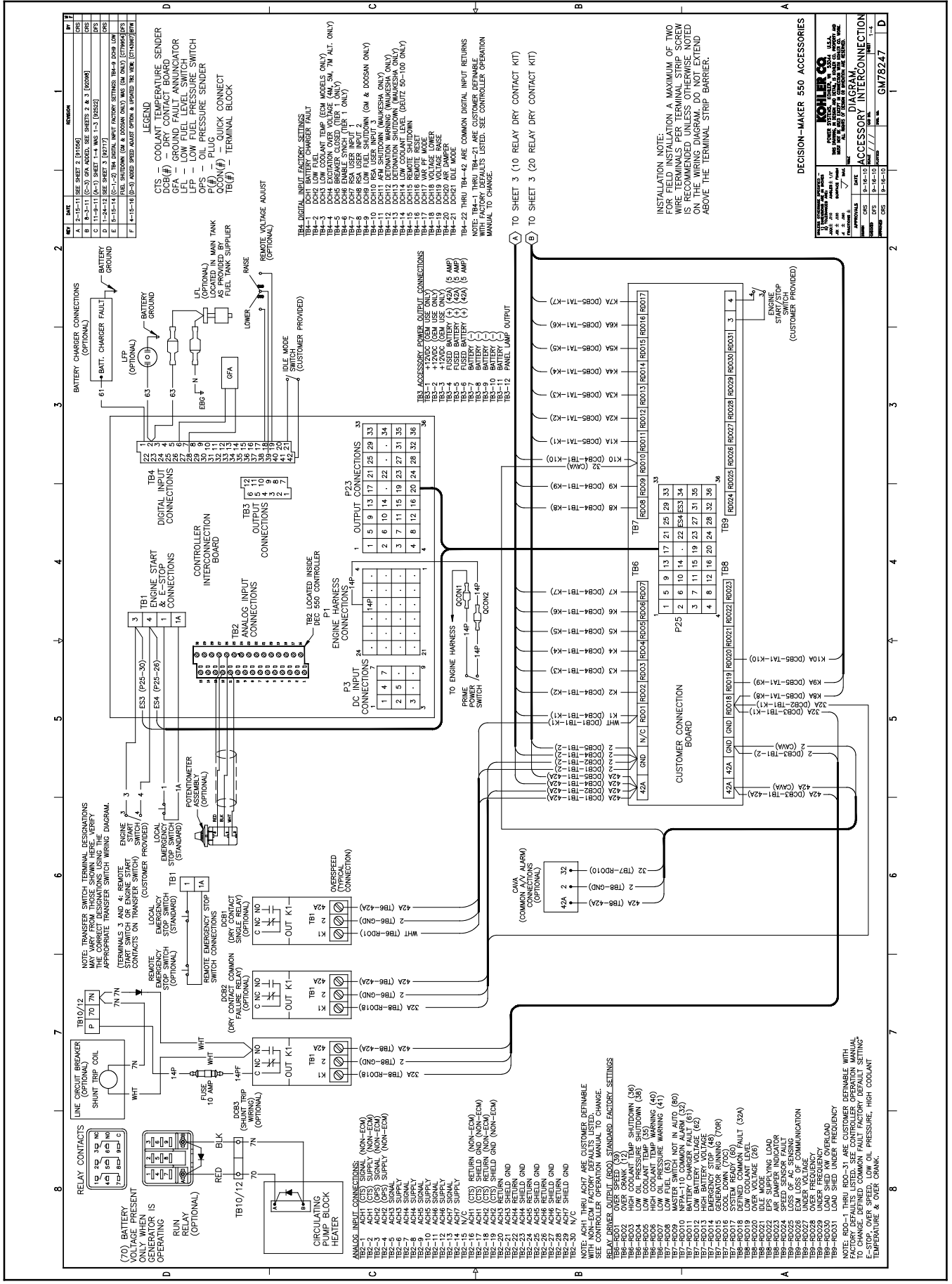
**Figure 6-35** Controller Terminal Strip Identification

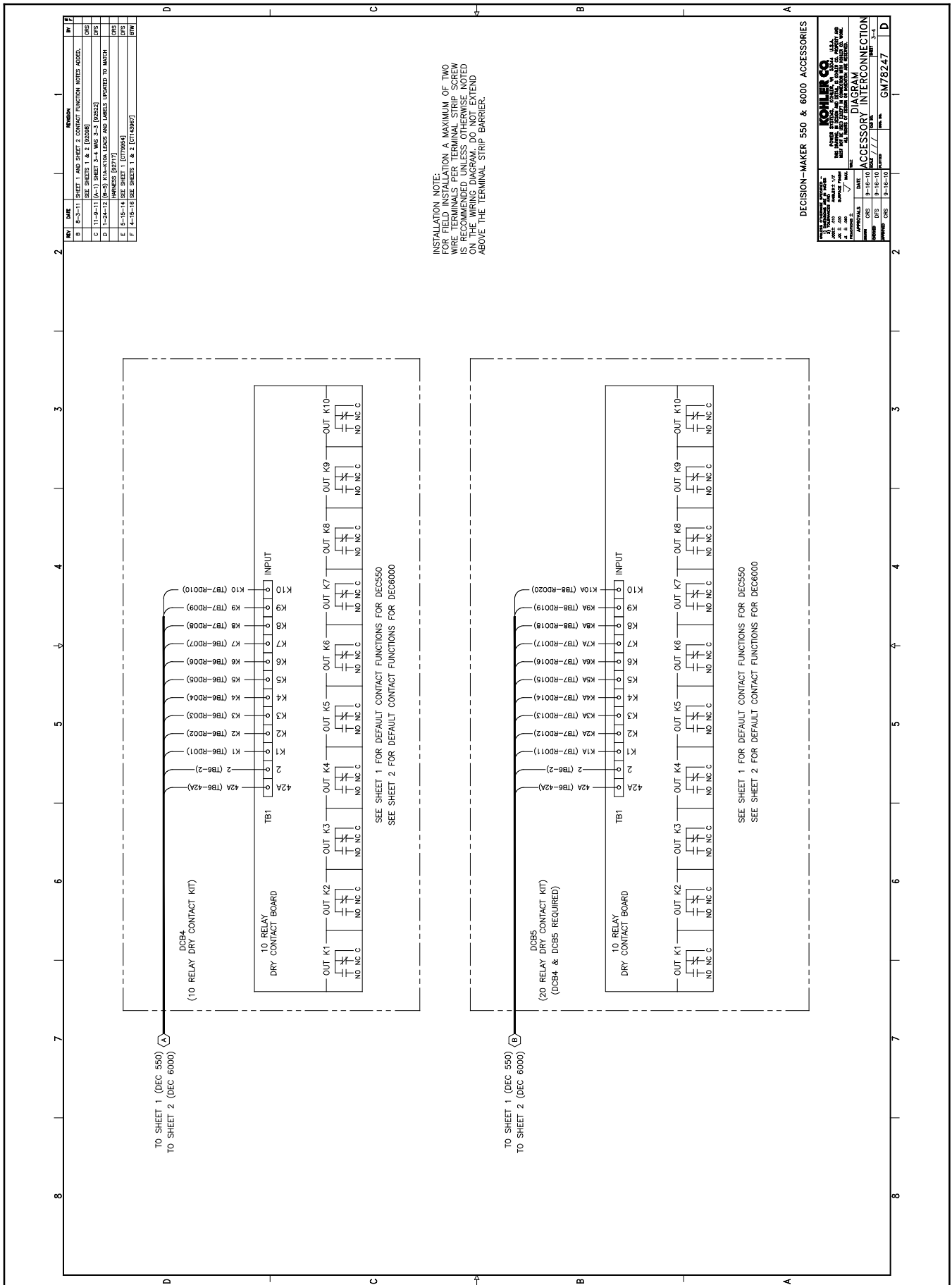


**Figure 6-36** Terminal Strips TB6, TB7, TB8, and TB9 on the Controller Connection Kit in the Junction Box

| <b>TB6 Terminal Strip—RDOs 1-7</b>   |  | <b>TB9 Terminal Strip—RDOs 24-31</b>  |                           |
|--------------------------------------|--|---|---------------------------|
| <b>Term.</b>                         | <b>Description</b>                           | <b>Term.</b>  | <b>Description</b>        |
| 42A                                  | Battery (+)                                  | RDO24   | Speed sensor fault        |
| GND                                  | Battery (-)                                  | RDO25   | Loss of AC sensing        |
| N/C                                  |  | RDO26   | ECM loss of communication |
| RDO1                                 | Overspeed (lead 39)                          | RDO27   | Undervoltage              |
| RDO2                                 | Overcrank (lead 12)                          | RDO28   | Overfrequency             |
| RDO3                                 | High coolant temperature shutdown (lead 36)  | RDO29   | Underfrequency            |
| RDO4                                 | Low oil pressure shutdown (lead 38)          | RDO30   | Load shed kW overload     |
| RDO5                                 | Low coolant temperature (lead 35)            | RDO31   | Load shed underfrequency  |
| RDO6                                 | High coolant temperature warning (lead 40)   | 3   | Remote start              |
| RDO7                                 | Low oil pressure warning (lead 41)           | 4   | Remote start              |
| <b>TB7 Terminal Strip—RDOs 8-17</b>  |  | <b>Note:</b> Lead numbers shown in parentheses are the factory default wire designations.   |                           |
| <b>Term.</b>                         | <b>Description</b>                           | <b>Note:</b> RDO-1 though RDO-31 are user definable with the following factory defaults: emergency stop, high coolant temperature, low oil pressure, overcrank, and overspeed |                           |
| RDO8                                 | Low fuel (lead 63)                           | <b>*NFPA-110 common alarm faults include:</b>   |                           |
| RDO9                                 | Master switch not in auto (lead 80)          | Air damper indicator (RDO-23)   |                           |
| RDO10                                | NFPA 110 common alarm (lead 32)*             | Battery charger fault (RDO-11)  |                           |
| RDO11                                | Battery charger fault (lead 61)              | EPS supplying load (RDO-22)   |                           |
| RDO12                                | Low battery voltage (lead 62)                | High battery voltage (RDO-13)   |                           |
| RDO13                                | High battery voltage                         | High coolant temperature warning (RDO-06)   |                           |
| RDO14                                | Emergency stop (lead 48)                     | High coolant temperature shutdown (RDO-03)  |                           |
| RDO15                                | Generator set running (lead 70R)             | Low battery voltage (RDO-012)   |                           |
| RDO16                                | Time delay engine cooldown (TDEC) (lead 70C) | Low coolant level (RDO-19)  |                           |
| RDO17                                | System ready (lead 60)                       | Low coolant temperature warning (RDO-05)  |                           |
| <b>TB8 Terminal Strip—RDOs 18-23</b> |  | Low fuel (level or pressure) (RDO-08)   |                           |
| <b>Term.</b>                         | <b>Description</b>                           | Low oil pressure warning (RDO-07)   |                           |
| 42A                                  | Battery (+)                                  | Low oil pressure shutdown (RDO-04)  |                           |
| 42A                                  | Battery (+)                                  | Master switch not in auto (RDO-09)  |                           |
| GND                                  | Battery (-)                                  | Overcrank (RDO-02)  |                           |
| GND                                  | Battery (-)                                  | Overspeed (RDO-01)  |                           |
| RDO18                                | Defined common fault (lead 32A)              |   |                           |
| RDO19                                | Low coolant level                            |   |                           |
| RDO20                                | Overvoltage (lead 26)                        |   |                           |
| RDO21                                | Idle mode                                    |   |                           |
| RDO22                                | EPS supplying load                           |   |                           |
| RDO23                                | Air damper indicator (lead 56)               |   |                           |

**Figure 6-37** Controller (Customer) Connection Kit Terminal Strip Identification with Relay Driver Outputs (RDOs)





INSTALLATION NOTE:  
FOR INSTALLATION, A MAXIMUM OF TWO  
WIRE TERMINALS PER TERMINAL STRIP SCREW  
IS RECOMMENDED UNLESS OTHERWISE NOTED  
ON THE WIRING DIAGRAM. DO NOT EXTEND  
ABOVE THE TERMINAL STRIP BARRIER.

| REV | DATE    | REVISION  |
|-----|---------|---|
| B   | 8-3-11  | SHEET 1 AND SHEET 2 CONTACT FUNCTION NOTES ADDED.             |
| C   | 11-2-11 | SEE SHEETS 1 & 2 (DEC6000)                                    |
| D   | 11-2-11 | TERMINAL MARKING CHANGED TO (DCB4)                            |
| E   | 12-2-11 | TERMINAL MARKING CHANGED TO (DCB5)                            |
| F   | 4-15-14 | MARKING CHANGED FROM (DCB4) TO (DCB5) TO MATCH MARKING (DCB5) |
| G   | 5-15-14 | SEE SHEET 1 (CT70904)   |
| H   | 4-15-16 | SEE SHEETS 1 & 2 (CT140897)                                   |

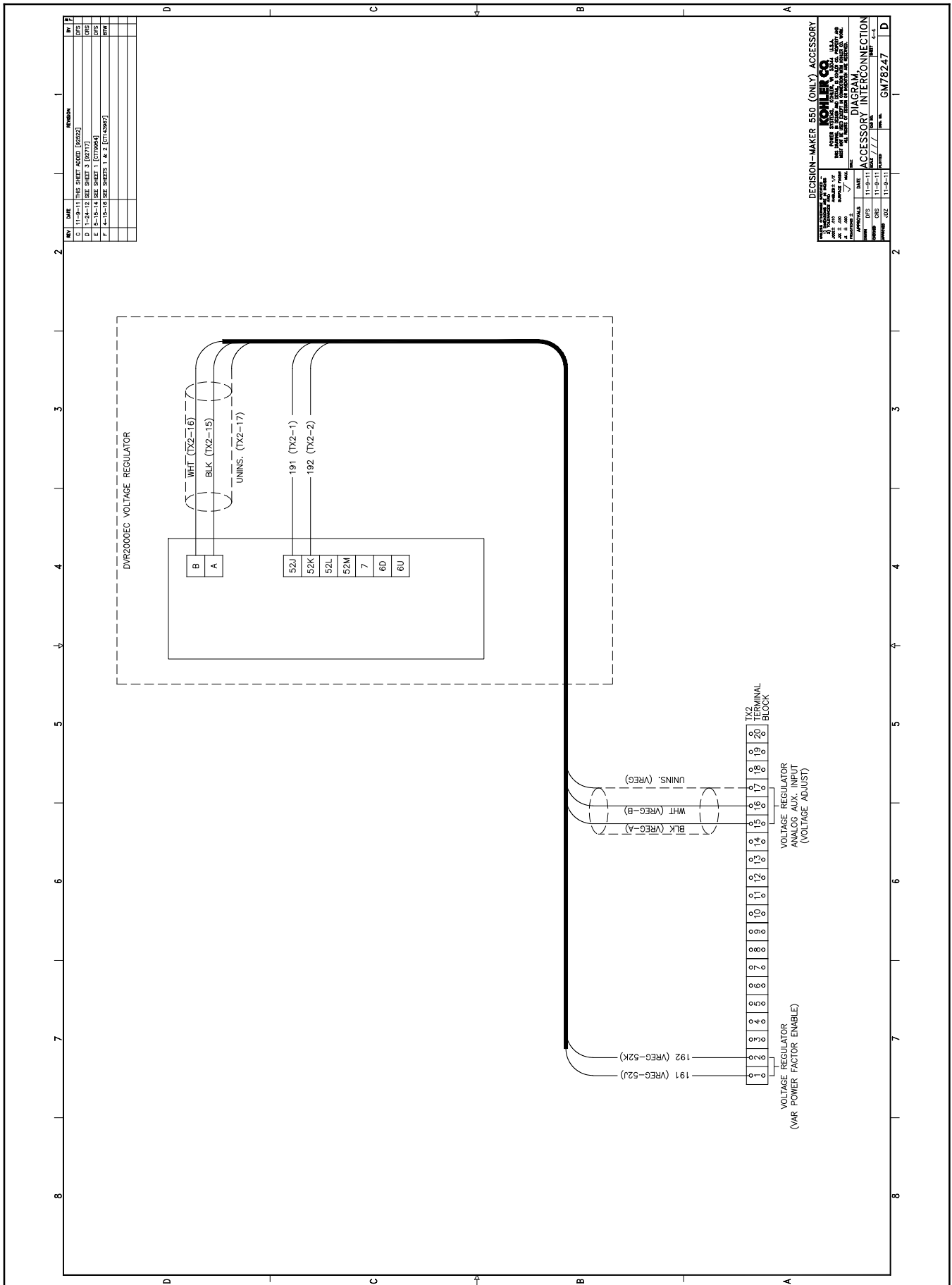
DECISION-MAKER 550 & 6000 ACCESSORIES

|             |         |             |         |
|-------------|---------|-------------|---------|
| DESIGNED BY | DATE    | APPROVED BY | DATE    |
| CS          | 8-15-10 | CS          | 8-15-10 |

DIAGRAM ACCESSORY INTERCONNECTION

GM78247F-3

Figure 6-39 Accessory Connections GM78247F-3



**Figure 6-40** Accessory Connections GM78247F-4

# Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

|           |  |                             |  |                      |  |
|-----------|--|-----------------------------|--|----------------------|--|
| A, amp    | ampere   | cfm                         | cubic feet per minute  | exh.                 | exhaust  |
| ABDC      | after bottom dead center   | CG                          | center of gravity  | ext.                 | external   |
| AC        | alternating current  | CID                         | cubic inch displacement  | F                    | Fahrenheit, female                                   |
| A/D       | analog to digital  | CL                          | centerline   | FHM                  | flat head machine (screw)                            |
| ADC       | advanced digital control;<br>analog to digital converter                                   | cm                          | centimeter   | fl. oz.              | fluid ounce  |
| adj.      | adjust, adjustment   | CMOS                        | complementary metal oxide<br>substrate (semiconductor)                               | flex.                | flexible   |
| ADV       | advertising dimensional<br>drawing   | com                         | communications (port)  | freq.                | frequency  |
| Ah        | amp-hour   | coml                        | commercial   | FS                   | full scale   |
| AHWT      | anticipatory high water<br>temperature   | Coml/Rec                    | Commercial/Recreational<br>connection  | ft.                  | foot, feet   |
| AISI      | American Iron and Steel<br>Institute   | conn.                       | connection   | ft. lb.              | foot pounds (torque)                                 |
| ALOP      | anticipatory low oil pressure  | cont.                       | continued  | ft./min.             | feet per minute                                      |
| alt.      | alternator   | CPVC                        | chlorinated polyvinyl chloride   | ftp                  | file transfer protocol                               |
| Al        | aluminum   | crit.                       | critical   | g                    | gram   |
| ANSI      | American National Standards<br>Institute (formerly American<br>Standards Association, ASA) | CSA                         | Canadian Standards<br>Association  | ga.                  | gauge (meters, wire size)                            |
| AO        | anticipatory only  | CT                          | current transformer  | gal.                 | gallon   |
| APDC      | Air Pollution Control District   | Cu                          | copper   | gen.                 | generator  |
| API       | American Petroleum Institute   | cUL                         | Canadian Underwriter's<br>Laboratories   | genset               | generator set  |
| approx.   | approximate, approximately   | CUL                         | Canadian Underwriter's<br>Laboratories   | GFI                  | ground fault interrupter                             |
| APU       | Auxiliary Power Unit   | cu. in.                     | cubic inch   | GND, ⊕               | ground   |
| AQMD      | Air Quality Management District  | cw.                         | clockwise  | gov.                 | governor   |
| AR        | as required, as requested  | CWC                         | city water-cooled  | gph                  | gallons per hour                                     |
| AS        | as supplied, as stated, as<br>suggested  | cyl.                        | cylinder   | gpm                  | gallons per minute                                   |
| ASE       | American Society of Engineers  | D/A                         | digital to analog  | gr.                  | grade, gross   |
| ASME      | American Society of<br>Mechanical Engineers  | DAC                         | digital to analog converter  | GRD                  | equipment ground                                     |
| assy.     | assembly   | dB                          | decibel  | gr. wt.              | gross weight   |
| ASTM      | American Society for Testing<br>Materials  | dB(A)                       | decibel (A weighted)   | H x W x D            | height by width by depth                             |
| ATDC      | after top dead center  | DC                          | direct current   | HC                   | hex cap  |
| ATS       | automatic transfer switch  | DCR                         | direct current resistance  | HCHT                 | high cylinder head temperature                       |
| auto.     | automatic  | deg., °                     | degree   | HD                   | heavy duty   |
| aux.      | auxiliary  | dept.                       | department   | HET                  | high exhaust temp., high<br>engine temp.             |
| avg.      | average  | dia.                        | diameter   | hex                  | hexagon  |
| AVR       | automatic voltage regulator  | DI/EO                       | dual inlet/end outlet  | Hg                   | mercury (element)                                    |
| AWG       | American Wire Gauge  | DIN                         | Deutsches Institut fur Normung<br>e. V. (also Deutsche Industrie<br>Normenausschuss) | HH                   | hex head   |
| AWM       | appliance wiring material  | DIP                         | dual inline package  | HHC                  | hex head cap   |
| bat.      | battery  | DPDT                        | double-pole, double-throw  | HP                   | horsepower   |
| BBDC      | before bottom dead center  | DPST                        | double-pole, single-throw  | hr.                  | hour   |
| BC        | battery charger, battery<br>charging   | DS                          | disconnect switch  | HS                   | heat shrink  |
| BCA       | battery charging alternator  | DVR                         | digital voltage regulator  | hsg.                 | housing  |
| BCI       | Battery Council International  | E <sup>2</sup> PROM, EEPROM | electrically-erasable<br>programmable read-only<br>memory                            | HVAC                 | heating, ventilation, and air<br>conditioning        |
| BDC       | before dead center   | E, emer.                    | emergency (power source)   | HWT                  | high water temperature                               |
| BHP       | brake horsepower   | ECM                         | electronic control module,<br>engine control module                                  | Hz                   | hertz (cycles per second)                            |
| blk.      | black (paint color), block<br>(engine)   | EDI                         | electronic data interchange  | IBC                  | International Building Code                          |
| blk. htr. | block heater   | EFR                         | emergency frequency relay  | IC                   | integrated circuit                                   |
| BMEP      | brake mean effective pressure  | e.g.                        | for example ( <i>exempli gratia</i> )  | ID                   | inside diameter, identification                      |
| bps       | bits per second  | EG                          | electronic governor  | IEC                  | International Electrotechnical<br>Commission         |
| br.       | brass  | EGSA                        | Electrical Generating Systems<br>Association   | IEEE                 | Institute of Electrical and<br>Electronics Engineers |
| BTDC      | before top dead center   | EIA                         | Electronic Industries<br>Association   | IMS                  | improved motor starting                              |
| Btu       | British thermal unit   | EI/EO                       | end inlet/end outlet   | in.                  | inch   |
| Btu/min.  | British thermal units per minute   | EMI                         | electromagnetic interference   | in. H <sub>2</sub> O | inches of water                                      |
| C         | Celsius, centigrade  | emiss.                      | emission   | in. Hg               | inches of mercury                                    |
| cal.      | calorie  | eng.                        | engine   | in. lb.              | inch pounds  |
| CAN       | controller area network  | EPA                         | Environmental Protection<br>Agency   | Inc.                 | incorporated   |
| CARB      | California Air Resources Board   | EPS                         | emergency power system   | ind.                 | industrial   |
| CAT5      | Category 5 (network cable)   | ER                          | emergency relay  | int.                 | internal   |
| CB        | circuit breaker  | ES                          | engineering special,<br>engineered special   | int./ext.            | internal/external                                    |
| CC        | crank cycle  | ESD                         | electrostatic discharge  | I/O                  | input/output   |
| cc        | cubic centimeter   | est.                        | estimated  | IP                   | internet protocol                                    |
| CCA       | cold cranking amps   | E-Stop                      | emergency stop   | ISO                  | International Organization for<br>Standardization    |
| ccw.      | counterclockwise   | etc.                        | et cetera (and so forth)   | J                    | joule  |
| CEC       | Canadian Electrical Code   |                             |  | JIS                  | Japanese Industry Standard                           |
| cert.     | certificate, certification, certified  |                             |  | k                    | kilo (1000)  |
| cfh       | cubic feet per hour  |                             |  | K                    | kelvin   |
|           |  |                             |  | kA                   | kiloampere   |
|           |  |                             |  | KB                   | kilobyte (2 <sup>10</sup> bytes)                     |
|           |  |                             |  | KBus                 | Kohler communication protocol                        |
|           |  |                             |  | kg                   | kilogram   |



|                      |  |           |   |         |   |
|----------------------|--|-----------|---|---------|---|
| kg/cm <sup>2</sup>   | kilograms per square centimeter                      | NBS       | National Bureau of Standards                        | RTU     | remote terminal unit  |
| kgm                  | kilogram-meter                                       | NC        | normally closed                                     | RTV     | room temperature vulcanization  |
| kg/m <sup>3</sup>    | kilograms per cubic meter                            | NEC       | National Electrical Code                            | RW      | read/write  |
| kHz                  | kilohertz  | NEMA      | National Electrical Manufacturers Association       | SAE     | Society of Automotive Engineers                                       |
| kJ                   | kilojoule  | NFPA      | National Fire Protection Association                | scfm    | standard cubic feet per minute  |
| km                   | kilometer  | Nm        | newton meter  | SCR     | silicon controlled rectifier  |
| kOhm, kΩ             | kilo-ohm   | NO        | normally open                                       | s, sec. | second  |
| kPa                  | kilopascal   | no., nos. | number, numbers                                     | SI      | <i>Systeme international d'unites</i> , International System of Units |
| kph                  | kilometers per hour                                  | NPS       | National Pipe, Straight                             | SI/EO   | side in/end out   |
| kV                   | kilovolt   | NPSC      | National Pipe, Straight-coupling                    | sil.    | silencer  |
| kVA                  | kilovolt ampere                                      | NPT       | National Standard taper pipe thread per general use | SMTP    | simple mail transfer protocol   |
| kVAR                 | kilovolt ampere reactive                             | NPTF      | National Pipe, Taper-Fine                           | SN      | serial number   |
| kW                   | kilowatt   | NR        | not required, normal relay                          | SNMP    | simple network management protocol                                    |
| kWh                  | kilowatt-hour  | ns        | nanosecond  | SPDT    | single-pole, double-throw   |
| kWm                  | kilowatt mechanical                                  | OC        | overcrank   | SPST    | single-pole, single-throw   |
| kWth                 | kilowatt-thermal                                     | OD        | outside diameter                                    | spec    | specification   |
| L                    | liter  | OEM       | original equipment manufacturer                     | specs   | specification(s)  |
| LAN                  | local area network                                   | OF        | overfrequency                                       | sq.     | square  |
| L x W x H            | length by width by height                            | opt.      | option, optional                                    | sq. cm  | square centimeter   |
| lb.                  | pound, pounds  | OS        | oversize, overspeed                                 | sq. in. | square inch   |
| lbm/ft <sup>3</sup>  | pounds mass per cubic feet                           | OSHA      | Occupational Safety and Health Administration       | SMS     | short message service   |
| LCB                  | line circuit breaker                                 | OV        | overvoltage   | SS      | stainless steel   |
| LCD                  | liquid crystal display                               | oz.       | ounce   | std.    | standard  |
| LED                  | light emitting diode                                 | p., pp.   | page, pages   | stl.    | steel   |
| Lph                  | liters per hour                                      | PC        | personal computer                                   | tach.   | tachometer  |
| Lpm                  | liters per minute                                    | PCB       | printed circuit board                               | TB      | terminal block  |
| LOP                  | low oil pressure                                     | pF        | picofarad   | TCP     | transmission control protocol   |
| LP                   | liquefied petroleum                                  | PF        | power factor  | TD      | time delay  |
| LPG                  | liquefied petroleum gas                              | ph., ∅    | phase   | TDC     | top dead center   |
| LS                   | left side  | PHC       | Phillips® head Crimptite® (screw)                   | TDEC    | time delay engine cooldown  |
| L <sub>wa</sub>      | sound power level, A weighted                        | PHH       | Phillips® hex head (screw)                          | TDEN    | time delay emergency to normal  |
| LWL                  | low water level                                      | PHM       | pan head machine (screw)                            | TDES    | time delay engine start   |
| LWT                  | low water temperature                                | PLC       | programmable logic control                          | TDNE    | time delay normal to emergency  |
| m                    | meter, milli (1/1000)                                | PLG       | programmable logic control                          | TDOE    | time delay off to emergency   |
| M                    | mega (10 <sup>6</sup> when used with SI units), male | PMG       | permanent magnet generator                          | TDON    | time delay off to normal  |
| m <sup>3</sup>       | cubic meter  | pot       | potentiometer, potential                            | temp.   | temperature   |
| m <sup>3</sup> /hr.  | cubic meters per hour                                | ppm       | parts per million                                   | term.   | terminal  |
| m <sup>3</sup> /min. | cubic meters per minute                              | PROM      | programmable read-only memory                       | THD     | total harmonic distortion   |
| mA                   | milliampere  | psi       | pounds per square inch                              | TIF     | telephone influence factor  |
| man.                 | manual   | psig      | pounds per square inch gauge                        | tol.    | tolerance   |
| max.                 | maximum  | pt.       | pint  | turbo.  | turbocharger  |
| MB                   | megabyte (2 <sup>20</sup> bytes)                     | PTC       | positive temperature coefficient                    | typ.    | typical (same in multiple locations)                                  |
| MCCB                 | molded-case circuit breaker                          | PTO       | power takeoff                                       | UF      | underfrequency  |
| MCM                  | one thousand circular mils                           | PVC       | polyvinyl chloride                                  | UHF     | ultrahigh frequency   |
| meggar               | megohmmeter  | qt.       | quart, quarts                                       | UIF     | user interface  |
| MHz                  | megahertz  | qty.      | quantity  | UL      | Underwriter's Laboratories, Inc.                                      |
| mi.                  | mile   | R         | replacement (emergency)                             | UNC     | unified coarse thread (was NC)  |
| mil                  | one one-thousandth of an inch                        | rad.      | radiator, radius                                    | UNF     | unified fine thread (was NF)  |
| min.                 | minimum, minute                                      | RAM       | random access memory                                | univ.   | universal   |
| misc.                | miscellaneous  | RDO       | relay driver output                                 | URL     | uniform resource locator (web address)                                |
| MJ                   | megajoule  | ref.      | reference   | US      | undersize, underspeed   |
| mJ                   | millijoule   | rem.      | remote  | UV      | ultraviolet, undervoltage   |
| mm                   | millimeter   | Res/Coml  | Residential/Commercial                              | V       | volt  |
| mOhm, mΩ             | milliohm   | RFI       | radio frequency interference                        | VAC     | volts alternating current   |
| MOhm, MΩ             | megohm   | RH        | round head  | VAR     | voltampere reactive   |
| MOV                  | metal oxide varistor                                 | RHM       | round head machine (screw)                          | VDC     | volts direct current  |
| MPa                  | megapascal   | rly.      | relay   | VFD     | vacuum fluorescent display  |
| mpg                  | miles per gallon                                     | rms       | root mean square                                    | VGA     | video graphics adapter  |
| mph                  | miles per hour                                       | rnd.      | round   | VHF     | very high frequency   |
| MS                   | military standard                                    | RO        | read only   | W       | watt  |
| ms                   | millisecond  | ROM       | read only memory                                    | WCR     | withstand and closing rating  |
| m/sec.               | meters per second                                    | rot.      | rotate, rotating                                    | w/      | with  |
| mtg.                 | mounting   | rpm       | revolutions per minute                              | WO      | write only  |
| MTU                  | Motoren-und Turbinen-Union                           | RS        | right side  | w/o     | without   |
| MW                   | megawatt   | RTDs      | Resistance Temperature Detectors                    | wt.     | weight  |
| mW                   | milliwatt  |           |   | xfrm    | transformer   |
| μF                   | microfarad   |           |   |         |   |
| N, norm.             | normal (power source)                                |           |   |         |   |
| NA                   | not available, not applicable                        |           |   |         |   |
| nat. gas             | natural gas  |           |   |         |   |

# Appendix B User-Defined Settings

Use the table below to record user-defined settings during the generator set controller setup and calibration. The controller default settings and ranges provide guidelines. The table contains all faults with ranges and time delays including items that do not have adjustments. Not adjustable user-defined settings result when the controller logic does not allow changes or the values are engine limited.

**Note:** Inhibit time delay is the time delay period after crank disconnect.

**Note:** The engine ECM may limit the crank cycle even if the controller is set to a longer time period.

## User-Defined Settings

| Status Event or Fault                      | Refer to Menu | Digital Display       | Relay Driver Output (RDO) | Range Setting  | Default Selection  | Inhibit Time Delay (sec.) | Time Delay (sec.) | User-Defined Settings |
|--|---------------|-----------------------|---------------------------|--|--|---------------------------|-------------------|-----------------------|
| Access Code (password)                     | 14            |                       |                           | User-Selectable  | 0 (zero)   |                           |                   |                       |
| AC Sensing Loss                            | 10            | AC SENSING LOSS       | RDO-25 *                  |  |  |                           |                   | Not adjustable        |
| Air Damper Control (if used) **            | 10            |                       |                           |  |  |                           |                   | Not adjustable        |
| Air Damper Indicator (if used), see D20 ** |               |                       |                           |  |  |                           |                   | —                     |
| Air/Fuel Module (AFM) Engine Start Delay ‡ | 10            | AFM ENG START DELAY   |                           | Fixed  |  |                           |                   | Not adjustable        |
| Air/Fuel Module (AFM) Remote Start ‡       | 10            | AFM REMOTE START      | RDO-25 ‡                  |  |  |                           |                   | Not adjustable        |
| Air/Fuel Module (AFM) Shutdown (see D11) ‡ |               |                       |                           |  |  |                           |                   | Not adjustable        |
| Alternator Protection Shutdown             | 10            | ALTERNATOR PROTECTION |                           |  |  |                           |                   | Not adjustable        |
| Analog Aux. Input 0                        | 9             | LOCAL BATT VDC        |                           | Fixed  |  |                           |                   | Not adjustable        |
| Analog Aux. Inputs A01-A07                 | 9             | USER-DEFINED A01-A07  |                           | Default Values with Warning Enabled:<br>HI warning 90%<br>LO warning 10%<br>HI shutdown 100%<br>LO shutdown 1%   | 30 sec. inhibit,<br>5 sec. delay                                   | 0-60                      | 0-60              |                       |
| Analog Aux. Input A01 (non-ECM only)       | 9             | A01 COOLANT TEMP      |                           | Default Values with Warning Enabled:<br>HI/LO warning and HI/LO shutdown are all engine dependent                | 30 sec. inhibit,<br>0 sec. delay warning,<br>5 sec. delay shutdown |                           |                   | Not adjustable        |
| Analog Aux. Input A02 (non-ECM only)       | 9             | A02 OIL PRESSURE      |                           | Default Values with Warning Enabled:<br>HI/LO warning and HI/LO shutdown are all engine dependent (255 psi max.) | 30 sec. inhibit,<br>0 sec. delay warning,<br>5 sec. delay shutdown |                           |                   | Not adjustable        |
| Analog Aux. Input A03 ‡                    | 9             | A03 INTAKE AIR TEMP   |                           | Default Values with Warning Enabled:<br>HI/LO warning are all engine dependent                                   | 30 sec. inhibit,<br>0 sec. delay warning                           |                           |                   | Not adjustable        |
| Analog Aux. Input A04 *                    | 9             | A04 FUEL LEVEL        |                           | Default Values with Warning Enabled:<br>HI/LO warning are engine dependent                                       | 30 sec. inhibit,<br>0 sec. delay warning                           |                           |                   |                       |

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† Non-paralleling applications

‡ Waukesha-powered models

§ Paralleling applications

|| Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual.

\*\* NFPA applications

†† DDC/MTU engine with MDEC/ADEC

‡‡ FAA only

| Status Event or Fault   | Refer to Menu | Digital Display                | Relay Driver Output (RDO) | Range Setting   | Default Selection                     | Inhibit Time Delay (sec.) | Time Delay (sec.) | User-Defined Settings                           |
|---|---------------|--------------------------------|---------------------------|---|---------------------------------------|---------------------------|-------------------|---|
| Analog Aux. Input A04 ‡   | 9             | A04 OIL TEMP                   |                           | Default Values with Warning Enabled: HI/LO warning are engine dependent | 30 sec. inhibit, 0 sec. delay warning |                           |                   | Not adjustable                                  |
| Analog Aux. Input A06 VSG (Volvo, GM, Doosan, and KDI only)   | 9, 12         | A06 ANALOG AUXILIARY IN        |                           |   |                                       |                           |                   | Analog VSG 06 for Speed Adjust in Menu 7        |
| Analog Aux. Input A07   | 9, 11         | A07 ANALOG VOLT ADJUST         |                           | ±10% of system voltage over the range of 0.5-4.5 VDC                    |                                       |                           |                   |   |
| Battery Charger Communication Error   |               | CHRG COMM ERROR                |                           |   |                                       |                           |                   | —   |
| Battery Charger Fault (see D01) **<br><b>Note:</b> On charger GM87448, Battery Charger Fault is communicated through CAN communication and D01 is not used.   |               | BATTERY CHRGR FAULT            |                           |   |                                       |                           |                   | —   |
| Battery Charger Value Mismatch Error  |               | CHGR VAL ERROR                 |                           |   |                                       |                           |                   | —   |
| Battle Switch (Fault Shutdown Override Switch)  | 9             | BATTLE SWITCH                  |                           | Fixed   |                                       |                           |                   | Not adjustable                                  |
| Block Heater Control ††   | 10            | BLOCK HEATER CONTROL           | RDO only                  |   |                                       |                           |                   |   |
| Breaker Trip §  | 10            | BREAKER TRIP                   | RDO-30                    |   |                                       |                           |                   | Not adjustable                                  |
| Charger Absorption Current Termination Target (A)   | 18            | ABSORPTION TERMINATION         |                           | 1 – 5   | 2                                     |                           |                   |   |
| Charger Automatic Equalize Enable<br><b>Note:</b> Equalize is only available with FLA/VRLA topology selected.   | 18            | AUTOMATIC EQUALIZE ENABLED     |                           | Active<br>Inactive  | Inactive                              |                           |                   |   |
| Charger Charge Cycles Between Auto Equalize Cycles<br><b>Note:</b> Equalize is only available with FLA/VRLA topology selected.  | 18            |                                |                           | 0 – 99  |                                       |                           |                   | Adjustable with Charger Custom Profile enabled. |
| Charger Custom Profile Enable   | 18            | CUSTOM CHARGING PROFILE ENABLE |                           | Active<br>Inactive  | Inactive                              |                           |                   |   |
| Charger Depleted Battery Current Limit  | 18            |                                |                           | 1 – 5   | 2                                     |                           |                   |   |
| Charger Depleted Battery Voltage Target   | 18            |                                |                           | 4 – 12 (12 V)<br>18 – 24 (24 V)   | 10 (12 V)<br>20 (24 V)                |                           |                   | Adjustable with Charger Custom Profile enabled. |
| * All models, except Waukesha-powered models.<br>† Non-paralleling applications<br>‡ Waukesha-powered models<br>§ Paralleling applications<br>   Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual. |               |                                |                           | ** NFPA applications<br>†† DDC/MTU engine with MDEC/ADEC<br>‡‡ FAA only |                                       |                           |                   |   |



| Status Event or Fault  | Refer to Menu | Digital Display                | Relay Driver Output (RDO) | Range Setting   | Default Selection                 | Inhibit Time Delay (sec.) | Time Delay (sec.) | User-Defined Settings                           |
|--|---------------|--------------------------------|---------------------------|---|-----------------------------------|---------------------------|-------------------|---|
| Charger Temperature Compensation Slope (mV/°C)   | 18            | TEMPERATURE COMP SLOPE         |                           | -40 – 0<br>(12 V)<br>-80 – 0<br>(24 V)  | -30<br>(12 V)<br>-60<br>(24 V)    |                           |                   | Adjustable with Charger Custom Profile enabled. |
| Charger Voltage Absorption (V)   | 18            | ABSORPTION VOLTAGE             |                           | 13 – 15<br>(12 V)¶<br>26 – 30<br>(24 V)¶  | 14.25<br>(12 V)<br>28.5<br>(24 V) |                           |                   | Adjustable with Charger Custom Profile enabled. |
| Charger Voltage Bulk (V)   | 18            | BULK VOLTAGE                   |                           | 13 – 15<br>(12 V)¶<br>26 – 30<br>(24 V)¶  | 14.25<br>(12 V)<br>28.5<br>(24 V) |                           |                   | Adjustable with Charger Custom Profile enabled. |
| Charger Voltage Equalize (V)<br><b>Note:</b> Equalize is only available with FLA/VRLA topology selected. | 18            | EQUALIZE VOLTAGE               |                           | 14 – 16<br>(12 V)<br>28 – 32<br>(24 V)  |                                   |                           |                   | Adjustable with Charger Custom Profile enabled. |
| Charger Voltage Float (V)  | 18            | FLOAT VOLTAGE                  |                           | 13 – 14<br>(12 V)¶<br>26 – 28<br>(24 V)¶  | 13.25<br>(12 V)<br>26.5<br>(24 V) |                           |                   | Adjustable with Charger Custom Profile enabled. |
| Common Protective Relay Output §   | 10            | COMMON PROTECTIVE RELAY OUTPUT | RDO-31 §                  |   |                                   |                           |                   | Not adjustable                                  |
| Critical Overvoltage Shutdown  | 10            | CRITICAL OVERVOLTAGE           |                           | Fixed   | 275 volts (L1-L2)                 |                           |                   | Not adjustable                                  |
| Cyclic Cranking  | 8             |                                |                           | 1–6 crank cycles<br>10–30 sec. crank on<br>1–60 sec. pause  | 3<br>15 sec.<br>15 sec.           |                           |                   |   |
| Defined Common Faults (each input value is set separately)   | 10            | DEFINED COMMON FAULT           | RDO-18 (lead 32A)         | Default shutdowns include:<br>Emergency stop<br>High coolant temp<br>Low oil pressure<br>Overcrank<br>Overspeed | 30 sec. inhibit,<br>5 sec. delay  | 0–60                      | 0–60              |   |
| Detonation Shutdown (see D13) ‡  |               |                                |                           |   |                                   |                           |                   | —   |
| Detonation Warning (see D12) ‡   |               |                                |                           |   |                                   |                           |                   | —   |
| Digital Aux. Input D01–D21   | 9, 10         | USER-DEFINED D01–D21           |                           |   | 30 sec. inhibit,<br>5 sec. delay  | 0–60                      | 0–60              |   |
| Digital Aux. Input D01 Battery Charger Fault **  | 9, 10         | D01 BATTERY CHARGER FAULT      | RDO-11 (lead 61)          | Fixed   | 0 sec. inhibit,<br>0 sec. delay   |                           |                   | Not adjustable                                  |
| Digital Aux. Input D02 Low Fuel Warning **   | 9, 10         | D02 LOW FUEL WARNING           | RDO-08 (lead 63)          | Fixed   | 0 sec. inhibit,<br>0 sec. delay   |                           |                   | Not adjustable                                  |
| Digital Aux. Input D03 Low Coolant Temperature **  | 9, 10         | D03 LOW COOLANT TEMP           | RDO-05 (lead 35)          | Fixed   | 0 sec. inhibit,<br>0 sec. delay   |                           |                   | Not adjustable                                  |
| Digital Aux. Input D04 Field Overvoltage (M4, M5, or M7 alternator only)                                 | 9, 10         | D04 FIELD OVERVOLTAGE          |                           | Fixed   | 1 sec. inhibit,<br>15 sec. delay  |                           |                   | Not adjustable                                  |

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† Non-paralleling applications      †† DDC/MTU engine with MDEC/ADEC  
‡ Waukesha-powered models      ‡‡ FAA only  
§ Paralleling applications  
¶ Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual.

| Status Event or Fault   | Refer to Menu | Digital Display       | Relay Driver Output (RDO) | Range Setting      | Default Selection             | Inhibit Time Delay (sec.) | Time Delay (sec.)          | User-Defined Settings |
|---|---------------|-----------------------|---------------------------|--------------------|-------------------------------|---------------------------|----------------------------|-----------------------|
| Digital Aux. Input D05 Breaker Closed §                           | 9, 10         | D05 BREAKER CLOSED    |                           | Fixed              | 0 sec. inhibit, 0 sec. delay  |                           |                            | Not adjustable        |
| Digital Aux. Input D06 §  | 9, 10         | D06 ENABLE SYNCH      |                           |                    | 20 sec. inhibit, 0 sec. delay |                           |                            | Not adjustable        |
| Digital Aux. Input D09 Low Fuel Pressure Shutdown (125RZG only)   | 9, 10         | D09 LOW FUEL SHUTDOWN |                           | Fixed              | 5 sec. inhibit, 0 sec. delay  |                           |                            | Not adjustable        |
| Digital Aux. Input D11 Air/Fuel Module (AFM) Shutdown ‡           | 9, 10         | D11 AFM SHUTDOWN      |                           | Fixed              | 0 sec. inhibit, 0 sec. delay  |                           |                            | Not adjustable        |
| Digital Aux. Input D12 Detonation Warning ‡                       | 9, 10         | D12 DETON WARNING     |                           | Fixed              | 2 sec. inhibit, 0 sec. delay  |                           |                            | Not adjustable        |
| Digital Aux. Input D13 Detonation Sensing Module (DSM) Shutdown ‡ | 9, 10         | D13 DETON SHUTDOWN    |                           | Fixed              | 0 sec. inhibit, 0 sec. delay  |                           |                            | Not adjustable        |
| Digital Aux. Input D13 Knock Detection Module (KDM) Shutdown ‡    | 9, 10         | D13 KNOCK SHUTDOWN    |                           | Fixed              | 0 sec. inhibit, 0 sec. delay  |                           |                            | Not adjustable        |
| Digital Aux. Input D14 Low Coolant Level, (with LCL switch) **    | 9, 10         | D14 LOW COOLANT LVL   | RDO-19                    | Fixed              | 30 sec. inhibit, 5 sec. delay |                           |                            | Not adjustable        |
| Digital Aux. Input D15 Remote Shutdown                            | 9, 10         | D15 REMOTE SHUTDOWN   |                           |                    | 0 sec. inhibit, 0 sec. delay  |                           |                            | Not adjustable        |
| Digital Aux. Input D16 Remote Reset                               | 9, 10         |                       |                           |                    |                               |                           |                            | Not adjustable        |
| Digital Aux. Input D17 VAR/PF mode                                | 9, 10         |                       |                           |                    |                               |                           |                            | Not adjustable        |
| Digital Aux. Input D18 Voltage Lower                              | 9, 10         |                       |                           |                    |                               |                           |                            | Not adjustable        |
| Digital Aux. Input D19 Voltage Raise                              | 9, 10         |                       |                           |                    |                               |                           |                            | Not adjustable        |
| Digital Aux. Input D20 Air Damper Indicator (if used) **          | 9, 10         | D20 AIR DAMPER        | RDO-23 * (lead 56)        | Fixed              | 0 sec. inhibit, 0 sec. delay  |                           |                            | Not adjustable        |
| Digital Aux. Input D21 Idle (speed) Mode Function                 | 9, 10         | D21 IDLE MODE ACTIVE  | RDO-21                    | Fixed inhibit time | 0 sec. inhibit, 60 sec. delay |                           | 0-600 or 9:99 for infinity | Not adjustable        |
| ECM Red Alarm (was MDEC Yellow Alarm) ††                          | 10            | ECM RED ALARM         |                           |                    |                               |                           |                            | Not adjustable        |
| ECM Yellow Alarm (was MDEC Yellow Alarm) ††                       | 10            | ECM YELLOW ALARM      |                           |                    |                               |                           |                            | Not adjustable        |
| EEPROM Write Failure  | 10            | EEPROM WRITE FAILURE  |                           |                    |                               |                           |                            | Not adjustable        |
| Emergency Stop Shutdown   | 10            | EMERGENCY STOP        | RDO-14 (lead 48)          |                    |                               |                           |                            | Not adjustable        |
| Engine Cooldown (see Time Delay-)                                 |               |                       |                           |                    |                               |                           |                            | —                     |

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† Non-paralleling applications

‡ Waukesha-powered models

§ Paralleling applications

\*\* NFPA applications

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‡‡ FAA only

|| Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual.

| Status Event or Fault  | Refer to Menu | Digital Display       | Relay Driver Output (RDO) | Range Setting                        | Default Selection          | Inhibit Time Delay (sec.) | Time Delay (sec.) | User-Defined Settings                           |
|--|---------------|-----------------------|---------------------------|--------------------------------------|----------------------------|---------------------------|-------------------|---|
| Engine Derate Active   | 10            | ENGINE DERATE ACTIVE  |                           |                                      |                            |                           |                   | Not adjustable                                  |
| (Engine) J1939 CAN Engine Shutdown   | 10            | J1939 CAN SHUTDOWN    |                           |                                      |                            |                           |                   | Not adjustable                                  |
| Engine Stalled   | 10            | ENGINE STALLED        |                           |                                      |                            |                           |                   | Not adjustable                                  |
| Engine Start (see Time Delay-)   |               |                       |                           |                                      |                            |                           |                   | —   |
| EPS (Emergency Power System) Supplying Load  | 10            | EPS SUPPLYING LOAD    | RDO-22                    | Fixed                                | 1% of rated line current   |                           |                   | Not adjustable                                  |
| Equalize Current Limit (A)<br><b>Note:</b> Equalize is only available with FLA/VRLA topology selected. | 18            |                       |                           | 1–5                                  |                            |                           |                   | Adjustable with Charger Custom Profile enabled. |
| Field Overvoltage (see D04)  |               |                       |                           |                                      |                            |                           |                   | Not adjustable                                  |
| Forced Charge Cycle Reset  | 18            |                       |                           | Active<br>Inactive                   | Inactive                   |                           |                   |   |
| Fuel Level (see A04)   |               |                       |                           |                                      |                            |                           |                   | —   |
| Fuel Valve Relay ‡   | 10            | FUEL VALVE RELAY      | RDO-23 ‡                  |                                      |                            |                           |                   | Not adjustable                                  |
| Generator Set Running  | 10            |                       | RDO-15 (lead 70R)         |                                      |                            |                           |                   | Not adjustable                                  |
| Ground Fault Detected  | 10            | GROUND FAULT          |                           |                                      |                            |                           |                   | Not adjustable                                  |
| High Battery Voltage   | 10            | HIGH BATTERY VOLTAGE  | RDO-13                    | 14.5–16.5 V (12 V)<br>29–33 V (24 V) | 16 V (12 V)<br>32 V (24 V) |                           | 10                |   |
| High Coolant Temperature Shutdown  | 10            | HI COOL TEMP SHUTDOWN | RDO-03 (lead 36)          |                                      |                            | 30                        | 5                 | Not adjustable                                  |
| High Coolant Temperature Warning   | 10            | HI COOL TEMP WARNING  | RDO-06 (lead 40)          |                                      |                            | 30                        |                   | Not adjustable                                  |
| High Oil Temperature Shutdown  | 10            | HI OIL TEMP SHUTDOWN  |                           |                                      |                            | 30                        | 5                 | Not adjustable                                  |
| High Oil Temperature Warning ‡ ††  | 10            | HI OIL TEMP WARNING   |                           |                                      |                            | 30                        |                   | Not adjustable                                  |
| Idle (speed) Mode Function (see D21)   |               |                       |                           |                                      |                            |                           |                   | —   |
| In Synch §   | 10            | IN SYNCH              | RDO-29 *                  |                                      |                            |                           |                   | Not adjustable                                  |
| Intake Air Temperature Shutdown ††   | 10            | INTAKE AIR TEMP SDWN  |                           |                                      |                            | 30                        |                   | Not adjustable                                  |
| Intake Air Temp. Warning ††  | 10            | INTAKE AIR TEMP WARN  |                           |                                      |                            | 30                        |                   | Not adjustable                                  |
| Intake Air Temp. Warning (see A03) ‡   |               |                       |                           |                                      |                            |                           |                   | —   |
| Intake Air Temp. Shutdown (see A03)‡   |               |                       |                           |                                      |                            |                           |                   | —   |
| Internal Fault Shutdown  | 10            | INTERNAL FAULT        |                           |                                      |                            |                           |                   | Not adjustable                                  |

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\*\* NFPA applications

†† DDC/MTU engine with MDEC/ADEC

‡‡ FAA only

| Status Event or Fault  | Refer to Menu | Digital Display            | Relay Driver Output (RDO) | Range Setting                      | Default Selection                   | Inhibit Time Delay (sec.) | Time Delay (sec.) | User-Defined Settings |
|--|---------------|----------------------------|---------------------------|------------------------------------|-------------------------------------|---------------------------|-------------------|-----------------------|
| J1939 CAN Shutdown (see Engine J1939 CAN Shutdown)                         |               |                            |                           |                                    |                                     |                           |                   | —                     |
| Knock Shutdown (see D13) ‡   |               |                            |                           |                                    |                                     |                           |                   | —                     |
| kW Overload (see Load Shed)  |               |                            |                           |                                    |                                     |                           |                   | —                     |
| Load Shed kW Overload ‡‡   | 10            | LOAD SHED KW OVER          | RDO-30 ‡‡                 | 80%–120%                           | 100% of kW rating with 5 sec. delay |                           | 2–10              |                       |
| Load Shed Over Temperature †† (Activated by a High Coolant Temp. shutdown) | 10            | LOAD SHED OVER TEMPERATURE | RDO only                  |                                    |                                     |                           |                   | Not adjustable        |
| Load Shed Underfrequency †   | 10            | LOAD SHED UNDER FREQUENCY  | RDO-31 †                  |                                    | 59 Hz (60 Hz)<br>49 Hz (50 Hz)      |                           | 5                 | Not adjustable        |
| Locked Rotor Shutdown  | 10            | LOCKED ROTOR               |                           |                                    |                                     |                           |                   | Not adjustable        |
| Loss of ECM Communication (ECM only)                                       | 10            | LOSS OF ECM COMM           | RDO-26 *                  |                                    |                                     |                           | 4                 | Not adjustable        |
| Loss of Field Shutdown §   | 10            | SD LOSS OF FIELD           |                           |                                    |                                     |                           |                   | Not adjustable        |
| Low Battery Voltage  | 10            | LOW BATTERY VOLTAGE        | RDO-12 (lead 62)          | 10–12.5 V (12 V)<br>20–25 V (24 V) | 12 V (12 V)<br>24 V (24 V)          | 0                         | 10                |                       |
| Low Coolant Level (see D14) (with LCL switch) **                           |               |                            |                           |                                    |                                     |                           |                   | —                     |
| Low Coolant Temperature (see D03) **                                       |               |                            |                           |                                    |                                     |                           |                   | —                     |
| Low Coolant Temperature Shutdown ††  | 10            | LOW COOLANT TEMP SHUTDOWN  |                           |                                    |                                     |                           |                   | Not adjustable        |
| Low Fuel (Level or Pressure) Warning (see D02) **                          |               |                            |                           |                                    |                                     |                           |                   | —                     |
| Low Fuel Pressure Shutdown (see D09) (125RZG only)                         |               |                            |                           |                                    |                                     |                           |                   | —                     |
| (Low) Oil Pressure Shutdown  | 10            | OIL PRESSURE SHUTDOWN      | RDO-04 (lead 38)          |                                    |                                     | 30                        | 5                 | Not adjustable        |
| (Low) Oil Pressure Warning   | 10            | OIL PRESSURE WARNING       | RDO-07 (lead 41)          |                                    |                                     | 30                        |                   | Not adjustable        |
| Maintenance Due  | 10            | MAINTENANCE DUE            |                           |                                    |                                     |                           |                   | Not adjustable        |
| Master Not In Auto (Generator Set Switch)                                  | 10            | MASTER NOT IN AUTO         | RDO-09 (lead 80)          |                                    |                                     |                           |                   | Not adjustable        |
| Master Switch Error  | 10            | MASTER SWITCH ERROR        |                           |                                    |                                     |                           |                   | Not adjustable        |

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\*\* NFPA applications

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‡ Waukesha-powered models

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| Status Event or Fault                          | Refer to Menu | Digital Display        | Relay Driver Output (RDO) | Range Setting                        | Default Selection                                       | Inhibit Time Delay (sec.) | Time Delay (sec.) | User-Defined Settings |
|--|---------------|------------------------|---------------------------|--------------------------------------|---|---------------------------|-------------------|-----------------------|
| Master Switch to Off                           | 10            | MASTER SWITCH TO OFF   |                           |                                      |   |                           |                   | Not adjustable        |
| Master Switch Open                             | 10            | MASTER SWITCH OPEN     |                           |                                      |   |                           |                   | Not adjustable        |
| NFPA 110 Fault **                              | 10            | NFPA 110 FAULT         | RDO-10 (lead 32)          |                                      |   |                           |                   | Not adjustable        |
| No Air Temperature Signal Warning ‡            | 10            | NO AIR TEMP SIGNAL     |                           |                                      |   | 30                        | 4                 | Not adjustable        |
| No Coolant Temperature Signal                  | 10            | NO COOL TEMP SIGNAL    |                           |                                      |   | 30                        | 4                 | Not adjustable        |
| No Oil Pressure Signal                         | 10            | NO OIL PRESSURE SIGNAL |                           |                                      |   | 30                        | 4                 | Not adjustable        |
| No Oil Temperature Signal Warning ‡            | 10            | NO OIL TEMP SIGNAL     |                           |                                      |   | 30                        | 4                 | Not adjustable        |
| Output Enable                                  | 18            |                        |                           | Fixed                                | Active  |                           |                   | Not adjustable        |
| Overcrank Shutdown                             | 8, 10         | OVER CRANK             | RDO-02 (lead 12)          | 0-6 Cycles                           | 3 Cycles  |                           |                   |                       |
| Overcurrent                                    | 10            | OVER CURRENT           |                           |                                      | 110%  |                           | 10                | Not adjustable        |
| Over Current VR (voltage restraint) Shutdown § | 10            | SD OVER CURRENT VR     |                           |                                      |   |                           |                   | Not adjustable        |
| Overfrequency Shutdown                         | 7, 10         | OVER FREQUENCY         | RDO-28                    | 102%-140%                            | 110% Std.<br>103% FAA                                   |                           | 10                |                       |
| Over Power Shutdown §                          | 10            | SD OVER POWER          |                           |                                      | 102% Stdby<br>112% Prime                                |                           |                   | Not adjustable        |
| Overspeed Shutdown                             | 7, 10         | OVER SPEED             | RDO-01 (lead 39)          | 65-70 Hz (60 Hz)<br>55-70 Hz (50 Hz) | 70 (60 Hz)<br>70 (50 Hz)                                |                           | 0.25              |                       |
| Overvoltage Shutdown                           | 7, 8, 10      | OVER VOLTAGE           | RDO-20 (lead 26)          | 105%-135% of nominal                 | 115%<br>2-sec time delay†<br>135%<br>10-sec time delay§ |                           | 2-10              |                       |
| Password (see Access Code)                     |               |                        |                           |                                      |   |                           |                   | —                     |
| Pre Lube Relay ‡                               | 10            | PRE LUBE RELAY         | RDO-26 ‡                  |                                      |   |                           | 4                 | Not adjustable        |
| Remote Reset (see D16)                         |               |                        |                           |                                      |   |                           |                   | —                     |
| Remote Shutdown (see D15)                      |               |                        |                           |                                      |   |                           |                   | —                     |
| Reverse Power Shutdown §                       | 10            | SD REVERSE POWER       |                           |                                      |   |                           |                   | Not adjustable        |
| Speed Sensor Fault                             | 10            | SPEED SENSOR FAULT     | RDO-24                    |                                      |   |                           |                   | Not adjustable        |
| Starting Aid (see Time Delay Starting Aid)     |               |                        |                           |                                      |   |                           |                   | —                     |
| System Ready                                   | 10            |                        | RDO-17 (lead 60)          |                                      |   |                           |                   | Not adjustable        |

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‡ Waukesha-powered models

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\*\* NFPA applications

†† DDC/MTU engine with MDEC/ADEC

‡‡ FAA only

| Status Event or Fault                               | Refer to Menu | Digital Display     | Relay Driver Output (RDO) | Range Setting       | Default Selection  | Inhibit Time Delay (sec.) | Time Delay (sec.) | User-Defined Settings |
|---|---------------|---------------------|---------------------------|---------------------|--|---------------------------|-------------------|-----------------------|
| Time Delay Engine Cooldown (TDEC)                   | 8, 10         | DELAY ENG COOLDOWN  | RDO-16 (lead 70C)         | 00:00-10:00 min:sec | 5:00   |                           |                   |                       |
| Time Delay Engine Start (TDES)                      | 8, 10         | DELAY ENG START     |                           | 00:00-5:00 min:sec  | 00:01  |                           |                   |                       |
| Time Delay Starting Aid                             | 8, 10         |                     |                           | 0-10 sec.           |  |                           |                   |                       |
| Turbocharger Temperature Shutdown (1750/2000REOZMD) | 10            | TURBO TEMP SHUTDOWN |                           |                     |  | 30                        |                   | Not adjustable        |
| Turbocharger Temperature Warning (1750/2000REOZMD)  | 10            | TURBO TEMP WARNING  |                           |                     |  | 30                        |                   | Not adjustable        |
| Underfrequency                                      | 7, 10         | UNDER FREQUENCY     | RDO-29 ‡                  | 80%-97%             | 97% FAA<br>90% †<br>80% §                                |                           | 10                |                       |
| Undervoltage Shutdown                               | 7, 8, 10      | UNDER VOLTAGE       | RDO-27                    | 70%-95%             | 85%<br>10-sec time delay †<br>70%<br>30-sec time delay § |                           | 5-30              |                       |
| Variable Speed Governor (VSG) (see A06)             |               |                     |                           |                     |  |                           |                   | —                     |
| VAR/PF Mode (see D17)                               |               |                     |                           |                     |  |                           |                   | —                     |
| Voltage Lower (see D18)                             |               |                     |                           |                     |  |                           |                   | —                     |
| Voltage Raise (see D19)                             |               |                     |                           |                     |  |                           |                   | —                     |
| Weak Battery  | 10            | WEAK BATTERY        |                           |                     | 60% of nominal   |                           | 2                 |                       |

\* All models, except Waukesha-powered models.

† Non-paralleling applications

‡ Waukesha-powered models

§ Paralleling applications

|| Denotes the default parameter range. Typically, ranges for the NiCad battery topology are slightly wider. For more details, refer to the battery charger operation manual.

\*\* NFPA applications

†† DDC/MTU engine with MDEC/ADEC

‡‡ FAA only

# Notes

# Appendix C Voltage Regulator Definitions and Adjustments

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The following definitions and adjustment/setting specifications are intended for users planning to adjust the voltage regulator beyond the default settings in order to customize the alternator for a specific application.

This information is not intended to be a comprehensive explanation of all the terms mentioned. There are numerous documents available that define these terms more completely than described herein. Any user planning to change the generator set controller adjustment settings or to apply the generator set to these types of applications should understand these terms.

This appendix contains references to other sections of this manual. Please refer to these sections for further information and explanation.

Paralleling generator sets can be a complicated and dangerous exercise. Application programming must be performed by appropriately skilled and suitably-trained personnel.

## Definitions

### Underfrequency Unloading

Underfrequency unloading is a function used in the alternator excitation control system to improve the overall generator set system (engine and alternator) response. In particular, underfrequency unloading relates to large-block load applications. When applied to engine-driven alternators, large-block loads cause a subsequent transient torque load on the engine. This torque load can reduce the engine's speed below the normal operating point. Typically, the engine speed controller or governor will compensate for this by commanding an increase in fuel. If, however, the fuel system is inadequate to recover from a relatively large load, the speed may never recover. In these instances, other measures must be taken. This is where the underfrequency unloading occurs.

When the excitation control system detects a drop in the speed or electrical frequency below some predetermined point, the control system enters an unloading condition. This can be described as moving to a lower voltage regulation point. By reducing the output voltage of the alternator, the load on the generator set is reduced. This can be shown

mathematically by Ohm's law, which states that power is equal to the voltage squared divided by the impedance. As the voltage is reduced, the power delivered by the alternator decreases by a squared relationship. Since it is the power in the alternator that translates into engine torque, the engine load is also reduced.

By changing various parameters of this compensation technique, the controlling system can be tailored to match the performance capabilities of most engine and alternator combinations. The point at which the unloading begins to act or how much unloading occurs can be adjusted to impact maximum voltage droop, maximum speed droop, or time to recover. Some applications may not need unloading and, in these cases, set the unloading parameter to disable the function. These parameters are further described below. An example is provided to help clarify the relationship between these parameters.

### Underfrequency Unload Slope

Underfrequency unload slope is the term used to describe the amount that the voltage is reduced, per-cycle-per-second or per-hertz (Hz), when in an underfrequency condition. The slope or schedule is sometimes called the volts-per-hertz slope. When the electrical frequency drops below the cut-in point (see below), the excitation control system temporarily reduces the regulated voltage to reduce the subsequent torque on the engine. The amount that the control system reduces voltage is defined as the product or multiplication of the slope and the amount of frequency or speed below the cut-in point. For every Hz below the cut-in point, the control system reduces the line-to-line voltage by an amount equal to the slope.

Because each engine responds differently to the various loads encountered, the slope may be adjusted to improve the system response. If, when large loads are applied to the generator set, the engine speed drops below the acceptable limit (as determined by the particular loads applied), the slope may need to be increased. Increasing the slope will cause the voltage to droop more during load applications, consequently reducing the load torque on the engine and allowing the speed to increase. If, however, the voltage drops below an acceptable lower limit (as determined by the particular loads connected to the generator set), a lower slope may work better. The underfrequency unloading function may be disabled by setting the slope to zero.

## Frequency Setpoint or Cut-In Point

The point at which the underfrequency unloading begins to take effect is adjustable, allowing the system to be tailored for each application. Because the characteristics of the engine have the largest effect on the system's performance, the engine's response should determine the unloading point. The unloading setpoint is the frequency below which the excitation control will reduce the voltage so that the engine may begin to recover.

The cut-in point, or frequency setpoint, should be set 0.5–3.0 Hz lower than the normal steady-state band of operation. If the engine normally operates within a very narrow range of speeds close to the nominal, a setpoint of 0.5 to 1.0 Hz below nominal should be suitable. If the engine normally operates over a wide range of speeds, the setpoint may need to be 2.0–3.0 Hz from the nominal. The underfrequency unloading function can be eliminated by setting the cut-in point below the minimum expected operating frequency.

### Example

A 90 kW load is applied to a 100 kW, 60 Hz generator set driven by a turbocharged diesel engine with an electrical control module (ECM). The speed drops 10% and takes 20 seconds to recover to at least 59.5 Hz. The voltage, meanwhile, drops from 480 to 460 and recovers to 480 within 15 seconds. Therefore, some underfrequency unloading should be provided. A good starting point would be a frequency setpoint or cut-in of 59 Hz. A slope of 15 volts per-cycle-per-second is appropriate as well. If after these adjustments the speed recovers very quickly, in about 5 seconds, but the voltage drops below 440 volts, the slope should be reduced to 12 volts per cycle. More adjusting may be required to get the most desirable compromise between speed and voltage.

## Three-Phase Sensing

Three-phase sensing describes how the excitation control or voltage regulator determines the condition of the alternator output voltage. Early types of regulators sensed the voltage on just one phase of the alternator. Single-phase sensing is not uncommon today as most

alternators are designed to produce balanced, equal voltage on all three phases. If the loads applied to the generator set including no load are equal and balanced, the output voltage on each phase will be nearly equal.

However, in some applications, individual phases may have unequal or unbalanced loads. In these cases, the output voltages will not be equal on each phase. In general, the phase with the greatest load will have the lowest voltage while the phase with the least load will have the highest voltage. This is true regardless of the type of sensing used in the regulator system. A single-phase sensing excitation controller will keep the voltage of the sensed phase at the voltage adjustment value. A three-phase sensing system will average the three phases and hold the average to the adjustment setting. The average is the sum of the voltages of three phases divided by 3.

As stated above, three-phase sensing does not eliminate the unequal voltage phenomenon. Three-phase sensing balances the inequality of voltage between the phases to the desired value. In other words, if a system with unbalanced loads uses a single-phase control feedback, the voltage on the sensed phase would be at the setpoint while the other two phases would vary by their proportional loads. For example, if the sensed phase had rated load while the two other phases were only loaded at half the rated value, those two phases would have higher-than-rated voltage which may be undesirable. If a three-phase sensing feedback were utilized, the phase with rated load would be regulated to a voltage slightly below the rated voltage while the other two phases would be slightly above the rated voltage (but lower than in the previous case). The sum of the three, divided by 3, would be equal to the regulation setpoint.

In a single-phase system, line-to-line voltage is held equal to the line-to-line voltage adjust setting. In a three-phase system, the average of the three line-to-line voltage is regulated to the voltage adjust setting. In some cases, it may be desirable to keep one phase at a particular value. Modify the voltage adjust setting higher or lower accordingly for any unique requirements for the particular application. Each of the individual phase voltages is available in Menu 11, Voltage Regulator.

## Reactive Droop

Reactive droop refers to another compensation technique used in excitation control systems. Reactive droop means that the generator set voltage droops with increasing reactive current. Although this sounds like an undesirable effect, it is quite beneficial in paralleling applications with multiple generator sets. Because the terminals of the generator set are connected to another generator set(s), the voltage at the terminals is not solely determined by either generator set's excitation. Rather, it is determined by the combination of the excitation level, the generated voltage, and the voltage drop across the armature impedance or armature reactance for each generator set.

Normally the generated voltage is higher than the voltage at the terminals because the generator set current causes a drop across the armature impedance. In a parallel application, the generated voltage of one generator set may be slightly higher than the generated voltage of another generator set. Differences in potential between the generator sets will cause current to flow into the lower voltage generator set and will also cause the generator sets to share the load current disproportionately. Both results are undesirable.

By introducing reactive droop, the reactive current can be better predicted and controlled. If the current is measured, the regulator/controller can adjust the excitation up or down accordingly, reducing excitation as more current is supplied or increasing excitation as the reactive current decreases. If all the parallel generator sets incorporate this type of compensation, the reactive current can be shared equally based on the proportional size of the generator sets. For an example, see below.

The stability and accuracy of this technique depends on several factors. Most important, the regulation point for each generator set must be equal. That is, each voltage adjust setting must be the equal to the other(s). This is a basic requirement prior to the actual paralleling connection. Also, the effects of the reactive current in each generator set must be compensated for individually, which requires an adjustable droop for each generator set. This adjustment happens to be the reactive droop adjust. The reactive droop adjust is quantified as the droop in operating voltage from the adjusted setting when full rated load with 0.8 power factor (PF) is applied. A droop setting of 4% voltage at full rated load is a recommended starting point. If the reactive current is not shared proportionately in each generator set, the respective droops may need adjustment. Adjust those generator sets that have proportionately higher current for more droop and those generator sets with lower reactive current for less

droop. If the reactive current is not stable in the system, adjust the droop lower in all generator sets.

As implied above, the reactive droop is not usually necessary in stand-alone applications. Therefore, some means of disabling the feature is provided. If the generator set will not be paralleled with other generator sets, the reactive droop feature should be disabled. A reactive droop setting of 0 will also effectively disable the reactive droop feature. It should be noted that reactive droop applies strictly to the reactive current or volt-ampere-reactive (VAR) loading. Primarily, the fueling or speed governing system controls the real current which contributes to watts loading.

The gain of the reactive droop function is determined by the voltage droop setting. For most applications, a droop of 3%–5% of rated voltage at rated load at 0.8 PF is adequate. Prior to actually connecting the generator sets in parallel, test the droop by applying full rated load at 0.8 PF. The system is operating correctly if this test shows a reduction in voltage equal to the voltage droop setting. If the available load is less than full load, the correct voltage droop should be proportional to the applied VAR load as a fraction of the rated VAR output for the generator set. For instance, a 480-volt generator set with a voltage droop setting of 4% should drop 19.2 volts with full rated (0.8 PF) load applied ( $480 \times 0.04$ ) or 9.6 volts with half the rated load applied ( $480 \times 0.04 / 2$ ).

When a generator set will be connected in parallel with the utility, VAR or PF control should be ENABLED. If there are multiple generator sets in parallel as well, then reactive droop should be ENABLED also.

### Example

Two 100 kilowatt (kW) generator sets are paralleled to provide 150 kW of power at 0.8 PF and wired for a 277/480-volt wye system.

#### Total kVA load:

$$\text{kVA} = \text{kW} / \text{PF}$$

$$187.5 = 150 / 0.8$$

#### KVAR load:

$$\text{kVAR} = \text{kVA} * \sin(\arccos[\text{PF}])$$

$$112.5 = 187.5 * 0.6$$

#### Line current:

$$I = (\text{VA} / 3) / V_{L-N}$$

$$226 \text{ amps} = (187500 / 3) / 277$$

## Reactive current:

$$I = (\text{VAR} / 3) / V_{L-N}$$

$$135 \text{ amps} = (112500 / 3) / 277$$

**Where:**    acos is arccosine or inverse cosine  
          W is Watt  
          L-N is line-to-neutral  
          PF is power factor  
          VA is volt-ampere  
          k is kilo (= 1000)

Therefore, each generator set in this case should carry 113 amps per phase or half the 226 calculated line amps. The 113 amps includes 67.5 amps of reactive current, half of the calculated reactive current of 135 amps. The reactive droop should be adjusted until each generator set carries equal reactive current. The load sharing control should be adjusted so that real current and/or watts are shared equally as well.

If one generator set is larger than the other, it should be adjusted to carry proportionate current. For this example, if a 150 kW generator set is paralleled to a 75 kW generator set, the larger generator set would carry 90 amps reactive ( $135 * 2 / 3$ ) and the other would carry 45 amps reactive ( $135 * 1 / 3$ ). Adjust the reactive droop based on the ratio of the actual measured currents, not the calculated values.

## VAR Control

VAR control is analogous to the reactive droop function described above. It differs in that it applies to utility paralleling applications. Because the utility represents a nearly infinite bus, the voltage at the load terminals is not controlled at all by the generator set, and it is impossible to compare the ratio of the generator set current to the utility based on its rated output. In this situation, the excitation control changes from voltage feedback to VAR feedback. More specifically, the excitation is controlled to maintain a certain VAR output rather than a voltage output. This is called VAR control and again is used only in utility paralleling applications.

The VAR adjust can be set to any value within the generator set's rated capability. Because the VARs cause heating in the armature, any value beyond the generator set's rating could damage the alternator. In most cases, the generator set will be adjusted to generate VAR (lagging PF) but could absorb VARs (leading PF) as well. However, the VAR setting is maintained regardless of the relative PF. If the particular load requires more VARs than the generator set setting, the excess is derived from the utility bus.

The term *rated VARs* is a bit obscure. In essence, it is a value derived from the rated kW of the generator set. For a typical standby rating, the full load of the generator set is defined to have 0.8 PF. This means that the kW load is eight-tenths of the VA load. As described earlier, the PF for a linear load may be calculated as the cosine of the angle between voltage and current. This relationship is based on the power triangle. Using this power triangle concept, it can be shown that the reactive power for a linear load is equal to the sine of the power angle. Then, using these trigonometric functions, it can be shown that for a PF of 0.8, the VARs are related similarly to the VA by a factor of 0.6. More explicitly, the power angle is equal to the inverse cosine (arccosine) of the PF. For a PF of 0.8, the power angle is 36.9 degrees (0.2 radians). The sine of this angle, sine (36.9 degrees) is 0.6. This is the factor for calculating rated VARs from the rated VA. The ratio of these two factors is 0.75 ( $0.6 / 0.8$ ), which can be used to calculate rated VARs directly from the rated kW; rated VARs equals rated watts \* 0.75.

When a generator set will be connected in parallel with the utility, VAR or PF control should be ENABLED. If multiple generator sets are in parallel as well, then reactive droop should be ENABLED also. Additionally, note that VAR control should be used only when the generator set is connected in parallel with the utility. Parallel connection with the utility requires the logical indication that the circuit breakers tying the generator set bus to the utility bus are closed. This indication is made by use of the programmable digital input for VAR/PF mode. If this input function is activated, the excitation control changes to the selected VAR or PF control. If the logical indicator is not present and the VAR or PF control is not enabled, the control will not switch to VAR or PF control. Because the active state for the digital input is a HI or open connection, the default for the digital input (VAR/PF Mode) is DISABLED (displays ENABLED NO). If the input is ENABLED by the user, it should be held low by a contact or jumper until the actual closing of the connecting circuit breaker(s). The proper control method, VAR or PF, must be ENABLED within the regulator's configuration menu.

## Power Factor Control

PF control is much like the VAR control above. PF control is used only when the generator set is paralleled to the utility grid. The difference is that the PF of the generator set current is held constant. The setting for the PF adjust determines the relationship of the current and voltage from the generator set. The PF is a term that defines the ratio of real watts to the volt-ampere (VA) product. For linear loads, a trigonometric relationship can describe the PF. The PF equals the cosine of the

angle between the current and voltage. PF is further defined as leading or lagging. That is to say, if the current lags the voltage (i.e., is later in time), the PF is lagging; if the current leads the voltage (i.e., is earlier in time), the PF is leading. Inductive loads have lagging PF while capacitive loads have leading PF. The current in a purely resistive load is in phase with the voltage (not leading or lagging) and the PF is 1.0 (cos. [0]).

Set the PF adjust according to the requirements of the application. When a generator set will be connected in parallel with the utility, VAR or PF control should be ENABLED. If there are multiple generator sets in parallel as well, then reactive droop should be ENABLED also. Additionally, note that PF control should be used only while the generator set is connected in parallel with the utility. Parallel connection with the utility requires the logical indication that the circuit breakers tying the generator set bus to the utility bus are closed. This indication is made by use of the programmable digital input for VAR/PF mode. If this input function is activated, the excitation control changes to the selected VAR or PF control. If the logical indicator is not present and the VAR or PF control is not enabled, the control will not switch to VAR or PF control. Because the active state for the digital input is a HI or open connection, the default for the digital input (VAR/PF mode) is DISABLED (displays ENABLED NO). If the input is ENABLED by the user, it should be held low by a contact or jumper until the actual closing of the connecting circuit breaker(s). The proper control method, VAR or PF must be ENABLED within the regulator's configuration menu.

## Adjustment and Setting Specifications

### Voltage Adjust

The voltage adjust is entered as the rated or otherwise desired line-to-line voltage. The average of the line-to-line voltages is then regulated to the corresponding value as previously described. The setting may be as fine as tenths of volts. The voltage adjust defaults to the rated system voltage whenever the system voltage is changed. The voltage adjust may be set to any value within  $\pm 10\%$  of the system voltage. The upper limit is  $\pm 10\%$  above the system voltage and the lower limit is  $\pm 10\%$  below the system voltage. If a value beyond these limits is entered, a RANGE ERROR message will be displayed.

As a reference, the present voltage adjust setting is displayed as well as the average value of the line-to-line voltages. The individual line-to-line voltages are also displayed on the subsequent menu screens. This allows the user to monitor any individual phase, if desired.

The voltage adjust setting may be changed by means other than the menu including user-defined digital input or remote communications. If voltage adjustment occurs, the new value will be displayed accordingly in the voltage adjust menu.

### Underfrequency Unload Enable

The underfrequency unload enable menu is used to turn the underfrequency unload on or off. A YES entry will turn the feature on and the display will show ENABLED YES. A NO entry will turn the feature off and the display will show ENABLED NO. The underfrequency unload defaults to an enabled (ON) condition.

### Frequency Setpoint

The frequency setpoint is the cut-in point for underfrequency unloading. At any operating frequency below the frequency setpoint, the output voltage will be reduced. The frequency may be entered with resolution to tenths of a Hz. The range of acceptable entries is 30 to 70 Hz. Any entry beyond these limits causes a RANGE ERROR display and the setting will not change. The default value is one cycle-per-second (or two for non-ECM engines) below the normal system frequency. The frequency setpoint changes to the default value if the system frequency changes. A setting of 30 Hz essentially disables the underfrequency unload feature because most engines do not normally drop to speeds this low, even during load applications.

### Underfrequency Unload Slope

The slope determines how much voltage is reduced during an unloading condition. The line-to-line voltage is regulated to a value less than the voltage adjust setting by this amount for every cycle below the frequency setpoint. The voltage may be entered with resolution as fine as one-tenth of one volt. The default value is 2.0 volts per-cycle-per-second. A zero entry for the slope in effect turns the underfrequency unload feature off.



## Reactive Droop Enable

This menu allows the user to enable the reactive droop feature. A YES entry turns the feature on and the display shows ENABLED YES. A NO entry turns the feature off and the display shows ENABLED NO. Reactive droop is intended to be used in a generator set-to-generator set paralleling application.

## Voltage Droop

The amount of reactive droop is entered here. The droop is entered as a percentage of system voltage when a fully rated load at 0.8 PF is applied. The entry may be made with resolution as fine as one-tenth of one volt. This entry determines how much the voltage will droop when the alternator provides reactive current. The actual amount the voltage changes is equal to the voltage droop setting times the VAR load as a fraction of the rated VARs (at 0.8 PF). If the generator set were providing full rated load (at 0.8 PF), the expected voltage change would equal the voltage droop setting as a percentage of system voltage. A voltage droop setting of zero in effect disables the reactive droop feature. The default value is 4% droop at full rated load at 0.8 PF.

The present voltage droop setting is displayed for reference. The display may change if this value is changed via remote communication.

## VAR Control Enable

In order for the VAR control function to operate, it must be enabled. Entering YES at this menu will turn the feature on. Because the function is designed to operate while the generator set is in parallel with the utility, VAR control also requires the proper indication that all tying circuit breakers are closed. This is done through the user-programmable digital inputs.

Because VAR control cannot be enabled at the same time that PF control is enabled, turning VAR control on (ENABLED) when PF control is enabled turns the PF control off (DISABLED).

## KVAR Adjust

Using the kVAR adjust sets the desired operating value for the generator set's reactive load when the generator set operates in a utility paralleling application. The desired generator set load is entered directly as kVARs. The value entered may be as low as zero or as high as the rated value (rated kW x 0.75). Any entry beyond the rated value will not be accepted, and a RANGE ERROR message will be displayed.

The default value for kVAR adjust is zero. Each time the system's rated kW is changed, the kVAR adjust will revert to zero. The displayed kVAR setting may change if the kVAR setting is changed via other inputs.

## Generating/Absorbing

While operating in the VAR control mode, the reactive load on the generator set may be specified to be out of GENERATING or into ABSORBING the generator set. Specifying the VAR type or direction is done through the GENERATING/ABSORBING menu. Because the normal flow of reactive current is out of the generator set, the default value is GENERATING. If ABSORBING is desired, a NO entry at this menu will change the control mode to ABSORBING. When ABSORBING is selected, another NO entry will revert the control mode back to GENERATING. It is assumed that this mode will not be changed when the generator set is running. An attempt to change the mode while running will return a RANGE ERROR message. The generator set will need to be shut down in order to change this setting.

## PF Adjust

Use the PF adjust to set the desired operating relationship for the generator set's output voltage and current when the generator set is connected in parallel with the utility. The excitation is regulated to maintain a PF equal to the entered value. The value entered may be as low as 0.7 for leading PFs or as low as 0.6 for lagging PFs. Any entries below these limits will cause a RANGE ERROR message to display.

The upper limit for PF adjust is 1.0 and the default value is 0.8 lagging. Each time the system's rated kW is changed, the PF adjust will revert to this default value. The PF adjust display setting may change if the PF adjust is changed via other inputs.

## Lagging/Leading

It is possible to select either a leading or lagging PF for utility parallel applications. The selected mode is displayed. A NO entry switches the controller to use the other reference. Because the most common mode of operation will be with a lagging PF, LAGGING is the default value. Because this mode should not be changed while the generator set is running, attempting to change this mode during operation will return a RANGE ERROR message. Always shut down the generator set to change the lagging/leading mode setting.

## Appendix D Alternator Protection

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The 550 controller has built-in thermal protection for the alternator. This feature functions similarly to a thermal circuit breaker. When the output current exceeds the nominal rating for a short period of time the condition causes the fault shutdown. The amount of time at which current is over the rating is inversely related to the amount of current above the nominal rating. In other words, the higher the current, the shorter the acceptable time.

The current and time limits are defined by actual test data and are maintained in the personality parameter file. Although the equation for detecting a fault is proprietary, some of the important limits are shown below for informational purposes.

| Rated Current | Time Delay |
|---------------|------------|
| 200%          | 40 seconds |
| 300%          | 10 seconds |
| 425%          | 5 seconds  |
| 950%          | 1 second   |

# Notes

## Appendix E Inputs and System Events by Application

The controller inputs and system events are typically driven by the engine manufacturer's ECM. NFPA 110 guidelines provide specific requirements that all controllers must have for compliance. While the controller displays all NFPA 110 required data, some

engine ECMs provide additional items that the controller will display. The following table illustrates the available alternator and engine outputs for monitoring and factory reserved connections.

| Controller Inputs and System Events                          | NFPA 110 Applications | Paralleling Applications | DD/MTU Engines with MDEC/ADEC | Waukesha Engines | 125RZG |
|--|-----------------------|--------------------------|-------------------------------|------------------|--------|
| AC Sensing Loss Warning                                      |                       |                          |                               |                  |        |
| Air Damper Control (if engine equipped)                      | X                     |                          |                               |                  |        |
| Air Damper Indicator Shutdown (see D20) (if engine equipped) | X                     |                          |                               |                  |        |
| Air/Fuel Module Engine Start Delay                           |                       |                          |                               | X                |        |
| Air/Fuel Module Remote Start                                 |                       |                          |                               | X                |        |
| Air/Fuel Module Shutdown (see D11)                           |                       |                          |                               | X                |        |
| Alternator Protection Shutdown                               |                       |                          |                               |                  |        |
| Analog Aux. Input 0 Local Battery VDC                        |                       |                          |                               |                  |        |
| Analog Aux. Inputs A01-A07 (Warning or Shutdown)             |                       |                          |                               |                  |        |
| Analog Aux. Input A01 Coolant Temperature (non-ECM)          |                       |                          |                               |                  |        |
| Analog Aux. Input A02 Oil Pressure (non-ECM)                 |                       |                          |                               |                  |        |
| Analog Aux. Input A03 Intake Air Temperature                 |                       |                          |                               | X                |        |
| Analog Aux. Input A04 Fuel Level                             |                       |                          |                               |                  |        |
| Analog Aux. Input A04 Oil Temperature Warning                |                       |                          |                               | X                |        |
| Analog Aux. Input A06 VSG (Volvo, GM, Doosan only)           |                       |                          |                               |                  |        |
| Analog Aux. Input A07 Analog Volt Adjust                     |                       |                          |                               |                  |        |
| Battery Charger Communication Error                          |                       |                          |                               |                  |        |
| Battery Charger Fault Warning (see D01)                      | X                     |                          |                               |                  |        |
| Battery Charger Value Mismatch Error                         |                       |                          |                               |                  |        |
| Battle Switch Warning  |                       |                          |                               |                  |        |
| Block Heater Control   |                       |                          | X                             |                  |        |
| Breaker Closed Warning (see D05)                             |                       | X                        |                               |                  |        |
| Breaker Trip Warning   |                       | X                        |                               |                  |        |
| Common Protective Relay Warning                              |                       | X                        |                               |                  |        |
| Critical Overvoltage Shutdown                                |                       |                          |                               |                  |        |
| Cyclic Cranking  |                       |                          |                               |                  |        |
| Defined Common Faults (Warning or Shutdown)                  |                       |                          |                               |                  |        |
| Detonation Shutdown (see D13)                                |                       |                          |                               | X                |        |
| Detonation Warning (see D12)                                 |                       |                          |                               | X                |        |
| Digital Aux. Inputs D01-D21 (Warning or Shutdown)            |                       |                          |                               |                  |        |
| Digital Aux. Input D01 Battery Charger Fault Warning         | X                     |                          |                               |                  |        |
| Digital Aux. Input D02 Low Fuel (Level or Pressure) Warning  | X                     |                          |                               |                  |        |
| Digital Aux. Input D03 Low Coolant Temperature Warning       | X                     |                          |                               |                  |        |
| Digital Aux. Input D04 Field Overvoltage Shutdown            |                       |                          |                               |                  |        |
| Digital Aux. Input D05 Breaker Closed Warning                |                       | X                        |                               |                  |        |
| Digital Aux. Input D06 Enable Synch                          |                       | X                        |                               |                  |        |
| Digital Aux. Input D09 Low Fuel Pressure Shutdown            |                       |                          |                               |                  | X      |
| Digital Aux. Input D11 Air/Fuel Module (AFM) Shutdown        |                       |                          |                               | X                |        |
| Digital Aux. Input D12 Detonation Warning                    |                       |                          |                               | X                |        |
| Digital Aux. Input D13 Detonation Shutdown                   |                       |                          |                               | X                |        |
| Digital Aux. Input D13 Knock Shutdown                        |                       |                          |                               | X                |        |
| Digital Aux. Input D14 Low Coolant Level Warning             | X                     |                          |                               |                  |        |

| Controller Inputs and System Events                                       | NFPA 110 Applications | Paralleling Applications | DD/MTU Engines with MDEC/ADEC | Waukesha Engines | 125RZG |
|---|-----------------------|--------------------------|-------------------------------|------------------|--------|
| Digital Aux. Input D15 Remote Shutdown                                    |                       |                          |                               |                  |        |
| Digital Aux. Input D16 Remote Reset                                       |                       |                          |                               |                  |        |
| Digital Aux. Input D17 VAR/PF mode  |                       |                          |                               |                  |        |
| Digital Aux. Input D18 Voltage Lower                                      |                       |                          |                               |                  |        |
| Digital Aux. Input D19 Voltage Raise                                      |                       |                          |                               |                  |        |
| Digital Aux. Input D20 Air Damper Indicator Shutdown (if engine equipped) | X                     |                          |                               |                  |        |
| Digital Aux. Input D21 Idle (Speed) Mode Warning                          |                       |                          |                               |                  |        |
| ECM Yellow Alarm Warning  |                       |                          | X                             |                  |        |
| ECM Red Alarm Shutdown  |                       |                          | X                             |                  |        |
| EEPROM Write Failure Shutdown   |                       |                          |                               |                  |        |
| Emergency Stop Shutdown   |                       |                          |                               |                  |        |
| Engine Derate Active  |                       |                          |                               |                  |        |
| (Engine) J1939 CAN Engine Shutdown (ECM only)                             |                       |                          |                               |                  |        |
| Engine Stalled (ECM only)   |                       |                          |                               |                  |        |
| EPS (Emergency Power System) Supplying Load Warning                       |                       |                          |                               |                  |        |
| Field Overvoltage Shutdown (M4, M5, M7, M10 alternator only) (see D04)    |                       |                          |                               |                  |        |
| Fuel Level (units with subbase fuel tanks) (see A04)                      |                       |                          |                               |                  |        |
| Fuel Valve Relay  |                       |                          |                               | X                |        |
| Generator Set Running   |                       |                          |                               |                  |        |
| Ground Fault Detected Warning   |                       |                          |                               |                  |        |
| High Battery Voltage Warning  |                       |                          |                               |                  |        |
| High Coolant Temperature Shutdown   |                       |                          |                               |                  |        |
| High Coolant Temperature Warning  |                       |                          |                               |                  |        |
| High Oil Temperature Shutdown   |                       |                          |                               |                  |        |
| High Oil Temperature Warning  |                       |                          | X                             | X                |        |
| Idle Speed Mode Function Warning  |                       |                          |                               |                  |        |
| Intake Air Temperature Shutdown   |                       |                          | X                             |                  |        |
| Intake Air Temperature Warning  |                       |                          | X                             |                  |        |
| Intake Air Temperature Warning (see A03)                                  |                       |                          |                               | X                |        |
| Internal Fault Shutdown   |                       |                          |                               |                  |        |
| Knock Shutdown (see D13)  |                       |                          |                               | X                |        |
| Load Shed kW Overload Warning (FAA only)                                  |                       |                          |                               |                  |        |
| Load Shed Over Temperature (activated by HCT shutdown)                    |                       |                          | X                             |                  |        |
| Load Shed Underfrequency Warning  |                       |                          |                               |                  |        |
| Locked Rotor Shutdown   |                       |                          |                               |                  |        |
| Loss of ECM Communication Shutdown (ECM engines only)                     |                       |                          |                               |                  |        |
| Loss of Field Shutdown (Reverse VARs)                                     |                       | X                        |                               |                  |        |
| Low Battery Voltage Warning   |                       |                          |                               |                  |        |
| Low Coolant Level Shutdown  |                       |                          |                               |                  |        |
| Low Coolant Level Warning (see D14)                                       | X                     |                          |                               |                  |        |
| Low Coolant Temperature Shutdown  |                       |                          | X                             |                  |        |
| Low Coolant Temperature Warning (see D03)                                 | X                     |                          |                               |                  |        |
| Low Fuel (Level or Pressure) Warning, (see D02)                           | X                     |                          |                               |                  |        |
| Low Fuel (Pressure) Shutdown (see D09)                                    |                       |                          |                               |                  | X      |
| (Low) Oil Pressure Shutdown   |                       |                          |                               |                  |        |
| (Low) Oil Pressure Warning  |                       |                          |                               |                  |        |
| Maintenance Due   |                       |                          |                               |                  |        |
| Master Not In Auto (Generator Set Switch)                                 |                       |                          |                               |                  |        |
| Master Switch Error Shutdown  |                       |                          |                               |                  |        |

| <b>Controller Inputs and System Events</b> | <b>NFPA 110 Applications</b> | <b>Paralleling Applications</b> | <b>DD/MTU Engines with MDEC/ADEC</b> | <b>Waukesha Engines</b> | <b>125RZG</b> |
|--|------------------------------|---------------------------------|--------------------------------------|-------------------------|---------------|
| Master Switch to Off Shutdown              |                              |                                 |                                      |                         |               |
| Master Switch Open Shutdown                |                              |                                 |                                      |                         |               |
| NFPA 110 Fault (Warning or Shutdown)       | X                            |                                 |                                      |                         |               |
| No Air Temperature Signal Warning          |                              |                                 |                                      | X                       |               |
| No Coolant Temperature Signal Shutdown     |                              |                                 |                                      |                         |               |
| No Oil Pressure Signal Shutdown            |                              |                                 |                                      |                         |               |
| No Oil Temperature Signal Warning          |                              |                                 |                                      | X                       |               |
| Overcrank Shutdown                         |                              |                                 |                                      |                         |               |
| Over Current Voltage Restraint Shutdown    |                              | X                               |                                      |                         |               |
| Over Current Warning                       |                              |                                 |                                      |                         |               |
| Over Frequency Shutdown                    |                              |                                 |                                      |                         |               |
| Over Power Shutdown                        |                              | X                               |                                      |                         |               |
| Over Speed Shutdown                        |                              |                                 |                                      |                         |               |
| Overvoltage Shutdown                       |                              |                                 |                                      |                         |               |
| Pre Lube Relay                             |                              |                                 |                                      | X                       |               |
| Remote Reset (see D16)                     |                              |                                 |                                      |                         |               |
| Remote Shutdown (see D15)                  |                              |                                 |                                      |                         |               |
| Synch Enable (see D06)                     |                              | X                               |                                      |                         |               |
| VAR/PF Mode (see D17)                      |                              |                                 |                                      |                         |               |
| Voltage Lower (see D18)                    |                              |                                 |                                      |                         |               |
| Voltage Raise (see D19)                    |                              |                                 |                                      |                         |               |
| Reverse Power Shutdown                     |                              | X                               |                                      |                         |               |
| Speed Sensor Fault Warning                 |                              |                                 |                                      |                         |               |
| System Ready                               |                              |                                 |                                      |                         |               |
| Time Delay Engine Cooldown (TDEC)          |                              |                                 |                                      |                         |               |
| Time Delay Engine Start (TDES)             |                              |                                 |                                      |                         |               |
| Time Delay Starting Aid                    |                              |                                 |                                      |                         |               |
| Underfrequency Shutdown                    |                              |                                 |                                      |                         |               |
| Undervoltage Shutdown                      |                              |                                 |                                      |                         |               |
| Variable Speed Governor (VSG) (see A06)    |                              |                                 |                                      |                         |               |
| VAR/PF Mode (see D17)                      |                              |                                 |                                      |                         |               |
| Voltage Lower (see D18)                    |                              |                                 |                                      |                         |               |
| Voltage Raise (see D19)                    |                              |                                 |                                      |                         |               |
| Weak Battery Warning                       |                              |                                 |                                      |                         |               |

# Notes

## Appendix F Controller Displays from the Engine ECM

The controller display showing engine information is dependent upon the engine manufacturer and the corresponding Engine Control Module (ECM). The following list indicates what engine displays are available by the engine manufacturer. This information is subject to change by the engine manufacturer.

Some engines do not have an ECM and in some cases the ECM information is not available as a controller display. In these situations, critical information like oil pressure and coolant temperature are displayed by the controller using independent engine sensors not used by the ECM.

| Controller Displays as Provided by the Engine ECM (availability subject to change by the engine manufacturer) |        |        |                   |               |                 |               |
|---|--------|--------|-------------------|---------------|-----------------|---------------|
| Display   | GM/PSI | Doosan | John Deere (JDEC) | Volvo (EMS 2) | Volvo (EDC III) | DD/MTU (ADEC) |
| Ambient temperature   |        | X      |                   |               |                 |               |
| Charge air pressure   | X      | X      |                   | X             | X               | X             |
| Charge air temperature  | X      | X      | X                 | X             | X               |               |
| Coolant level   |        |        |                   | X             | X               | X             |
| Coolant pressure  |        |        |                   | X             | X               |               |
| Coolant temperature   | X      | X      | X                 | X             | X               | X             |
| Crankcase pressure  |        |        |                   | X             | X               |               |
| ECM battery voltage   | X      | X      |                   |               |                 | X             |
| ECM fault codes   | X      | X      | X                 | X             | X               | X             |
| ECM serial number   |        |        |                   |               |                 | X             |
| Engine model number   |        |        | X                 |               |                 | X             |
| Engine serial number  |        |        | X                 |               |                 | X             |
| Engine speed  | X      | X      | X                 | X             | X               | X             |
| Fuel pressure   |        |        |                   | X             | X               |               |
| Fuel rate   | X      | X      | X                 | X             | X               | X             |
| Fuel temperature  |        |        | X                 | X             | X               | X             |
| Oil level   |        |        |                   |               | X               |               |
| Oil pressure  | X      | X      | X                 | X             | X               | X             |
| Oil temperature   |        |        |                   | X             | X               | X             |
| Trip fuel   |        |        |                   | X             | X               | X             |

**Note:** 40-60REOZK (Kohler KDI engines) do not have an ECM. REOZMD/ROZMC (Mitsubishi engines) have an ECM but do not send signals to the Decision-Maker® 550 controller.



# Notes

## Appendix G DEC 550 Controller Fault Displays

---

The controller fault display showing engine information is dependent upon the engine manufacturer and the corresponding Engine Control Module (ECM). The following list indicates what engine fault displays are available by the engine manufacturer as well as components added by the generator set manufacturer. This information is subject to change.

Some engines do not have an ECM and in some cases the ECM information is not available as a controller fault display. In these situations, critical information like oil pressure and coolant temperature faults are displayed by the controller using independent engine sensors not used by the engine ECM.

This chart is intended to be a guide for finding the corresponding component sensor based on the controller fault display since many of the sensors vary depending upon engine manufacturer. This information should be used in conjunction with Service Bulletin SB-616 as model specific information is available in this document including sensor lead identification.

In the table, where the word *Engine* is shown in italics, this is an indication that the sensor is provided by the engine manufacturer and component location, troubleshooting, and testing information would be found in the engine service literature.

**Note:** REOZMD/ROZMC (Mitsubishi engines) have an ECM but do not send signals to the Decision-Maker® 550 controller.

(1) All models use temperature sensor at lead 35A except: 40/50REOZJE which has an engine manufacturer-supplied temperature sensor. See SB-616 for lead nos./colors of the engine temperature sensor.

(2) The unit also incorporates a magnetic pickup at the flywheel with leads connected to terminals 5 and 6 on the flo-tech speed control (governor).

(3) Governor magnetic pickup leads are black/yellow/green leads to P36 connector, then black/white leads to governor on junction box, and then black/red to DEC550 controller.

While the table identifies the respective sensor as the trigger to the fault display, the actual cause of the fault must be investigated and corrected as needed. Also, keep in mind that if the sensor is determined to be the source of the fault display, the associated electrical connectors, terminals, and wiring must be examined as well as the sensor.

| Display  | Engine Manufacturer   |   |  |  |   |  |
|--|---|---|--|--|---|--|
|  | GM/PSI  | Doosan  | John Deere (JDEC)  | Volvo (EMS II)                                   | DD/MTU (ADEC)   | Mitsubishi   |
| <b>Warnings</b>  |   |   |  |  |   |  |
| Fuel leak alarm  | Not used  |   | Fuel leak alarm at fuel tank (lead 64)                     |  |   |  |
| High battery voltage warning                                 | DEC 550 controller logic  |   |  |  |   |  |
| High coolant temp warning                                    | <i>Engine temperature sensor, see SB-616 for lead nos./colors</i>   |   |  |  |   |  |
| High oil temp warning  | Not used  |   |  |  | <i>Engine temp. sensor</i>  | Not used   |
| Low battery voltage  | DEC 550 controller logic  |   |  |  |   |  |
| Low coolant temperature                                      | Temperature sensor at lead 35A  |   | (1)  | Temperature sensor at lead 35A                   | <i>Engine temp. sensor, see SB-616 for lead nos./colors</i>   | Temp. sensor at lead 35A                               |
| Low fuel (pressure) level warning                            | Low fuel level at fuel tank (lead 63 or 63C)  |   |  |  |   |  |
| Low oil pressure warning                                     | <i>Engine pressure sensor, see SB-616 for lead nos./colors</i>  |   |  |  |   |  |
| No oil temperature signal                                    | Not used  |   | DEC 550 controller logic                                   |  |   | Not used   |
| Speed sensor fault   | DEC 550 controller logic  |   |  |  |   |  |
| Turbocharger temperature warning                             | Not used  |   |  |  |   | <i>Engine temp. sensor on 1750/2000REOZMD</i>          |
| Weak battery   | DEC 550 controller logic  |   |  |  |   |  |
| <b>Shutdowns</b>   |   |   |  |  |   |  |
| Alternator protection shutdown                               | DEC 550 controller logic  |   |  |  |   |  |
| Critical overvoltage shutdown                                | DEC 550 controller logic  |   |  |  |   |  |
| Emergency stop   | Local and/or remote emergency stop switch circuit open (leads 1 and 1A)   |   |  |  |   |  |
| Engine J1939 CAN loss of comm. shutdown                      | DEC 550 controller logic  |   |  |  |   | Not used   |
| Engine stalled   | See Overspeed shutdown  |   |  |  |   |  |
| Field overvoltage (350–2000 kW only)                         | Not used  | DEC 550 controller logic  |  |  |   |  |
| High coolant temperature shutdown                            | <i>Engine temperature sensor, see SB-616 for lead nos./colors</i>   |   |  |  |   |  |
| High oil temp shutdown                                       | Not used  |   |  | <i>Engine temperature sensor</i>                 |   | Not used   |
| Intake air temperature shutdown                              | Not used  |   |  |  | <i>Engine temp. sensor</i>  | Not used   |
| Locked rotor   | See Overspeed shutdown  |   |  |  |   |  |
| Loss of ECM communication                                    | DEC 550 controller logic including the CAN communications port (the associated hardware and software) on the ECM and the CAN bus cabling between the devices. |   |  |  |   | Not used   |
| Loss of field (Reverse VARs) (Paralleling applications only) | DEC 550 controller logic  |   |  |  |   |  |
| Low coolant level shutdown                                   | Low water level sender at radiator (lead 31A)   |   |  |  |   |  |
| Low coolant temperature                                      | Not used  |   |  |  | <i>Engine temp. sensor</i>  | Not used   |
| Low fuel (pressure) level shutdown                           | Sensor at lead 65 (125REZG)   | Not used  |  |  |   |  |
| Low oil pressure shutdown                                    | <i>Engine pressure sensor, see SB-616 for lead nos./colors</i>  |   |  |  |   |  |
| No coolant signal temperature signal                         | DEC 550 controller logic  |   |  |  |   | Not used   |
| No oil pressure signal                                       | DEC 550 controller logic  |   |  |  |   | Not used   |
| Overcrank  | DEC 550 controller logic  |   |  |  |   |  |
| Overcurrent VR shutdown (Paralleling applications only)      | DEC 550 controller logic  |   |  |  |   |  |
| Overfrequency shutdown                                       | DEC 550 controller logic  |   |  |  |   |  |
| Overpower shutdown (Paralleling applications only)           | DEC 550 controller logic  |   |  |  |   |  |
| Overspeed shutdown (DTC-16)                                  | <i>Engine overcrank sensor at crankshaft with light green/red, white/purple, and purple/white leads</i>   | <i>Engine crank sensor with purple/white &amp; white/purple leads (2)</i> | <i>Engine crank position sensor with purple/gray leads</i> | <i>Engine flywheel sensor with red/blue lead</i> | <i>Engine Camshaft speed sensor (B1) and Crankshaft Speed Sensor (B13) typically with white leads</i> | <i>Governor magnetic pickup at engine flywheel (3)</i> |
| Overvoltage shutdown   | DEC 550 controller logic  |   |  |  |   |  |
| Reverse power shutdown (Paralleling applications only)       | DEC 550 controller logic  |   |  |  |   |  |
| Underfrequency shutdown                                      | DEC 550 controller logic  |   |  |  |   |  |
| Undervoltage shutdown  | DEC 550 controller logic  |   |  |  |   |  |

# Notes

# Notes



**TP-6200 3/17I**

*Original Instructions (English)*

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# **KOHLER**<sup>®</sup> Power Systems

KOHLER CO. Kohler, Wisconsin 53044  
Phone 920-457-4441, Fax 920-459-1646  
For the nearest sales/service outlet in the  
US and Canada, phone 1-800-544-2444  
KOHLERPower.com

Kohler Power Systems  
Asia Pacific Headquarters  
7 Jurong Pier Road  
Singapore 619159  
Phone (65) 6264-6422, Fax (65) 6264-6455



**ProAct™ Digital Speed Control System  
for Models I and II**

**Installation and Operation Manual**



## IMPORTANT



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

## DEFINITIONS

- **DANGER**—Indicates a hazardous situation which, if not avoided, will result in death or serious injury.
- **WARNING**—Indicates a hazardous situation which, if not avoided, could result in death or serious injury.
- **CAUTION**—Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.
- **NOTICE**—Indicates a hazard that could result in property damage only (including damage to the control).
- **IMPORTANT**—Designates an operating tip or maintenance suggestion.

## WARNING

The engine, turbine, or other type of prime mover should be equipped with an overspeed shutdown device to protect against runaway or damage to the prime mover with possible personal injury, loss of life, or property damage.

The overspeed shutdown device must be totally independent of the prime mover control system. An overtemperature or overpressure shutdown device may also be needed for safety, as appropriate.



Read this entire manual and all other publications pertaining to the work to be performed before installing, operating, or servicing this equipment. Practice all plant and safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage.



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Any unauthorized modifications to or use of this equipment outside its specified mechanical, electrical, or other operating limits may cause personal injury and/or property damage, including damage to the equipment. Any such unauthorized modifications: (i) constitute "misuse" and/or "negligence" within the meaning of the product warranty thereby excluding warranty coverage for any resulting damage, and (ii) invalidate product certifications or listings.

## NOTICE

To prevent damage to a control system that uses an alternator or battery-charging device, make sure the charging device is turned off before disconnecting the battery from the system.

## NOTICE

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual **82715**, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

■ Revisions—Text changes are indicated by a black line alongside the text.

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## Electrostatic Discharge Awareness

All electronic equipment is static-sensitive, some components more than others. To protect these components from static damage, you must take special precautions to minimize or eliminate electrostatic discharges.

Follow these precautions when working with or near the control.

1. Before doing maintenance on the electronic control, discharge the static electricity on your body to ground by touching and holding a grounded metal object (pipes, cabinets, equipment, etc.).
2. Avoid the build-up of static electricity on your body by not wearing clothing made of synthetic materials. Wear cotton or cotton-blend materials as much as possible because these do not store static electric charges as much as synthetics.
3. Keep plastic, vinyl, and Styrofoam materials (such as plastic or Styrofoam cups, cup holders, cigarette packages, cellophane wrappers, vinyl books or folders, plastic bottles, and plastic ash trays) away from the control, the modules, and the work area as much as possible.
4. Do not remove the printed circuit board (PCB) from the control cabinet unless absolutely necessary. If you must remove the PCB from the control cabinet, follow these precautions:
  - Do not touch any part of the PCB except the edges.
  - Do not touch the electrical conductors, the connectors, or the components with conductive devices or with your hands.
  - When replacing a PCB, keep the new PCB in the plastic antistatic protective bag it comes in until you are ready to install it. Immediately after removing the old PCB from the control cabinet, place it in the antistatic protective bag.

### **NOTICE**

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual 82715, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.



# Chapter 1.

## General Information

### Introduction

This manual describes the Woodward ProAct™ Digital Speed Control and ProAct 75 degree electric powered actuators, models I and II.

### Application

The ProAct control system is designed to control the speed of engines in mechanical drive or generator set service. The electric powered ProAct actuator has 75° of rotation and is designed for direct drive of the butterfly valve on gas engines, and through linkage the racks on diesel engines.

Actuators are available in different sizes to fit specific control demands. In most cases, the ProAct II actuator will be used. The ProAct II provides 6.8 J (5.0 ft-lb) of work (transient) and 2.7 N·m (2.0 lb-ft) of torque.

The ProAct I is extremely fast and provides 3.4 J (2.5 ft-lb) of work (transient) and 1.4 N·m (1.0 lb-ft) of torque at steady state. ProAct I controls may be operated on nominal 12 Vdc systems. ProAct II controls require nominal 24 Vdc supply.

Larger output ProAct III and ProAct IV controls are available. Information on these actuators is in manual 04127.

The ProAct Digital Speed Control includes an input for a 4 to 20 mA remote speed reference setting, an internal speed reference for local control of speed, and an auxiliary voltage input for load-sensor connection in load-sharing applications. A fuel limiting version is also available.

The ProAct control system includes:

- a ProAct Digital Speed Control
- an external 18–32 Vdc (24 Vdc nominal) power source for Model II or a 10–32 Vdc power source for Model I
- a speed-sensing device (MPU)
- a ProAct I or ProAct II actuator to position the fuel rack
- a hand held terminal for adjusting control parameters
- an optional load sensing device

The ProAct Digital Speed Control (Figure 1-2) consists of a single printed circuit board in a sheet metal chassis. Connections are via two terminal strips and a 9-pin J1 connector.

The control chassis has an aluminum shield to protect the circuits from electromagnetic interference (EMI) and electrostatic discharge (ESD).

## Control Applications

The ProAct II control requires 18–32 Vdc (24 Vdc nominal) uninterrupted power supply, with 125 watts as the maximum power consumption at rated voltage. ProAct I requires 8–32 Vdc (12 or 24 Vdc nominal) uninterrupted power supply with 50 W as the maximum power consumption at rated voltage.

ProAct actuators are designed to directly link to the butterfly in the gas engine carburetor. The control can be programmed to have variable gain to compensate for the variable gain characteristics of carbureted gas engines.

Diesel engine applications can use the control programmed to accommodate non-linear fuel controls or non-linear linkage arrangements.

## Speed Control Accessories

**Hand Held Programmer** (Figure 4-1, part number 9907-205) is used to adjust the ProAct control. It plugs into the serial port (J1 connector) of the control.

**Generator Load Sensor** (part number 9907-026) for load sharing or droop-parallel generator applications. This will connect to the Aux input on the control.

**SPM-A Synchronizer** for synchronizing the generator phase to that of the power bus. The synchronizer generates a close-generator-breaker signal to parallel the generator with the power bus. Connect the synchronizer to the Aux input to bias the speed setting.

## Actuator Accessories

Electrical plug to match plug on the actuator:

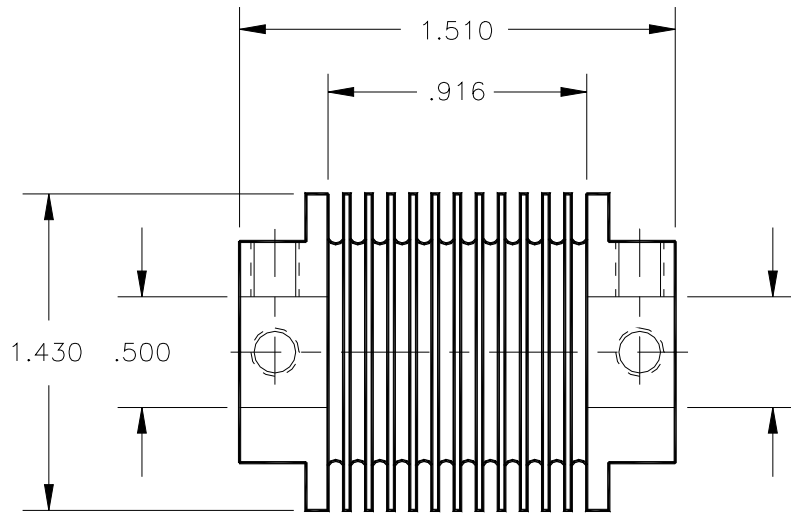
- 1631-187 straight plug
- 1631-633 90° plug

Actuator Lever for linkage connection:

- 3699-027 5-inch, 5 holes
- 3952-043 2-inch, 2 holes

Flexible Couplings for direct connection of the actuator output to a carburetor's butterfly-valve shaft (dimension "X" in Figure 1-1):

| Diameter of Butterfly Valve Shaft | Part Number |
|-----------------------------------|-------------|
| 0.250                             | 1431-431    |
| 0.312                             | 1431-433    |
| 0.375 (9.5 mm)                    | 1431-435    |
| 0.394 (10 mm)                     | 1431-437    |
| 0.472 (12 mm)                     | 1431-439    |
| 0.500                             | 1431-443    |
| 0.625                             | 1431-445    |
| 0.750                             | 1431-447    |
| 0.875                             | 1431-449    |



041-087  
93-4-8 RAM

Figure 1-1. Flexible Coupling

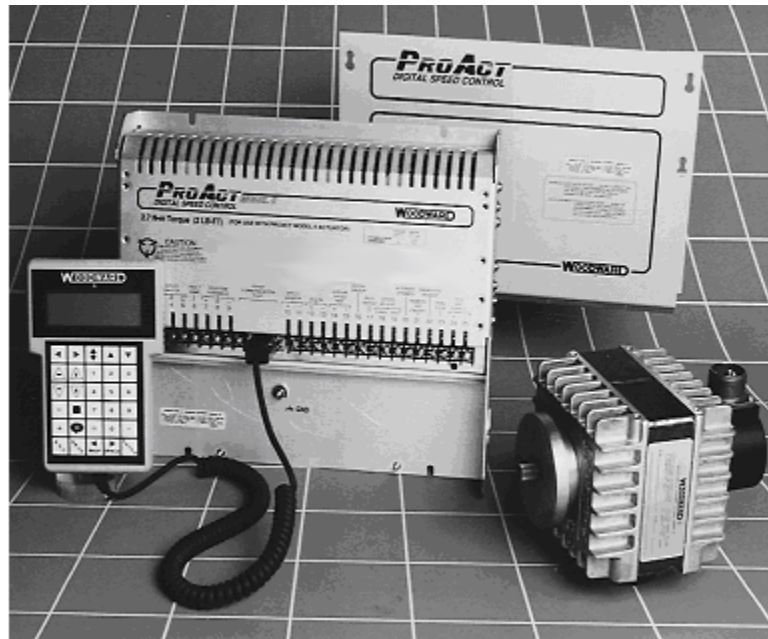


Figure 1-2. ProAct Digital Speed Control and Actuator



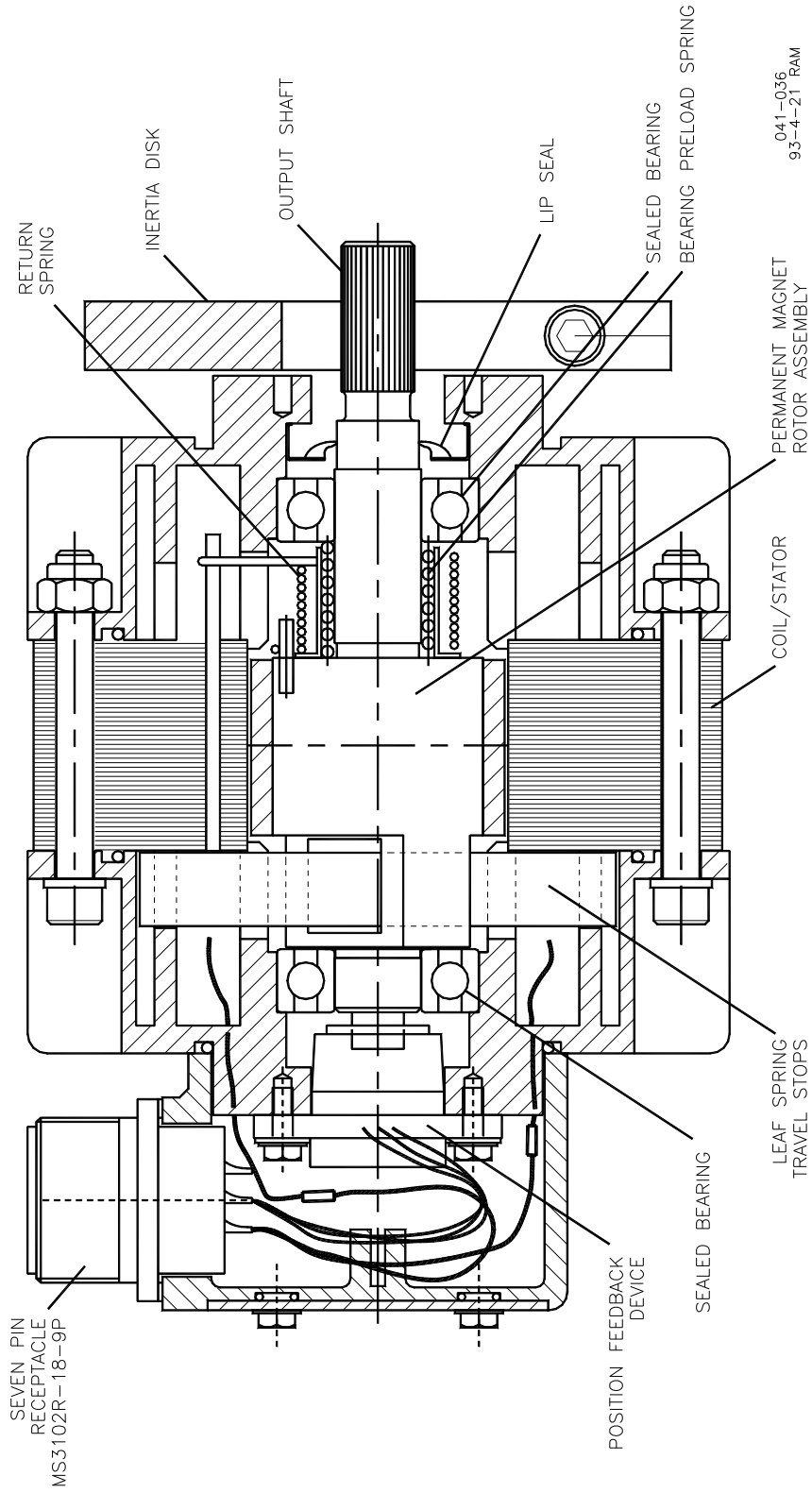


Figure 1-3. Example of ProAct II Actuator

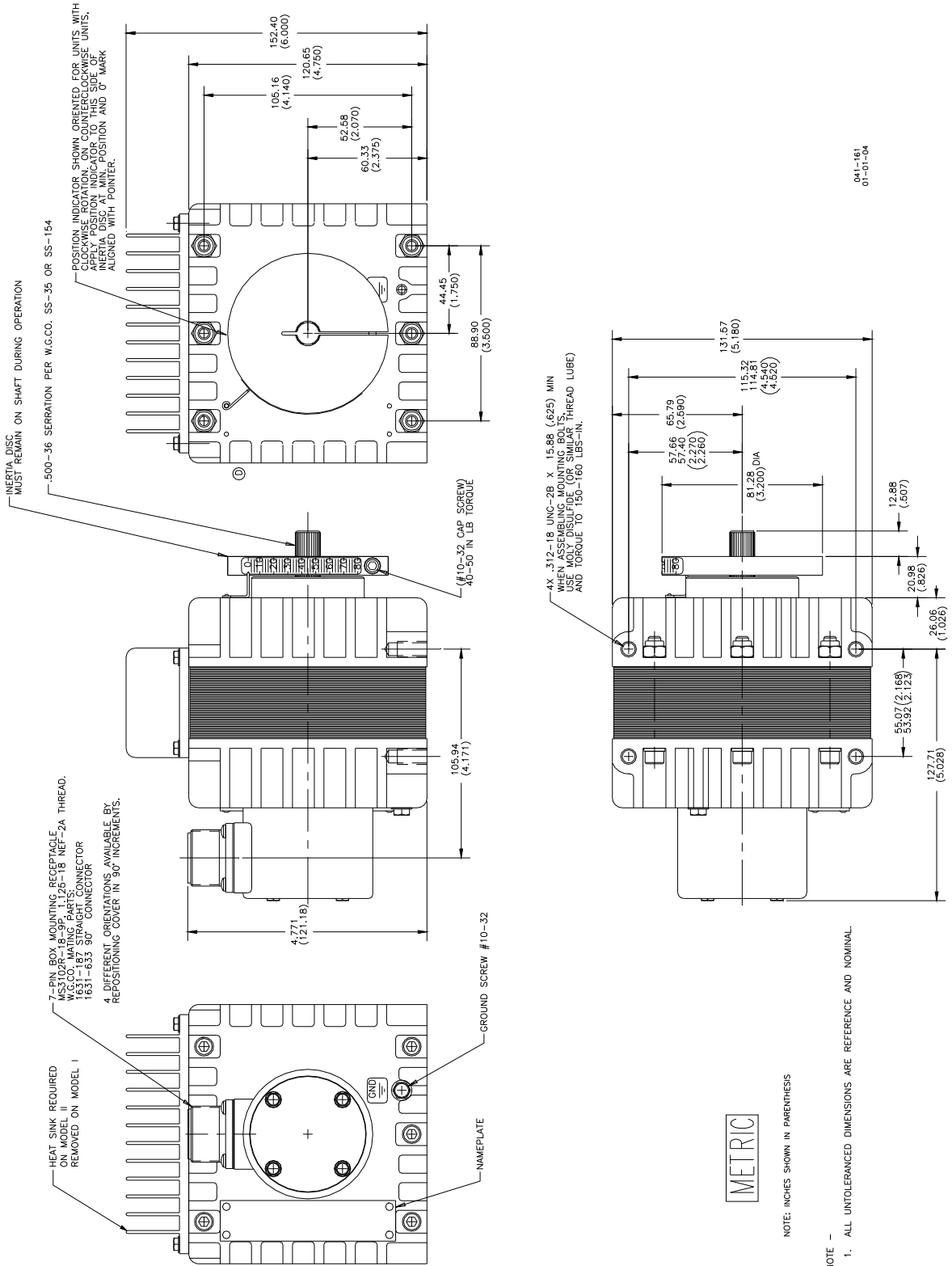
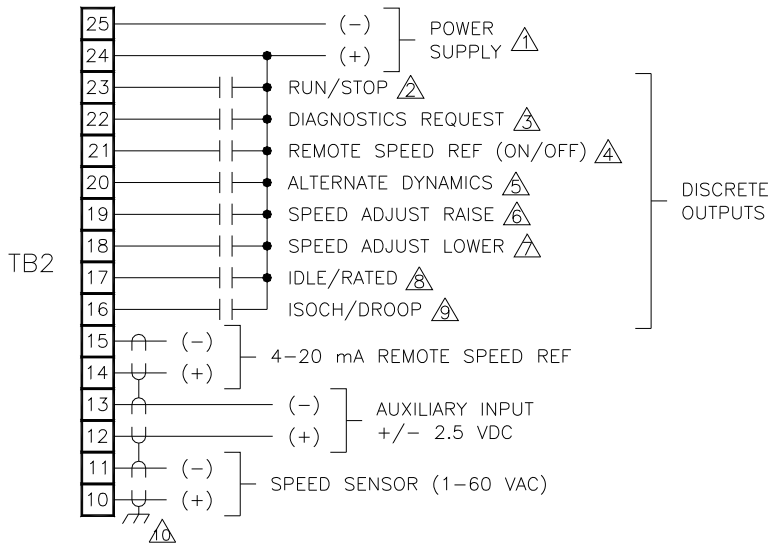
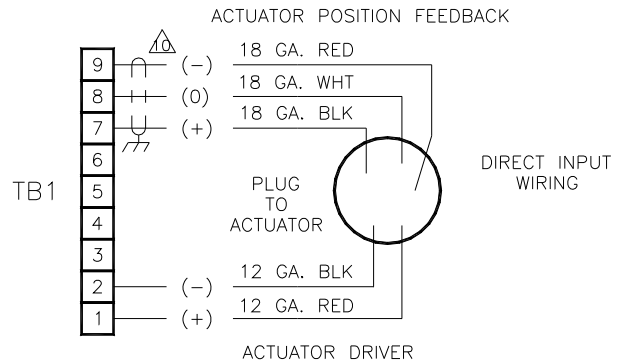
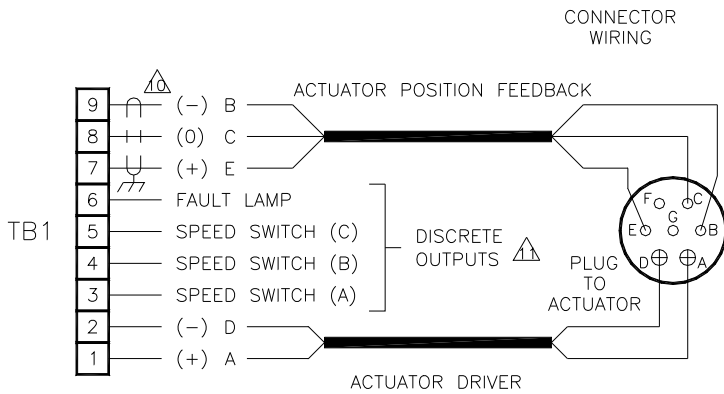
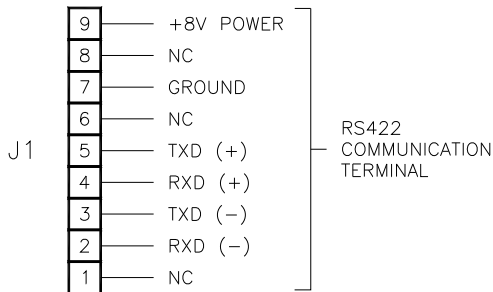


Figure 1-4. Outline Drawing of ProAct I or II Actuator



NOTES:

- ⚠ MODEL I CONTROL: 8-32 VDC  
MODEL II CONTROL: 18-32 VDC
- ⚠ CLOSE TO RUN.  
**WARNING:** DO NOT USE FOR EMERGENCY SHUTDOWN. THE PRIME MOVER SHOULD BE EQUIPPED WITH A SEPARATE OVERSPEED, OVERTEMPERATURE OR OVERPRESSURE SHUTDOWN DEVICE(S) TO PROTECT AGAINST RUNAWAY OR DAMAGE TO THE PRIME MOVER WITH POSSIBLE PERSONAL INJURY OR LOSS OF LIFE.
- ⚠ FACTORY USE ONLY.
- ⚠ CLOSE FOR REMOTE REF.
- ⚠ CLOSE FOR ALTERNATE DYNAMICS.
- ⚠ CLOSE TO RAISE SPEED REF.
- ⚠ CLOSE TO LOWER SPEED REF.
- ⚠ CLOSE FOR RATED.
- ⚠ CLOSE FOR ISOCH.
- ⚠ SHIELDED WIRES TO BE TWISTED, WITH SHIELD GROUNDED AT ONE END ONLY. WHEN MOUNTING CONTROL TO BULKHEAD, USE EXTERNAL TOOTH LOCK WASHER UNDER ONE SCREWHEAD TO ENSURE PROPER GROUNDING.
- ⚠ OUTPUT WILL SINK UP TO 0.5 AMPERE AT POWER SUPPLY VOLTAGE. THE OUTPUT IS A LOW SIDE SWITCH TO THE NEGATIVE OR THE POWER SUPPLY.



PLANT WIRING

STANDARD CONTROLS

041-093  
01-4-16

Figure 1-5. ProAct Wiring Diagram



## Chapter 2. Description of Operation

### General

This chapter provides an overview of the features and operation of the ProAct™ Digital Speed Control and Actuator system. Figure 1-4 shows the actuator outline. Figure 1-5 is the wiring diagram for reference in the following descriptions. Figure 1-3 is a schematic cutaway view of the ProAct II actuator.

The ProAct Digital Speed Control uses a 16-bit microprocessor for all control functions, such as computing engine speed, performing the control algorithm calculations, speed ramps, etc. All control adjustments are made with a hand held terminal/display (see Figure 4-1) that communicates with the control via a serial port. The terminal/display is disconnected from the control when not in service to provide security against tampering.

The operating program is adjusted through seven menus accessed through the hand held terminal display. Details of these seven menus are contained in Chapter 4 of this manual.

The speed sensor contains a special tracking filter, designed for reciprocating engines, which minimizes the effects of engine torsionals or irregularities in the gear used for sensing speed. This provides exceptionally smooth steady-state control and allows the control dynamics to be matched to the engine.

The speed signal itself is usually provided by a magnetic pickup supplying an AC signal from 1 to 60 Vrms to the control. The frequency (in Hz) is proportional to engine rpm.

The control features exceptional spike, ripple, and EMI (electromagnetic interference) rejection. Discrete inputs are optically isolated and capable of rejecting EMI and variable resistances in switch or relay contacts. Analog inputs are differential-type with extra filtering for common-mode noise rejection. This protects the control from spurious interference and noise which can cause speed and load shifts. The chassis should be bolted to a good ground to ensure effective EMI/RFI protection.

An auxiliary  $\pm 2.5$  volt input is provided to interface with Woodward Load Sensors, to provide isochronous load-sharing operation.

### Control Dynamics

The algorithms used in the ProAct control are designed specifically for reciprocating engine applications. Control dynamics vary automatically as functions of both speed and actuator position to provide better performance over the entire engine operating range.

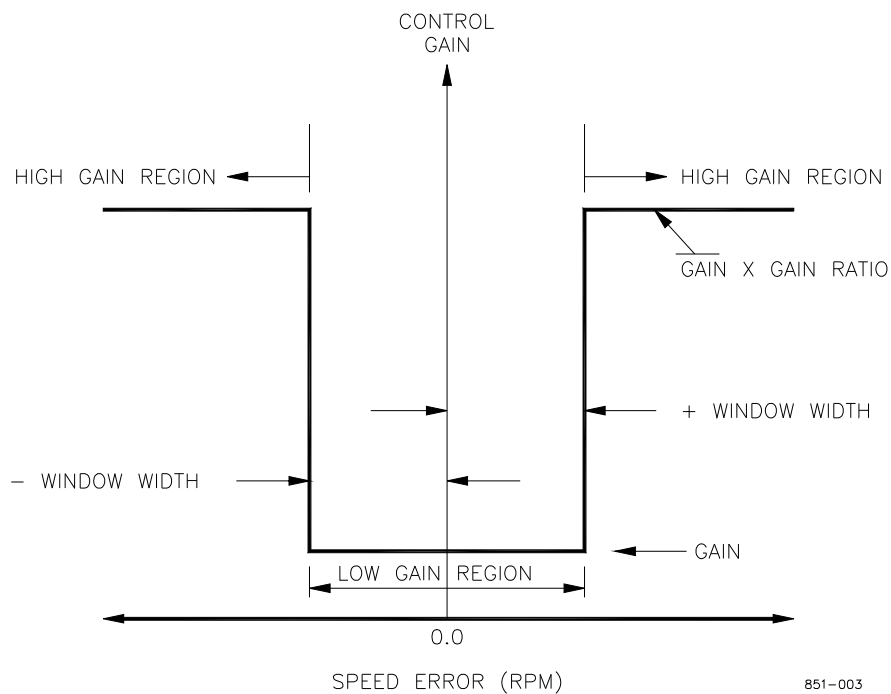
## Alternate Dynamics

The ProAct control provides two complete sets of dynamic adjustments, which are externally switch selectable. The two sets of dynamics are provided for use where engine operating conditions change, such as in systems which use two different fuels, clutched-in loads, and electrical power generation where the unit may be operated stand-alone and paralleled with an infinite bus.

Each set of dynamics provides different gain mapping, stability, compensation, gain ratio, and gain window settings. This allows instantaneous changes in control for engines which operate with different fuels or have load-type changes which require different dynamics.

Gain Ratio is the ratio of Gain setting during transient off-speed conditions to the gain setting at steady state. Speed Gain Ratio operates by multiplying the Gain set point by the Gain Ratio when the speed error is anticipated to be greater than the Window Width. This allows a lower gain at steady state for better stability and reduced steady-state actuator movement (see Figure 2-1).

### DUAL GAIN DYNAMICS SPEED CONTROL



851-003  
97-08-22

Figure 2-1. Window Width for Gain Ratio

During steady-state operation with a constant load, the control uses the base gain setting. This gain is adjusted by the user to a value to prevent the control from responding to minor fluctuations in engine speed, a common problem with gas-fuel, spark-ignited engines.

This feature eliminates the potentially damaging jiggle of the actuator and fuel system. The control automatically increases gain by an adjustable gain ratio when speed error exceeding an adjustable window occurs, or is anticipated to occur, based on measurements of the instantaneous rate of change of the engine. Operation with base gain is restored once the control senses the return to steady-state speed. The Window Width speed is a  $\pm$  value, centered around zero speed error.

## Variable Dynamics

The control is designed to compensate for non-linear fuel systems and changes in engine dynamics with load. The control gain is mapped as a function of actuator position.

Four break points work with four gain settings to map the actuator against expected non-linear conditions. This provides optimal dynamics and smooth steady-state operation for all conditions from no load to full engine load. The four different response rates are achieved by the creation of four different gain settings. Gas engine installations will usually require all four gain settings for different fuel flows, especially if the actuator is direct-coupled to the butterfly. Most diesel applications will need only one or two of the gain settings with the break points of the other settings moved up out of the way (set to 100%).

## Fuel Limiters

### Start Fuel Limit

The ProAct control has a start fuel limiter to provide smoother transitions and less over-fueling during start-up. The limiter is set to provide the desired position during starts. The control will reduce the fuel when the start speed set point is reached as required to control engine speed, but will not exceed the Start Limit. The Start Fuel limit is removed when the engine speed reaches the Start Speed set point.

The Start Fuel limit is combined with a user-tunable ramp that will increase the Start Fuel limit at a programmable rate while the engine speed is below the Start Speed set point. This ramp is designed to allow for easier starting of the engine during various temperature conditions, such as a cold start, which may require an increase in fuel.

### Maximum Fuel Limit

This programmable actuator position limit is in place when rated speed is selected. This is the maximum actuator position setting allowed for steady-state full load.

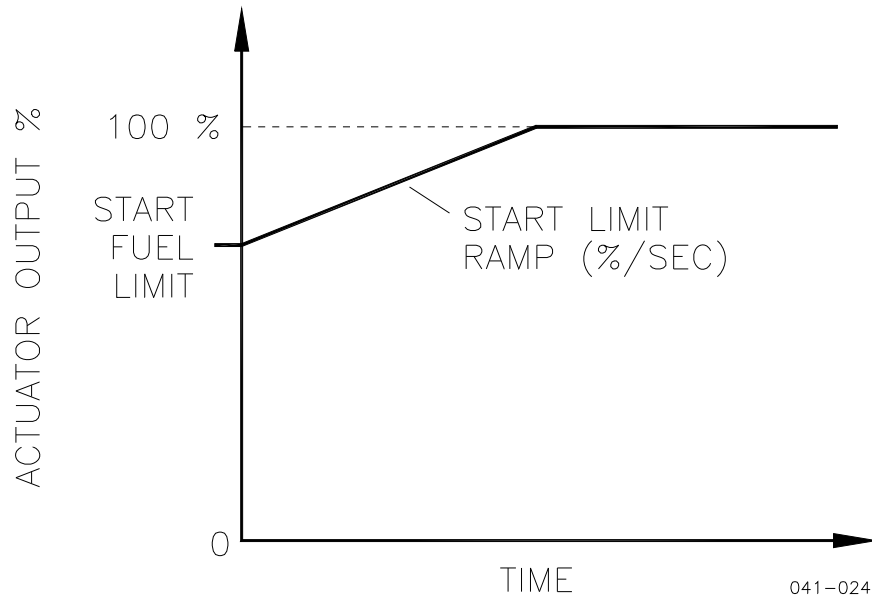


Figure 2-2. Start Fuel Limit

**Transient Overfuel**

This feature allows the user to set the Maximum Fuel Limit near the rated engine horsepower. The Transient Overfuel will allow exceeding this Maximum Fuel Limit for a tunable percentage for a tunable time (Transient Time). This ensures good transient load acceptance while maintaining safe steady-state-horsepower limiting.

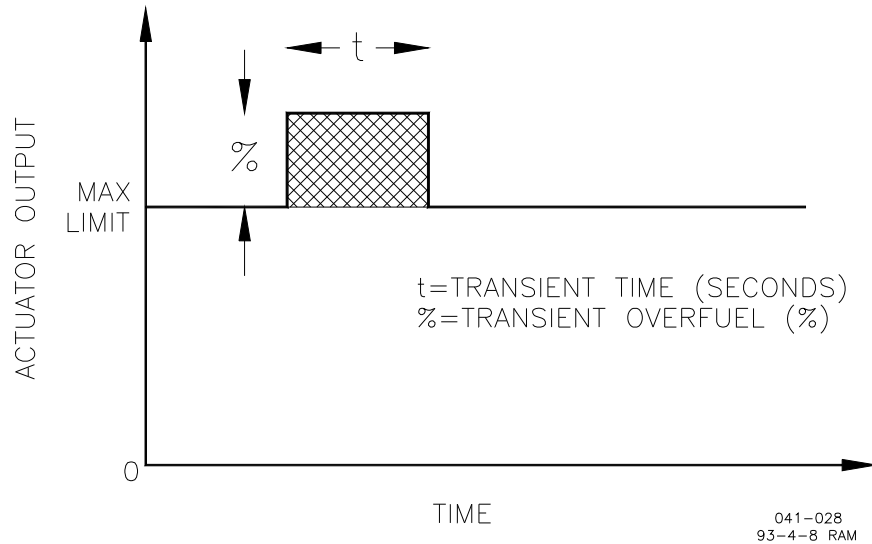


Figure 2-3. Transient Overfuel



## Torque Limit

A two-slope torque limiter is provided for mechanical-drive, variable-speed applications. The torque limiter provides a maximum fuel position determined by current engine speed to limit over-fueling. The torque limiter is compared with the maximum fuel limit and the lower percent value is used as the actuator position limit.

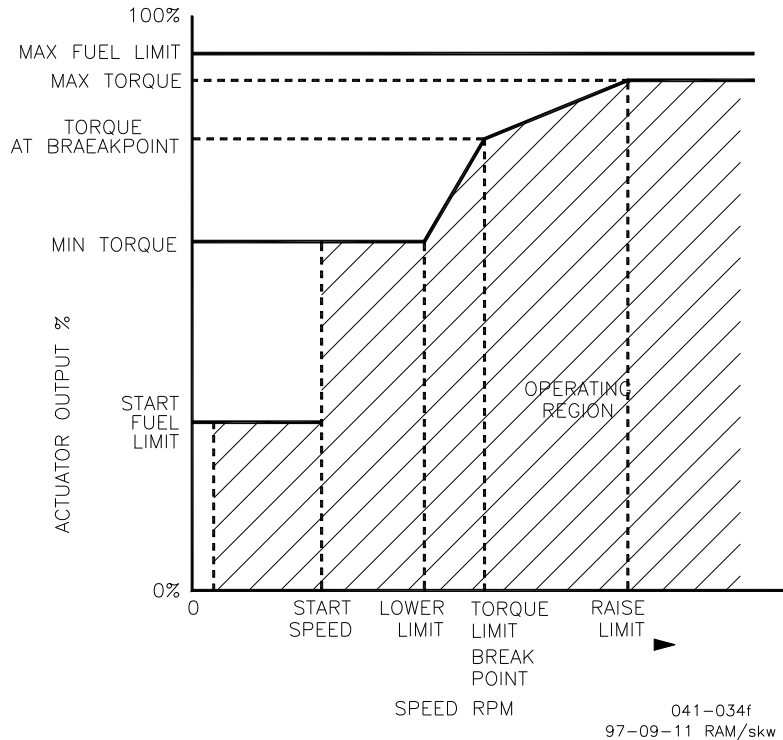


Figure 2-4. Torque Limit

## Speed Reference and Ramps

The ProAct control provides discrete local control of the speed reference with switch inputs to issue raise and lower speed commands. For remote speed setting, the control permits a 4 to 20 mA input which is used to vary the speed reference. This section describes the operation of each of the speed reference and ramp functions and their relation to each other. Read this section carefully to be sure your switch gear sequencing provides the proper operating modes.

The control provides an Idle/Rated discrete input with tunable Idle and Rated Speed settings. Raise and Lower inputs will raise and lower the speed reference at tunable rates.

The Idle Speed set point is provided for engine start-up or cool-down speed. Idle speed may be set equal to or less than the Rated Speed set point. Idle Speed is independent of the Lower Limit set point and may be set to a lower speed. When Idle is selected (Idle/Rated switch in Idle position with contacts open), Remote Speed Reference and Raise and Lower inputs are disabled. Idle speed cannot be changed except through programming the Idle Speed set point. The Idle Speed set point value can be changed using the hand held or PC when the engine is running, however the idle speed of the engine will remain at the previous set point until the Idle/Rated or Run/Stop switch has been toggled, or power cycled on the control.

When Rated Speed is selected by closing the Idle/Rated switch contact, the fuel limit is set to the Maximum Fuel Limit set point value or the Torque Limit, whichever is less, for the current engine operating speed. The speed reference selected at this time is determined by the status of the Enable Remote switch. If Remote reference is not selected (the Remote reference switch contacts are open), the speed reference will ramp from low idle to rated speed, based on the Accel Time set point. Closing either the Raise or Lower contacts (or the Remote contacts) while ramping from idle to rated results in immediate cancellation of the idle-to-rated ramp. The Raise/Lower ramp rates will take over, depending on whether Raise or Lower is selected.

The Raise and Lower commands ramp engine speed based on the Raise and Lower Rate set points. The Raise and Lower Limits determine the limits of these commands. If Enable Remote is selected (and Rated Speed is selected), the control will ramp speed to the reference value set by the remote speed-setting milliamp input (at the Raise or Lower Rate). The remote speed setting operates from 4 to 20 mA. The values of the 4 mA and 20 mA Remote Reference set points must be set between the Raise and Lower Limit set points. The 4 mA Remote Reference set point may be set to a lower or higher speed than the 20 mA set point, providing for either direct or reverse-acting remote speed setting.

If Remote is selected when the Idle/Rated switch contacts are closed, or during the idle-to-rated ramp, the speed reference will ramp to the speed reference value determined by the milliamps on the remote speed-setting input, based on the Raise Rate/Lower Rate set points.

Remote speed-setting inputs between 2 and 4 mA are treated as the minimum of 4 mA. Below 2 mA, the remote input is considered failed. Between 4 and 20 mA, the control determines the required speed reference based on a straight line interpolated between the 4 mA Remote Reference and 20 mA Remote Reference set points. If a difference is detected between the current speed reference and the remote reference computed from the mA input, the current speed reference is raised or lowered at the rate determined by the Raise or Lower Rate to bring the speed reference into agreement with the remote speed reference. The remote reference will not increase speed over the Raise Limit or lower it below the Lower Limit, nor change speed faster or slower than the Raise Rate/Lower Rate respectively.

When Remote Reference is selected and the remote input is failed (less than 2 mA), the speed reference remains at the current value. The speed reference can be changed in this situation only by increasing the remote reference above 2 mA or by opening the Remote Enable switch and toggling the Run/Stop switch or cycling the power to the control (cycling the power is *not* recommended).

When the current operating mode is Rated, switching to Idle results in ramping engine speed to idle based on the Decel Time set point.

If the control is in Remote Speed Reference and you wish to return to Rated Speed, the Remote switch must be in the open position and the Run/Stop switch toggled (or cycle the power to the control, which is *not* recommended).

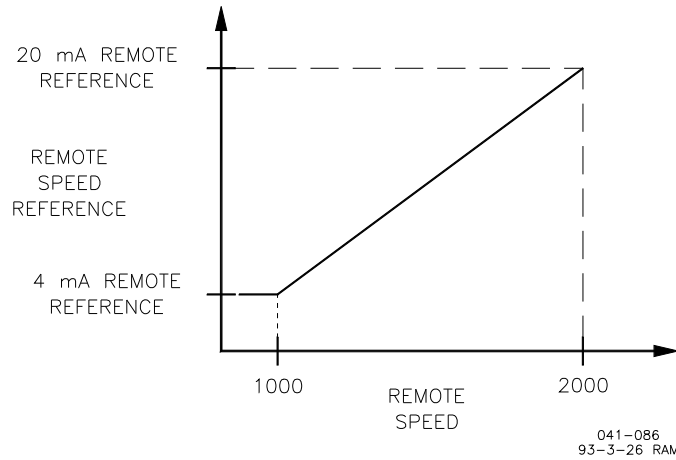


Figure 2-5. Remote Speed Reference

### Droop/Isochronous

The Droop/Isochronous switch allows selection of either type of governor operation. If Droop is selected, the ProAct control will hold engine speed according to a droop schedule entered in the program.

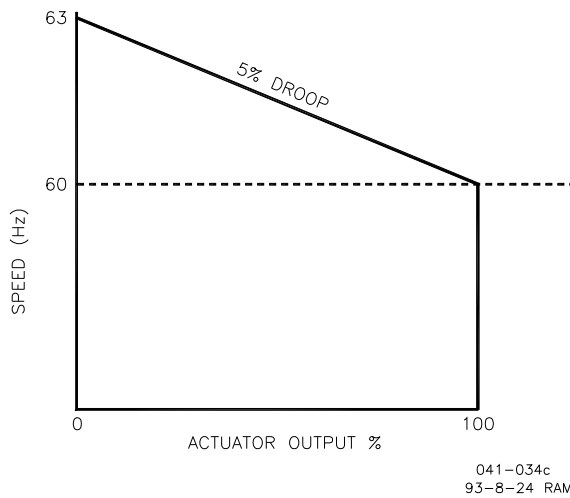


Figure 2-6. Droop Speed Setting

The droop schedule is based on a full 75 degrees of actuator rotation between minimum and maximum fuel. If less than 75 degrees of rotation is used, the amount of droop is reduced proportionally. Thus a control programmed for 5% droop will actually only have 2.5% droop if only 37.5° of actuator rotation is used, from no load to full load. Using only 37.5° of actuator travel will require programming 10% droop for an actual 5% droop curve (a minimum of 66° of travel is recommended).

## Power Up Diagnostics

The Power Up Diagnostics feature is provided to verify the proper operation of the microprocessor and memory components. The diagnostics take about ten seconds after the control is powered on. A failure of the test will turn off the output of the control. The ProAct control will not increase actuator signal from zero until diagnostics are complete.

## ProAct Actuator

The ProAct actuator is a limited-angle rotational torque motor designed specifically for the control of engine fuel. The torque motor is a “run-hold” device. It responds to a fuel-position error at full speed until the position feedback causes the electronic control to change the current signal to hold position. This characteristic makes the actuator extremely fast and at the same time extremely accurate and “stiff” in engine-fuel control.

The ProAct II uses a four-pole torque motor design to provide 2.7 N·m (2.0 lb-ft) of torque (3.4 J/2.5 ft-lb work) with 6 A, 24 V input at steady state, and 5.4 N·m (4.0 lb-ft) of torque (6.8 J/5.0 ft-lb work) with 12 A, 24 V input during transient.

The actuator is equipped with internal stop springs which allow rotational overshoot of 3° in each direction. The internal spring stops are necessary to halt the rotation of rotor and load inertia without damage to the actuator. This possible over-rotation of 3° in both directions must be considered when designing linkage or connecting to the butterfly shaft.

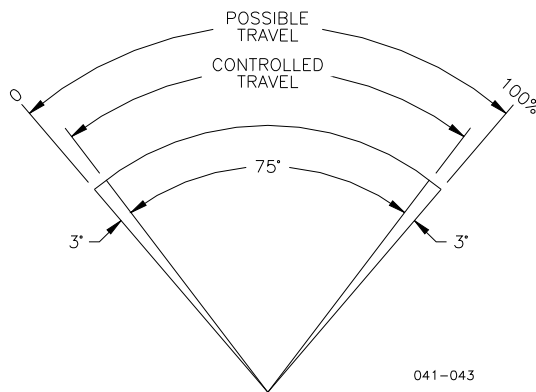


Figure 2-7. ProAct Output Travel

The terminal shaft on the actuator provides 0.500-36 (inch) serrations. The output shaft is connected to the butterfly valve or fuel control shaft either directly through a zero-backlash flexible coupling\* or through an attached lever and linkage. Installations should attempt to use as much of the actuator rotation as possible to use as much of the actuator's work capability as possible.

\*—When a flexible coupling is used, take care to assure that the maximum coupling misalignment is not exceeded and that the coupling is sized properly for the loads.

## Return Spring

The ProAct actuator has an internal return spring designed to move the actuator toward minimum fuel in case the electrical control should fail, or power is removed. Spring scale may not be enough to move the engine to shutdown.

### **WARNING**

The fuel system should be equipped with a spring return to minimum fuel capable of moving the fuel control in case of failure in the ProAct system, the connections between the ProAct actuator and the fuel control, or loss of electrical power. The return spring should be of sufficient force to return the fuel system to minimum fuel on loss of actuator control, but should not limit the actuator's ability to properly control the engine under all operating conditions.

## The Feedback Device

The ProAct actuator uses a brushless, magneto-resistive position sensor. The position feedback signal to the digital control is responsible for the accurate positioning of the actuator.

## ProAct 75 Actuator Selection

The actuator installed must match the system requirements. Select the actuator with either an MS connector or a conduit fitting with clockwise or counterclockwise rotation\*.

\*—Directions are determined by looking at the actuator shaft and the rotation to increase fuel.

## Chapter 3. Installation

### Unpacking

Before handling the control, read page iii, Electrostatic Discharge Awareness. Be careful when unpacking the electronic control. Check the control for signs of damage such as bent panels, scratches, and loose or broken parts. If any damage is found, immediately notify the shipper.

The ProAct™ actuator will come in a separate carton from the control. Inspect the carton for damage. The actuator is a rugged, heavy device and shipping damage is unlikely. Particularly inspect the receptacle and terminal shaft for possible damage.

### Power Requirements

The ProAct II control system requires a voltage source of 18 to 32 Vdc (24 Vdc nominal) uninterrupted power supply. Maximum power consumption is 125 W at rated voltage. The ProAct I system requires a voltage source of 8 to 32 Vdc (12 or 24 Vdc nominal). Maximum power consumption is 50 W at rated voltage.

**NOTICE**

To prevent damage to the control, do not exceed the input voltage range.

**IMPORTANT**

If a battery is used for operating power, an alternator or other battery charging device is necessary to maintain a stable supply voltage.

**NOTICE**

To prevent damage to the control, make sure that the alternator or other battery-charging device is turned off or disconnected before disconnecting the battery from the control.

### Control Box Location Considerations

Consider these requirements when selecting the mounting location for the ProAct control:

- adequate ventilation for cooling
- space for servicing and repair
- 54 inches (1.4 m) of connecting cord is provided with the Hand Held Programmer. If the location does not allow comfortable use of the programmer, an extension cord should be obtained at the time of installation. The RS-422 communications will allow a lengthy extension cord.
- protection from direct exposure to water or condensation-prone environment
- protection from high-voltage or high-current devices, or devices which produce electromagnetic interference
- avoidance of vibration
- selection of a location that will provide an operating temperature range of  $-40$  to  $+70$  °C ( $-40$  to  $+158$  °F).

The Digital Speed Control must NOT be mounted on the engine.

## Actuator Installation Considerations

### Thermal

The actuator is designed for installation on the engine. The actuator will generate heat, especially when stalled.

The feedback sensor located on the actuator has a maximum temperature limitation of 125 °C (257 °F). Should the actuator be shielded from air circulation, the installer must consider the heat conductivity of the installation bracket, and the operating temperature of the ultimate heat sink to which the bracket will be attached. Generally the heat transfer abilities of aluminum and low-carbon steel are better than high-carbon steel or stainless steel. Contact Woodward if operating temperature is a concern.

### Output Coupling or Linkage

The actuator will provide up to 75° rotation from minimum to maximum positions. This will allow direct installation to most butterfly shafts. Special connectors that permit the installation of the actuator directly to a butterfly valve shaft are available. The coupling selected (or any linkage used) must be of zero backlash design. If a coupling is used it should be drilled and pinned, or serrated.

The bracket that mounts the actuator must be of adequate precision to assure that misalignment limits of the coupling used are not exceeded. Contact Woodward for help in selection of an approved coupling.

Diesel engines will generally useless rotation, often about 30 degrees. Linkage should be designed to use as much actuator rotation as possible to take advantage of the actuator's full work capability. (If only 30 degrees of actuator rotation is used, the actuator will provide only 40 percent of its work capability.)

## Fuel Position Stops

Diesel installations will generally use the fuel system minimum and maximum position stops. The actuator travel should be centered within the total rotation needed from minimum to maximum fuel.

Diesel engine racks are normally designed to provide the minimum and maximum stops without binding.

Butterfly valves in carburetors will often bind if rotated too far toward minimum or maximum. For this reason, the stops in the actuator should be used at both minimum and maximum positions. Note that the stops will allow up to 3° of additional rotation in both directions during impact.

Make sure that the engine will always shut down when the actuator is at the minimum stop.

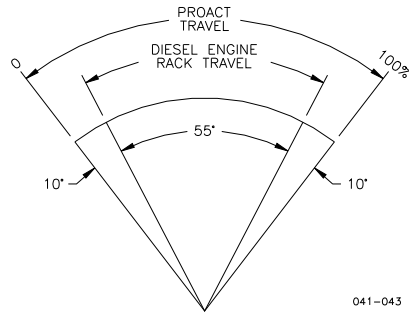


Figure 3-1. Diesel Engine Travel Stops

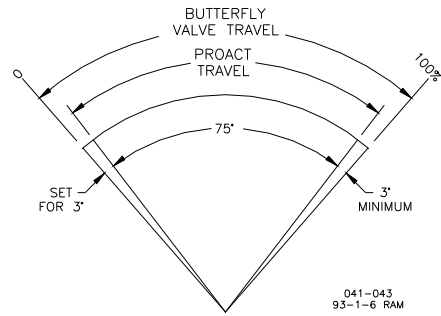
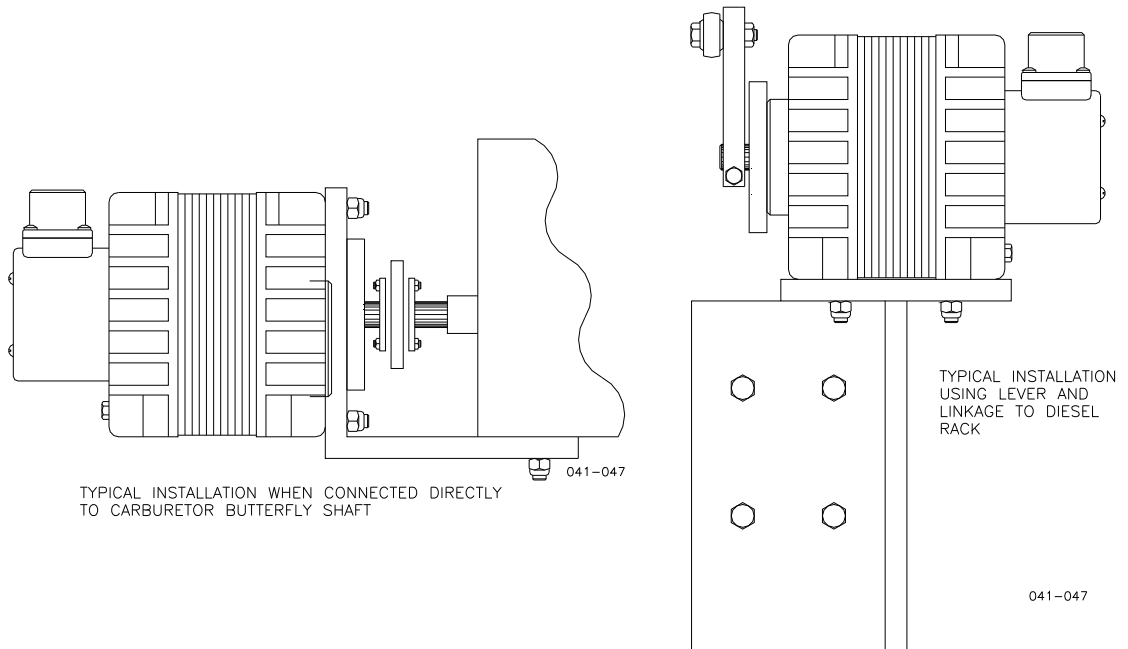


Figure 3-2. Carburetor Travel Stops

### Actuator Bracket

The actuator may be installed on a bracket holding to the 2.248–2.251 inch diameter male pilot concentric to the terminal shaft or to a bracket which attaches to the base with four .312-18 screws with a minimum engagement of 16 mm (0.625 inch). The actuator may be mounted in any attitude. The actuator is weather proof and resistant to the corrosive effects of water and salt water, however pressure washing of the feedback device side of the actuator should be minimized.



Replace the four outside through bolts with longer .250-20 bolts when mounting on a fixture locating on the pilot diameter. Torque the bolts to 7.3 to 8.5 N·m (65 to 75 lb-in).

NOTICE

The actuator will fall apart if the inner bolts are removed.

When mounting on the bottom of the actuator, torque the attaching bolts to 17 to 18 N·m (150 to 160 lb-in).

Figure 3-3. Examples of Actuator Brackets



## Electrical Connections

External wiring connections and shielding requirements for a typical control installation are shown in the wiring diagram. The wiring connections are explained in the rest of this chapter.

### Shielded Wiring

All shielded cable must be twisted conductor pairs. Do not attempt to tin the braided shield. All signal lines should be shielded to prevent picking up stray signals from adjacent equipment. Connect the shields to the nearest chassis ground. Wire exposed beyond the shield should be as short as possible, not exceeding 50 mm (2 inches). The other end of the shields must be left open and insulated from any other conductor. **DO NOT** run shielded signal wires along with other wires carrying large currents. See Woodward manual 50532, *EMI Control for Electronic Governing Systems*, for more information.

Where shielded cable is required, cut the cable to the desired length and prepare the cable as instructed below.

1. Strip outer insulation from **BOTH ENDS**, exposing the braided or spiral wrapped shield. **DO NOT CUT THE SHIELD.**
2. Using a sharp, pointed tool, carefully spread the strands of the shield.
3. Pull the inner conductor(s) out of the shield. If the shield is the braided type, twist it to prevent fraying.
4. Remove 6 mm (1/4 inch) of insulation from the inner conductors.

The shield must be considered as a separate circuit when wiring the system. The shield must be carried through connectors without interruption.

Installations with severe electromagnetic interference (EMI) may require additional shielding precautions. Contact Woodward for more information.

Failure to provide shielding can produce future conditions which are difficult to diagnose. Proper shielding at the time of installation is required to assure satisfactory operation of the speed control system.

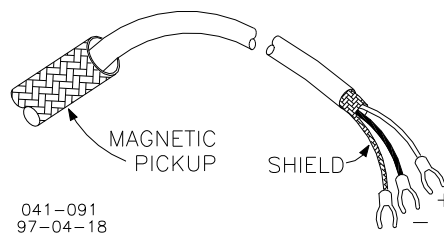
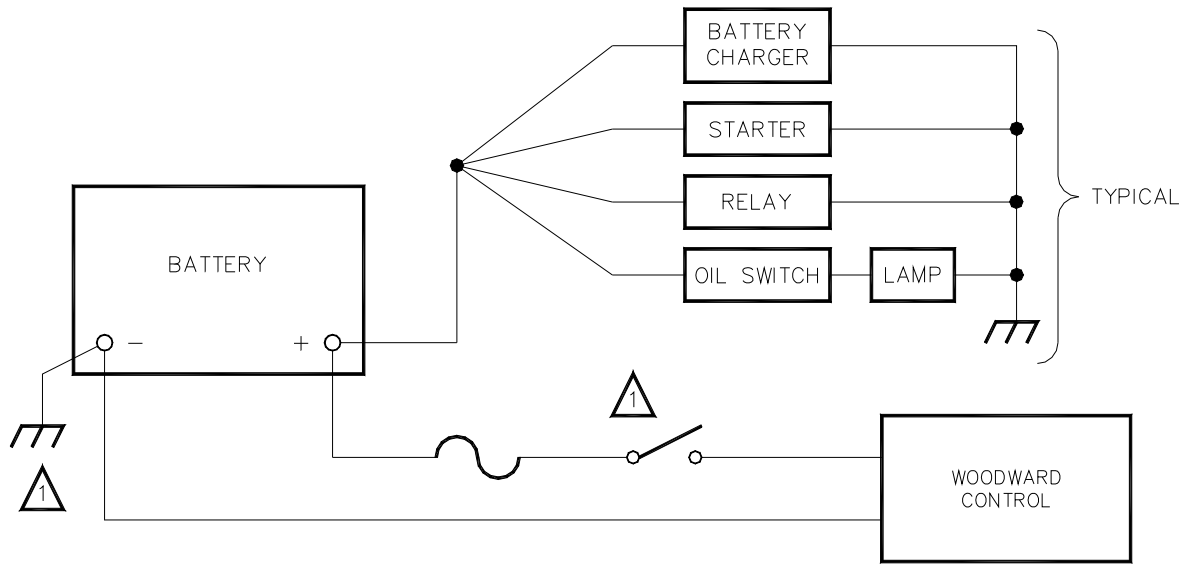


Figure 3-4. Preparing Shielded Wiring

## Power Supply

The power supply output must be low impedance (for example, directly from batteries).



RIGHT

NOTE:


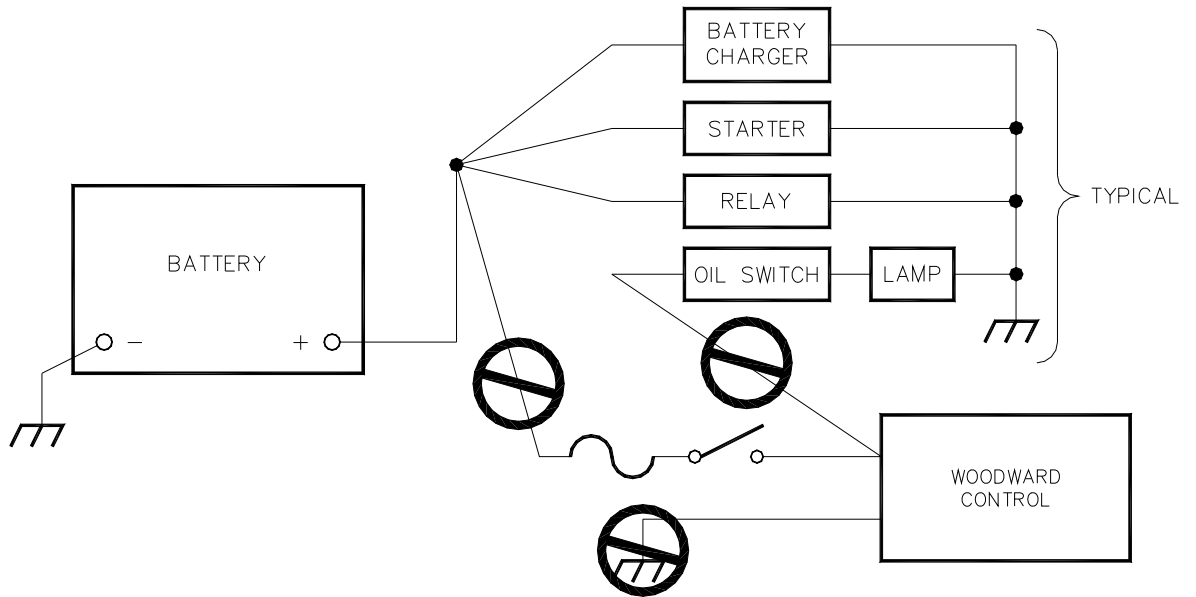
 A NEGATIVE GROUND SYSTEM IS SHOWN. IF A POSITIVE GROUND SYSTEM IS USED, THE SWITCH AND FUSE MUST BE LOCATED IN SERIES WITH BATTERY (-) AND TERMINAL (TB1-2) ON THE WOODWARD CONTROL. THE POSITIVE TERMINAL BECOMES CHASSIS GROUND.

Figure 3-5. Correct Wiring to Power Supply



WRONG

824-143  
97-08-22 skw

Figure 3-6. Incorrect Power Supply Wiring

Run the power leads directly from the power source to the control. DO NOT POWER OTHER DEVICES WITH LEADS COMMON TO THE CONTROL. Avoid long wire lengths. Connect the positive (line) to terminal 24 and the negative (common) to terminal 25. If the power source is a battery, be sure the system includes an alternator or other battery-charging device.

DO NOT turn off control power as part of a normal shutdown procedure. Use the Run/Stop discrete input (terminal 23) for normal shutdown.

**NOTICE**

Do NOT apply power to the control at this time. Applying power may damage the control.

**NOTICE**

To prevent damage to the engine, apply power to the ProAct control for at least ten seconds before starting the engine. The control must have time to perform its power-up diagnostics and become operational. Do not attempt to start the engine if the diagnostic tests fail, because test failure turns off the output of the control.

**NOTICE**

To prevent possible damage to the control or poor control performance resulting from ground loop problems, follow the electrical connection instructions. The control common is electrically isolated from the power supply input.

## Actuator and Position Feedback Wiring

The ProAct actuator will rotate in either direction. In models I and II, the actuator direction of rotation is selected by wiring in the actuator and the drift spring.

Connect the actuator wiring from the actuator to the ProAct control to terminals 1 (+) and 2 (-). Connect the actuator position feedback wires to terminals 7 (+), 8 (0), and 9 (-). Position feedback nominal voltages are approximately 3 V at minimum actuator position and 2 V at maximum actuator position.

## Discrete Inputs

Discrete inputs are the switch input commands to the ProAct Digital Speed Control. The discrete inputs are usually powered by the positive power supply.

### Isoch/Droop Contact

The Isoch/Droop contact (open for droop, closed for isochronous) connects to terminal 16. When terminal 16 is open, the ProAct control will operate in droop at the percentage entered in menu 3. When closed, the control will operate in isochronous.

The percent of droop entered in Menu 3 is based on 75° of actuator rotation between minimum and maximum positions. If the installation uses less than 75°, the amount of droop must be increased proportionally.

## Idle/Rated Contact

The Idle/Rated contact (open for Idle, closed for Rated) connects to terminal 17. When the Idle/Rated contact is closed, the control immediately switches the fuel limit to the maximum limit or torque limit (whichever is less) and ramps engine speed to the rated speed set point (or the speed specified by the Remote Input when the Remote Speed Setting input at terminal 21 is enabled). When the Idle/Rated contact is opened, the control ramps engine speed to the idle speed setting.

The idle set point cannot be set above the rated set point. The fuel limiters (start, torque, and maximum) remain effective regardless of the Remote Reference input.

## Lower and Raise Speed Contacts

The Lower Speed contact connects to terminal 18. Raise and Lower inputs are effective only if the control is in Rated. When the Lower Speed contact is closed, the control lowers speed at a rate determined by the Lower Rate set point. When the contact is open, speed remains at its current value. Closing the Lower Speed contact will cancel the ramps started by the Idle/Rated contact.

The Raise Speed contact connects to terminal 19. When the Raise Speed contact is closed, the control raises speed at a rate determined by the Raise Rate set point. When the contact is open, speed remains at its current value. Closing the Raise Speed contact will cancel the ramps started by the Idle/Rated contact.

Closing both Raise and Lower contacts at the same time will disable Raise and Lower speeds as long as both contacts are closed.

The Raise and Lower Speed contacts are disabled when the Remote Speed Setting mode is selected.

## Alternate Dynamics

The Alternate Dynamics contact connects to terminal 20. When this contact is open, Dynamics set 1 is selected. When this contact is closed, Alternate Dynamics is selected.

## Remote Reference

When Remote Reference is selected by closing the contacts to terminal 18, the Raise and Lower Speed inputs are disabled. The speed reference setting is based on the value of current in the remote speed reference input. When the contacts to terminal 21 are open and the Run/Stop switch is toggled, the Raise Speed and Lower Speed inputs are enabled. The remote speed reference is a 4–20 mA input. The remote speed reference range is tailored in menu 3.

A remote reference of less than 2 mA is considered failed, and the control will remain at the last speed setting. To return to rated speed, the remote switch must be open and the Run/Stop switch toggled.

## Diagnostics Request

The Diagnostics Request contact connects to terminal 22 and is used during factory testing of the control. This terminal should be left open during installation.

## Run/Stop Fuel Contact

The Run/Stop contact (terminal 23) is the preferred means for a normal shutdown of the engine. The control will not operate without voltage applied to terminal 23. When the contact is closed, the voltage applied to terminal 23 allows the control to move the actuator as required for operating conditions.



### **WARNING**

**The Run/Stop contact is not intended for use in any emergency stop sequence. To prevent possible serious injury from an overspeeding engine, do NOT use the Run/Stop contact as part of any emergency stop sequence.**

## Speed Signal Input

Connect a magnetic pickup (MPU) to terminals 10 and 11 using shielded wire. Connect the shield to the chassis only. Do not connect the shield at the MPU end. Make sure the shield has continuity the entire distance to the speed sensor, and make sure the shield is insulated from all other conducting surfaces.

We recommend that the MPU be dedicated to the control. The MPU output should be from 1 to 60 Vrms.

The Number of Gear Teeth is the number of teeth which will be exposed to the speed sensing device during one revolution of the engine. Should the sensed gear not rotate at engine speed, the number of teeth must be adjusted to reflect the proportion of engine speed to the sensed gear speed. The Number of Gear Teeth is tuned (entered) in Configuration Menu (Menu 6).



### **WARNING**

**The Number of Gear Teeth is used by the control to convert pulses from the speed-sensing device to engine rpm. To prevent possible serious injury from an overspeeding engine, make sure the control is properly programmed to convert the gear-tooth count into engine rpm. Improper conversion could cause engine overspeed.**

## Remote Speed Setting Input

Connect the 4 to 20 mA current transmitter or 1 to 5 Vdc voltage transmitter to terminals 14 (+) and 15 (-). Use a shielded, twisted-pair cable. Connect the shield to the control chassis only.

## Aux Voltage Input

Connect the output of a Woodward Load Sensor (if used) to terminals 12 (+) and 13 (-). Use a shielded twisted-pair cable. Wire the remainder of the load sensor in accordance with the wiring diagram for the sensor used.

## Control Outputs

### Actuator Control

The actuator is connected to terminals 1 (+) and 2 (-). The polarity of this connection must be correct if the actuator is to respond in the desired rotational direction. The actuator cannot be reversed by changing the polarity because of the factory-installed return spring. Use 4 mm<sup>2</sup> (12 AWG) wire to the actuator. The total length of the pairs of wires between the actuator and the control and between the battery and the control should not exceed 23 m (75 ft).

### Speed Switches

Terminals 3, 4, and 5 provide the outputs from speed switches A, B, and C. These outputs close a circuit to the power supply (+). The speed switches are rated to 500 mA. The output will operate a signal lamp directly, or may be connected to an intermediate relay to conduct heavier switch operations. The switch is a low side switch which connects the device attached to the switch to ground. The total length of the wire between the speed switches and the signal lamp or relay should not exceed 8 m (26 ft).

The switches are configured in Menu 3 and operate as shown in Figure 3-7.

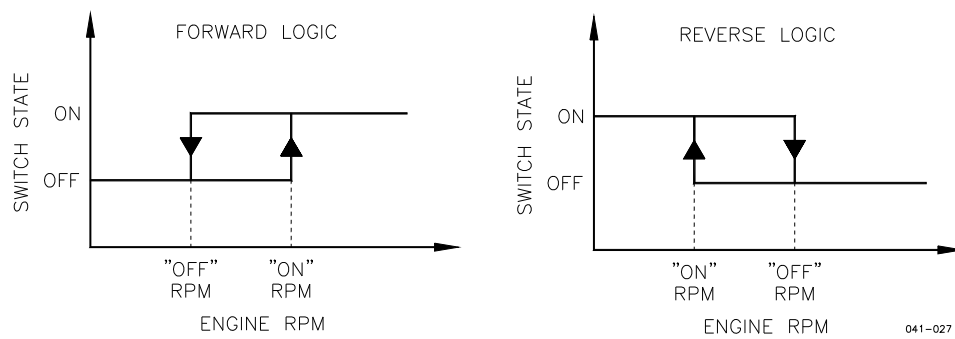


Figure 3-7. Speed Switch Operation

### Fault Lamp

Terminal 6 provides the output for the fault lamp indicator. This output closes a circuit to the power supply (+) and is rated for 500 mA to indicate a fault. The output will operate a signal lamp directly, or may be connected to an intermediate relay to conduct heavier switch operations. The faults indicated are actuator position feedback out of range ( $0.5 \text{ Vdc} < V_{\text{position}} < 4.5 \text{ Vdc}$ ), actuator driver circuit open, or actuator overcurrent. The total length of the wire between the speed switches and the signal lamp or relay should not exceed 8 m (26 ft).

### Actuator Position Feedback

Shielded wire must be connected to the Actuator Position Feedback terminals 7, 8, and 9. The shield must be continuous and grounded at the control end only to prevent interference with the position feedback signal.

## Installation Checkout Procedure

With the installation complete as described in this chapter, do the following check out procedure before beginning the start-up adjustments in Chapter 4.

1. Visual inspection
  - A. Check the linkage or coupling between the actuator and fuel metering device for looseness or binding.
  - B. Check for correct wiring in accordance with the wiring diagram (Figure 1-5).
  - C. Check for broken terminals and loose terminal screws.
  - D. Check the speed sensor for visible damage. If the sensor is a magnetic pickup, check the clearance between the gear and the sensor, and adjust if necessary. Clearance should be between 0.25 and 1.25 mm (0.010 and 0.050 inch) at the closest point. Make sure the gear runout does not exceed the pickup clearance.

2. Check for grounds

Check for grounds by measuring the resistance from all control terminals to chassis. All terminals except terminals 9, 11, and 25, should measure infinite resistance (the resistance of terminals 9 and 11 depends on whether a floating or grounded power source is used). If a resistance less than infinite is obtained, remove the connections from each terminal one at a time until the resistance is infinite. Check the line that was removed last to locate the fault.

3. Stroking the actuator

The actuator may be stroked electronically using the failsafe override in Menu 6 and the start fuel limiter in Menu 4.

### **IMPORTANT**

**Do not crank or attempt to start the engine during this procedure.**

- A. Verify the Run/Stop contact is open or in the stop mode.
- B. Set the Start Fuel Limiter (Menu 4) to 50% to 90%.
- C. Go to Menu 6 and enter Configuration Key (49). Step down to the Failsafe function and disable it.
- D. Close the Run/Stop contact to run mode.
- E. Go to Start Fuel Limiter (Menu 4) and move the set point up or down. Verify the actuator follows.
- F. Open the Run/Stop contact. Verify the actuator goes to the minimum fuel position (forward acting).

4. Chassis Ground

Check for resistance from chassis to earth ground. The resistance should be zero. If earth ground is not available, tie the chassis to system ground, battery positive or negative.

5. Go to Menu 6, enter Configuration Key (49), and enable the Failsafe switch.

### **WARNING**

**To prevent possible serious injury from an overspeeding engine, it is important to have the Failsafe switch enabled prior to cranking the engine.**

## Chapter 4. Operation and Adjustment

### Introduction

Because of the variety of installations, plus system and component tolerances, the control must be tuned to each system for optimum performance.

This chapter contains information on control calibration. It includes initial prestart-up and start-up settings and adjustments.



#### **WARNING**

**An improperly calibrated control could cause an engine overspeed or other damage to the engine. To prevent possible serious injury from an overspeeding engine, read this entire procedure before starting the engine.**

### Using the Hand Held Programmer

The Hand Held Programmer (Figure 4-1) is a hand-held terminal, powered by the ProAct™ Digital Speed Control. The terminal connects to the RS-422 D connector port on the control. Firmly seat the connector on the terminal into J1. Control boxes are equipped with a cover which must be removed to access the J1 receptacle and the two other terminal strips.

When power is applied to the terminal by plugging it into the control, it performs a power-up self-test. Upon successful completion of the self-test, the screen will remain blank. Press the ID key to display the part number and revision level of the software in the control. Refer to this number and revision level in any correspondence with Woodward.

The programmer screen is a four line, back-lighted LCD display. The display permits the user to look at two separate functions or menu items at the same time. Use the “up/down arrow” key to toggle between the two displayed items. The first letter of the active menu will blink.

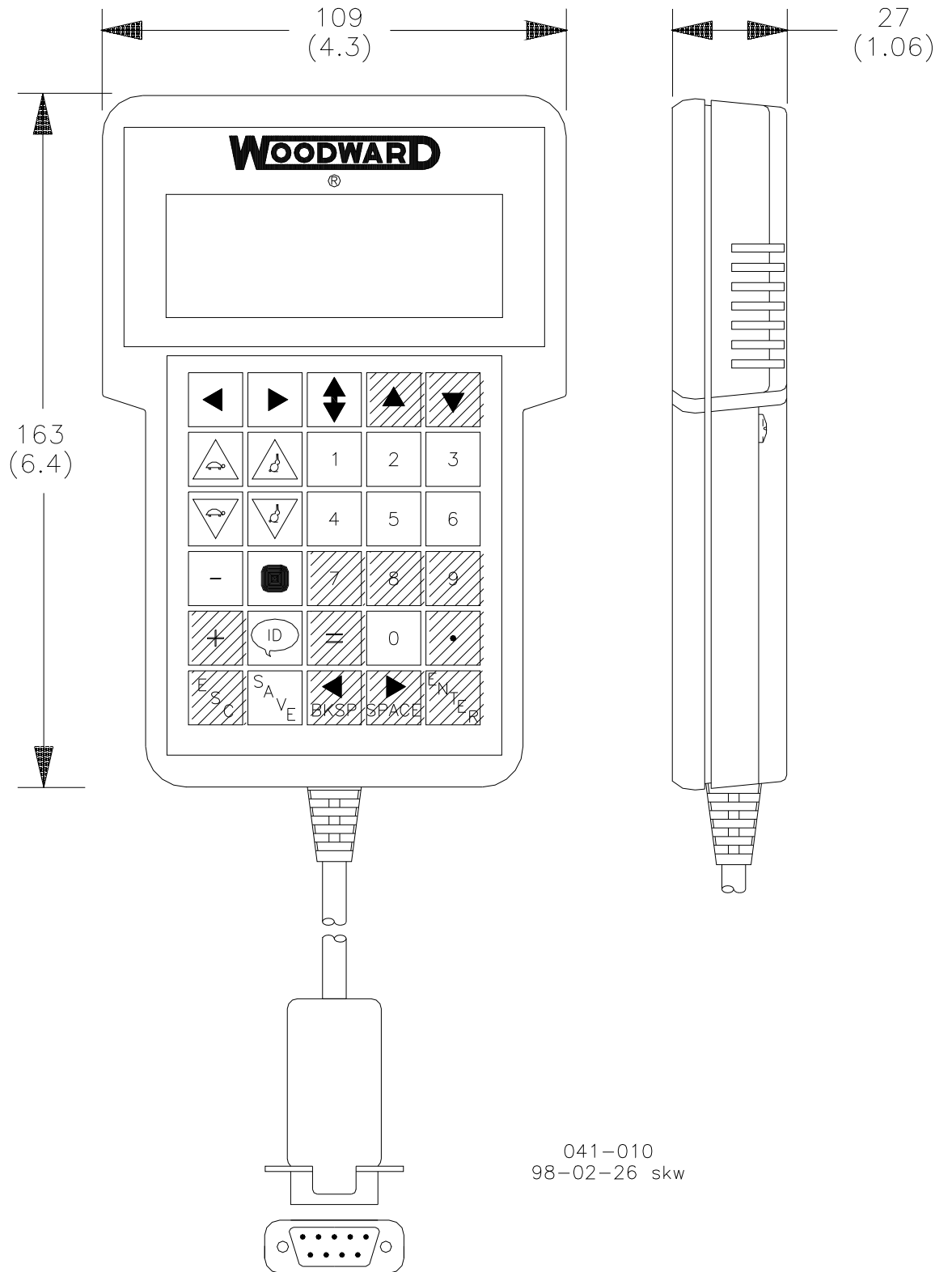
Changes recorded in the menus may be lost should the ProAct control be powered down. Push the SAVE key to permanently record changes before leaving a menu.



Only the keys listed above are used. Other keys are not used.

### **Key Function**

|               |   |
|---------------|---|
| left arrow    | Steps backward through the selected menu.   |
| right arrow   | Steps forward through the selected menu.  |
| up/down arrow | Toggles between the upper two-line menu display and the lower two-line menu display.  |
| up arrow      | NOT USED.   |
| down arrow    | NOT USED.   |
| turtle up     | Increases the displayed set point slowly.   |
| turtle down   | Decreases the displayed set point slowly.   |
| rabbit up     | Increases the displayed set point rapidly.  |
| rabbit down   | Decreases the displayed set point rapidly.  |
| 1,2,3,4,5,6,0 | Accesses Menus 1, 2, 3, 4, 5, 6, or 0. (Number keys are NOT used to change displayed values.)   |
| 7,8,9         | NOT USED.   |
| -             | Removes an inactive menu from the display screen. (This is the only function of the minus key.)   |
| +             | NOT USED.   |
| black square  | Clears the error log from the programmer.   |
| ID            | Displays the software part number and revision. Use this information when contacting Woodward or an authorized service facility.  |
| =             | NOT USED.   |
| •             | NOT USED.   |
| ESC           | NOT USED.   |
| SAVE          | Permanently saves changes made to a menu. Changes are NOT saved until the SAVE key is pressed. If the control is powered off before pressing SAVE, the entries will revert back to their previously saved values. |
| BKSP          | NOT USED.   |
| SPACE         | NOT USED.   |
| ENTER         | NOT USED.   |



The Programmer comes with a 54 inch long connecting cable and a "D" connector.

Figure 4-1. Hand Held Programmer (9907-205)

## ProAct Control Menus

### Menu 1—Dynamics Settings

| Menu Item    | Low Value | Default Value | High Value | Units   |
|--------------|-----------|---------------|------------|---------|
| Gain A       | 0.0003    | 0.25          | 10.00      | NA      |
| Gain A BP    | 0.00      | 0             | 100.00     | %       |
| Gain B       | 0.0003    | 0.25          | 10.00      | NA      |
| Gain B BP    | 0.00      | 30            | 100.00     | %       |
| Gain C       | 0.0003    | 0.25          | 10.00      | NA      |
| Gain C BP    | 0.00      | 60            | 100.00     | %       |
| Gain D       | 0.0003    | 0.25          | 10.00      | NA      |
| Gain D BP    | 0.00      | 100           | 100.00     | %       |
| Stability    | 0.00      | 0.25          | 10.00      | seconds |
| Compensation | 0.00      | 0.10          | 10.00      | seconds |
| Gain Ratio   | 1.00      | 1.00          | 50.00      | NA      |
| Window Width | 0.00      | 60            | 2000.00    | rpm     |

### Menu 2—Alternate Dynamics Settings

| Menu Item        | Low Value | Default Value | High Value | Units   |
|------------------|-----------|---------------|------------|---------|
| Alt Gain A       | 0.0003    | 0.10          | 10.00      | NA      |
| Alt Gain A BP    | 0.00      | 0             | 100.00     | %       |
| Alt Gain B       | 0.0003    | 0.10          | 10.00      | NA      |
| Alt Gain B BP    | 0.00      | 30            | 100.00     | %       |
| Alt Gain C       | 0.0003    | 0.10          | 10.00      | NA      |
| Alt Gain C BP    | 0.00      | 60            | 100.00     | %       |
| Alt Gain D       | 0.0003    | 0.10          | 10.00      | NA      |
| Alt Gain D BP    | 0.00      | 100           | 100.00     | %       |
| Alt Stability    | 0.00      | 1.0           | 10.00      | seconds |
| Alt Compensation | 0.00      | 0.20          | 10.00      | seconds |
| Alt Gain Ratio   | 1.00      | 1             | 50.00      | NA      |
| Alt Window Width | 0.00      | 60            | 2000.00    | rpm     |

### Menu 3—Speed Reference Settings

| Menu Item          | Low Value | Default Value | High Value | Units      |
|--------------------|-----------|---------------|------------|------------|
| Rated Speed        | 0         | 1800          | 2100       | rpm        |
| Idle Speed         | 0         | 1200          | 2100       | rpm        |
| Raise Limit        | 0         | 1890          | 2100       | rpm        |
| Lower Limit        | 0         | 1200          | 2100       | rpm        |
| Accel Time         | 0         | 8             | 500        | seconds    |
| Decel Time         | 0         | 8             | 500        | seconds    |
| Raise Rate         | 0         | 2500          | 9999       | rpm/minute |
| Lower Rate         | 0         | 2500          | 9999       | rpm/minute |
| 20 mA Remote Ref.  | 0         | 1890          | 2100       | rpm        |
| 4 mA Remote Ref.   | 0         | 1710          | 2100       | rpm        |
| Droop              | 0         | 5%            | 100        | %          |
| Idle Droop         | 0         | 0             | 100        | %          |
| Idle Droop BP      | 0         | 0             | 100        | %          |
| Speed Switch A On  | 0         | 600           | 2100       | rpm        |
| Speed Switch A Off | 0         | 540           | 2100       | rpm        |
| Speed Switch B On  | 0         | 1200          | 2100       | rpm        |
| Speed Switch B Off | 0         | 1140          | 2100       | rpm        |
| Speed Switch C On  | 0         | 2000          | 2100       | rpm        |
| Speed Switch C Off | 0         | 1900          | 2100       | rpm        |

## Menu 4—Limiter Settings

| Menu Item           | Low Value | Default Value | High Value | Units    |
|---------------------|-----------|---------------|------------|----------|
| Max Fuel Limit      | 0         | 100           | 100        | %        |
| Transient Over Fuel | 0         | 0             | 100        | %        |
| Transient Time      | 0         | 0             | 10         | seconds  |
| Start Fuel Limit    | 0         | 40            | 100        | %        |
| Start Ramp Rate     | 0         | 1             | 20         | %/second |
| Start Speed         | 0         | 400           | 1200       | rpm      |
| Min Torque Limit    | 0         | 50            | 100        | %        |
| Torque Limit BP     | 0         | 1500          | 2100       | rpm      |
| Torque Limit at BP  | 0         | 70            | 100        | %        |
| Max Torque Limit    | 0         | 90            | 100        | %        |

## Menu 5—Monitor Menu

|                           |             |
|---------------------------|-------------|
| Speed                     | rpm         |
| Speed Reference           | rpm         |
| Actuator Output           | %           |
| Aux Input                 | volts       |
| Remote Input              | mA          |
| Run/Stop Switch           | Open/Closed |
| Idle Rated Switch         | Open/Closed |
| Raise Switch              | Open/Closed |
| Lower Switch              | Open/Closed |
| Alternate Dynamics Switch | Open/Closed |
| Remote Reference Switch   | Open/Closed |
| Isoch Switch              | Open/Closed |
| Diagnostic Switch         | Open/Closed |
| Speed Switch A            | On/Off      |
| Speed Switch B            | On/Off      |
| Speed Switch C            | On/Off      |
| Fault Lamp                | On/Off      |

## Menu 6—Configuration Set Points

| Menu Item            | Low Value | Default Value | High Value | Units |
|----------------------|-----------|---------------|------------|-------|
| *Configuration Key   | 0         | 0             | 100        | NA*   |
| Number of Gear Teeth | 4         | 60            | 500        | NA    |
| Dynamics Map         | Linear    | Linear        | Nonlinear  | NA    |
| Failsafe Function    | Disabled  | Enabled       | Enabled    | NA    |

\*—Must be set at "49" before any changes can be made. Engine must be at 0 rpm and the Run/Stop at OPEN to make any changes in this menu.



### WARNING

The Failsafe Function must be enabled during normal engine operation to prevent possible overspeed should the MPU signal be lost for any reason. As soon as the control senses engine speed, the failsafe becomes enabled. The function can be overridden to allow some slow cranking engines to start, and to test parts of the governor system without running the engine. Failure to enable the Failsafe Function could allow overspeed with resulting damage to equipment and possible personal injury or death.

## Menu 0—Error Menu

| Menu Item        | Default | Units |
|------------------|---------|-------|
| Active Errors    | None    | N/A   |
| Logged Errors    | None    | N/A   |
| Self Test Result | 49*     | N/A   |

\*—The correct result is 49. Contact Woodward if the result is not 49.

Configuration, Menu 6, may be viewed at anytime. However, the engine must be shut down and the entry code must be increased from "0" to "49" before changes can be made to Menu 6.

### NOTICE

To prevent possible damage to the engine resulting from improper control settings, make sure you **SAVE** the set points before removing power from the control. Failure to **SAVE** the set points before removing power from the control causes them to revert to the previously saved settings.

## Description of Menu Set Points

### Menu 1—Dynamics Settings

The four Gain set points and break points determine the actuator response to a change in speed or load. These settings can vary as a percent of existing load in nonlinear fuel systems. The adjustments are settings that affect the stability and transient performance of the engine. A large number will provide a faster response to an error between actual speed and reference speed. A small number will provide a slower response to an observed error in speed.

Gain becomes an important portion of the programming that determines the response and stability of an engine.

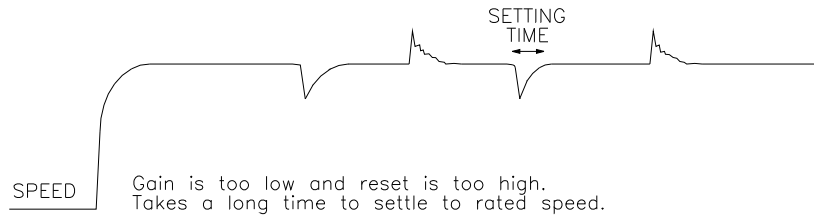
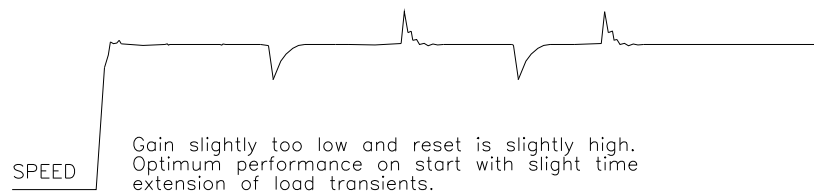
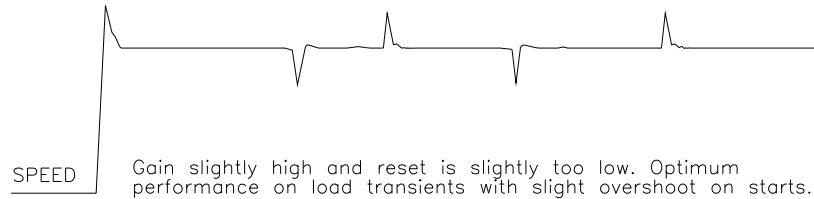
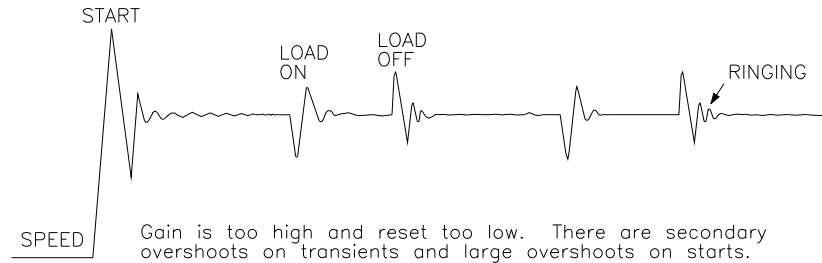
The control provides two sets of dynamics. Menu 1 sets the primary (normal) dynamics. Menu 2 provides a second set of dynamics for use with an alternate fuel or other conditions which require different control factors.

The set of dynamics being used is selected by the Alternate Dynamics contact input (open for normal dynamics and closed for alternate dynamics).

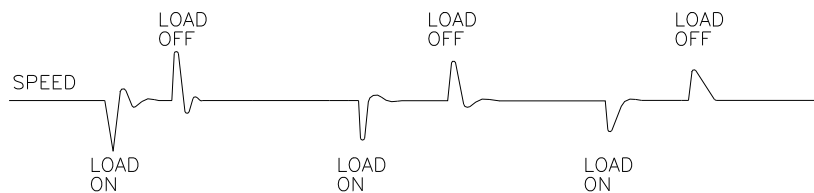
The following descriptions apply to either set of dynamics. See Figures 4-1 through 4-4.

The four Gain and Gain Breakpoint settings in Menus 1 and 2 provide different response scales to changes in load or speed depending on the existing actuator position. This allows the ProAct control to be programmed to provide a response scale that matches the engine response over the no load to full load range.

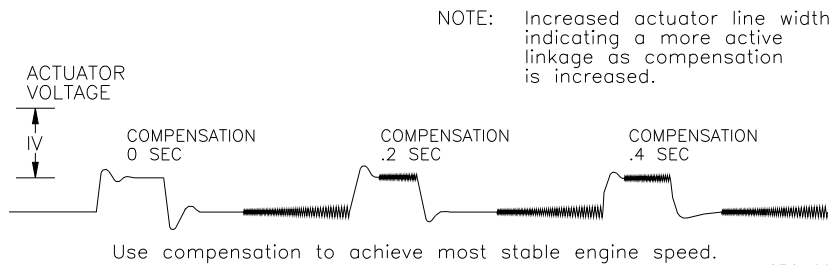
RESULTS – GAIN AND STABILITY ADJUSTMENTS



IDEAL LOAD STEP RESPONSE



RESULTS – COMPENSATION ADJUSTMENT

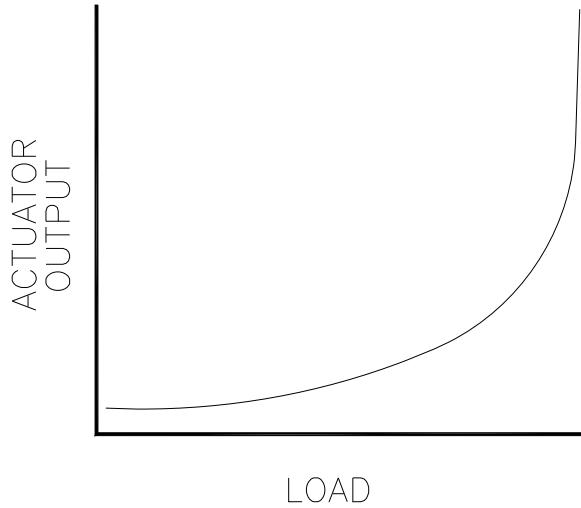


851-004

Figure 4-2. Typical Transient Response Curves

### Gas Engine Setup

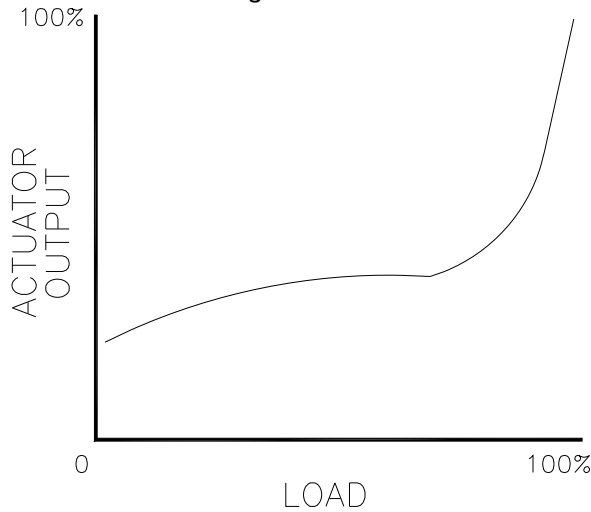
Change in the butterfly valve position is not linear in comparison to engine power output. In naturally-aspirated (non-turbocharged) engines, the position of the valve in comparison to engine output appears on a chart similar to Figure 4-2.



041-090  
93-4-8 RAM

Figure 4-3. Non-linear Valve Power Curve

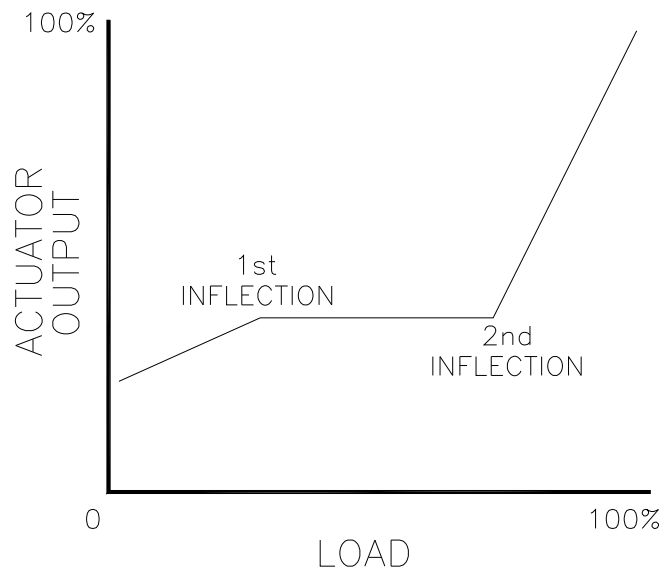
Turbocharged engines distort this curve, particularly as turbo pressure builds to the point of operating the waste gate. A turbocharged gas engine will likely have a butterfly position chart similar to Figure 4-4.



041-090A  
00-05-16

Figure 4-4. Sample Engine Plot

Note in both charts that valve position falls on a curve. The ProAct menu does not permit the construction of a curve. However, with four slope segments available, a rough approximation of the curve can be created (see Figure 4-5).



041-090B  
00-05-16

Figure 4-5. Linearized Engine Plot

## Diesel Engine Setup

Most Diesel engine fuel controls are nearly linear. The dynamics maps may still be used to accommodate nonlinear conditions caused either by the fuel system or by linkage between the actuator and the rack. For gain settings that are not used, set the associated Breakpoint at 100%.

## Control Gain Programming Steps

1. Gain programming is needed whenever the gain of the engine and fuel system is non-linear. This usually occurs in gas engine applications. A plot of the fuel system must be determined to properly adjust the gain of the control to match the gain of the system at all loads.

The plot reflects the actuator output, as seen in Menu 5, versus the engine load as load is varied from no load to full load.

To construct a gain plot:

- a. Set the Gain A breakpoint for 100%. This ensures that there won't be any confusion with other settings while plotting the system characteristics. Only Gain A, Stability, and Actuator Compensation will be used.
- b. Start the engine and obtain good control at no load using Gain A, Stability, and Actuator Compensation. Record these settings and the actuator output as displayed in Menu 5.



- c. Step load the engine with as many load steps as are practical. At each load step, Gain A may need to be varied to maintain engine stability. Do not change stability or actuator compensation after the first setting in step b. Should it be necessary to change these settings to obtain good control, repeat all previous steps until only Gain is changed at each load step. At each load step, record the actuator output that is displayed in Menu 5. Also record the engine load and Gain A at each point.

The table on the next page aids in collecting the data for the Gain Plot.

Gain settings reflect the amount of slope as shown in Figure 4-4. Flat portions of the engine plot will require relatively small amounts of gain, steep portions of the plot will require larger gain numbers.

- d. Create a plot of the system by plotting actuator output as a function of load. A typical result is shown in Figure 4-4.

The following table may help in the construction of the plot. Use as many load steps as possible.

| Load Step    | Gain (for good control) | Actuator Output |
|--------------|-------------------------|-----------------|
| Load Step 1  |                         |                 |
| Load Step 2  |                         |                 |
| Load Step 3  |                         |                 |
| Load Step 4  |                         |                 |
| Load Step 5  |                         |                 |
| Load Step 6  |                         |                 |
| Load Step 7  |                         |                 |
| Load Step 8  |                         |                 |
| Load Step 9  |                         |                 |
| Load Step 10 |                         |                 |
| Load Step 11 |                         |                 |
| Load Step 12 |                         |                 |
| Load Step 13 |                         |                 |
| Load Step 14 |                         |                 |
| Load Step 15 |                         |                 |
| Load Step 16 |                         |                 |
| Load Step 17 |                         |                 |
| Load Step 18 |                         |                 |
| Load Step 19 |                         |                 |
| Load Step 20 |                         |                 |

2. Set Gain A to the value recorded in Step 1b. This should give good control at no load.
3. Use the plot of the engine to determine the linearity of the fuel system. This curve should be linearized between inflection points as shown in Figure 4-5.
4. Set the Gain A Breakpoint for the actuator output at or slightly below the value at the first inflection point. The gain of the electronics is constant for actuator outputs less than the Gain A Breakpoint.
5. Set the Gain B Breakpoint at the point slightly above the first inflection point in the actuator output versus load plot.
6. Gain B should now be adjusted to obtain good control at the inflection point. Note: you may already have obtained the correct value in Step 1c.
7. Set the Gain C Breakpoint slightly below the next inflection point in the curve obtained in 1d.
8. Gain C should now be adjusted to obtain best control at this point. Note: the correct value for Gain C may already have been obtained in Step 1c for this load.
9. Gain D breakpoint is normally higher than the second inflection point. The gain of the control is constant after this point.
10. Gain D is adjusted for the best response at full load. This value may also have been determined in Step 1c.

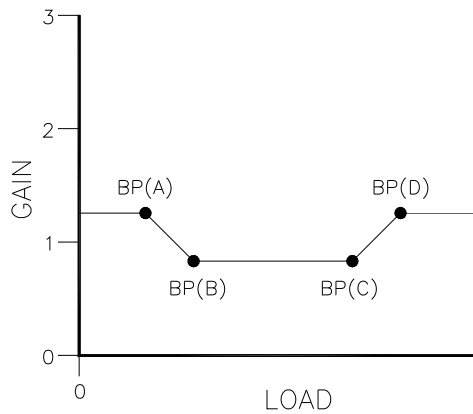


Figure 4-6. Example of Plot Created from GAIN Column

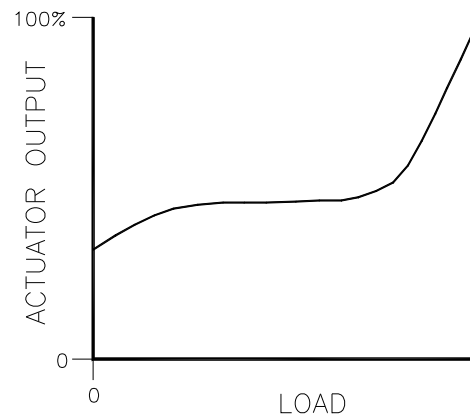


Figure 4-7. Example of Plot Created from ACTUATOR OUTPUT Column

## Stability, Actuator Compensation, Gain Ratio, Window Width

11. Stability (also known as Reset) compensates for the lag time of the engine. It adjusts the time required for the control to return the speed to zero error after a disturbance. Stability is adjusted to prevent slow hunting and to minimize speed overshoot after a load disturbance.
12. Compensation compensates for the actuator and fuel system time constant.
13. Gain Ratio operates in conjunction with the Window Width and Gain adjustments by multiplying the Gain set point by the Gain Ratio when the speed error is greater than the Window Width. This makes the control dynamics fast enough to minimize engine speed overshoot on start-up and to reduce the magnitude of speed error when loads are changing. This allows a lower gain at steady state for better stability and reduced steady-state actuator movement.
14. Window Width is the magnitude (in  $\pm$  rpm) of a speed error at which the control automatically switches to fast response. The control does not use the absolute value of speed error, but an “anticipated” speed error, to make this switch. This method provides for quick switching to the high gain value when an off speed occurs, and early switching to the low gain value when recovering from the speed transient. This provides smoother switching than if the absolute speed error were used for the window.

## Menu 2—Alternate Dynamics Settings

Menu 2 should be programmed similar to Menu 1, but with the alternate fuel or other operating condition expected. The four Gain settings and breakpoints may be set like those used in Menu 1. The Stability, Compensation, Gain Ratio, and Gain Window will probably be quite different if different fuels are being used.

If the engine will not use the alternate operating condition, the menu will not have to be programmed or it can be programmed identically with the Menu 1 to prevent unintentional changes in the dynamics program.

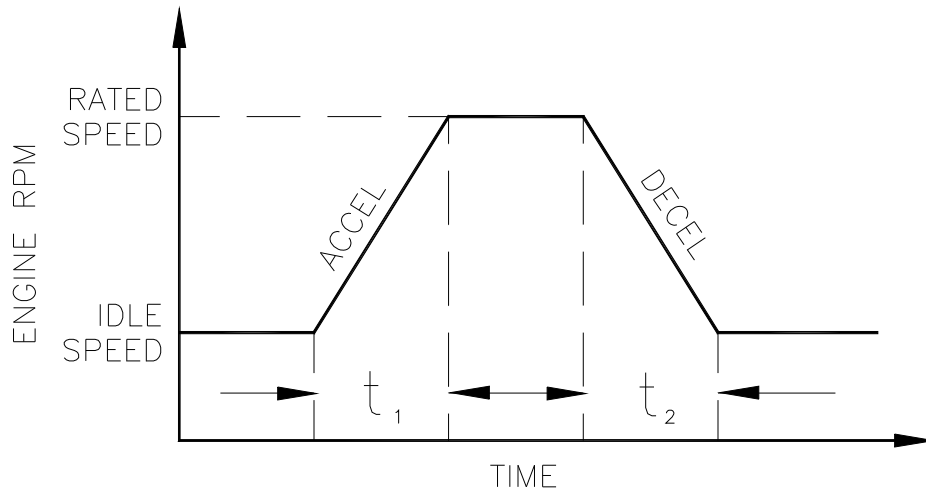
| Load Step    | Gain (for good control) | Actuator Output |
|--------------|-------------------------|-----------------|
| Load Step 1  |                         |                 |
| Load Step 2  |                         |                 |
| Load Step 3  |                         |                 |
| Load Step 4  |                         |                 |
| Load Step 5  |                         |                 |
| Load Step 6  |                         |                 |
| Load Step 7  |                         |                 |
| Load Step 8  |                         |                 |
| Load Step 9  |                         |                 |
| Load Step 10 |                         |                 |
| Load Step 11 |                         |                 |
| Load Step 12 |                         |                 |
| Load Step 13 |                         |                 |
| Load Step 14 |                         |                 |
| Load Step 15 |                         |                 |
| Load Step 16 |                         |                 |
| Load Step 17 |                         |                 |
| Load Step 18 |                         |                 |
| Load Step 19 |                         |                 |
| Load Step 20 |                         |                 |

### Menu 3—Speed Reference Settings

Speed adjustments are the settings that affect the speed reference. Descriptions of each menu item follow.

1. Rated Speed Reference sets the normal operating speed of the engine in rpm.
2. Idle Speed Reference sets the speed in rpm at which the engine is operated at start-up. It sometimes is used during cool down.
3. Raise Limit is the maximum speed reference setting in rpm. It is used to limit the Raise Speed command and Remote Reference to a maximum. It normally is set at the maximum rated engine speed.
4. Lower Limit is the minimum speed reference setting in rpm. It is used to limit the Lower Speed command and Remote Reference. It normally is set at the minimum operating speed of the engine.
5. Accel Time is the time required for the control to ramp the engine speed from idle speed to rated speed. The time is set from 0 to 500 seconds. The ramp is started whenever the Idle/Rated switch is closed.

6. Decel Time is the time required for the control to ramp the engine speed from rated speed to idle speed. The time is set from 0 to 500 seconds. The ramp is started whenever the Idle/Rated switch is opened.



$t = \text{IDLE/RATED RAMP TIME (SECONDS)}$

$t_1 = \text{Accel Time}$       $t_2 = \text{Decel Time}$

041-023  
93-3-25 RAM

Figure 4-8. Accel/Decel Example

### IMPORTANT

Actual engine deceleration may be slower than set by the Decel Time set point. This occurs when the Decel Time set point is faster than system inertias will allow the engine to slow down in speed. This condition is indicated by the control actuator output going to the minimum fuel position. See Idle Droop below.

7. Raise Rate is the rate at which the speed reference is ramped when using the Raise command or when the Remote Speed Setting input is changed in the increase direction. The rate programmed is in rpm per minute. A step change in the remote input does not cause an immediate change in the reference, which is ramped to the new setting at the Raise Rate.
8. Lower Rate is the rate at which the speed reference is ramped when using the Lower Speed command or when the Remote Speed Setting input is changed in the decrease direction. The rate is set in rpm per minute. A step change in the remote input does not cause an immediate change in the reference, which is ramped to the new setting at the Lower Rate.
9. 20 mA Remote Reference is the engine speed desired when 20 mA is applied to the Remote Speed Reference input. The desired speed is set in rpm.
10. 4 mA Remote Reference is the engine speed desired when 4 mA is applied to the Remote Speed Reference input. The desired speed is set in rpm.

11. Droop is set as the percent rated speed will be decreased from no load to full load. Droop will be included in the engine control schedule only when the Isoch/Droop contact is open.

The percentage of Droop entered is based on 75° of actuator travel. If less than full travel is used, the droop percentage must be increased proportionally.

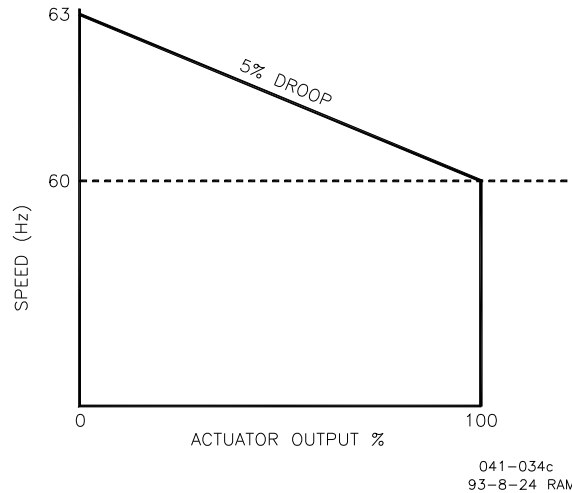


Figure 4-9. Droop Curve

12. Idle Droop combined with the Idle Droop Breakpoint is used to limit speed undershoot when large decel rates are used from rated to idle.
- Idle Droop is based on the actuator output when it drops below the Idle Droop Breakpoint setting. Dependencies on linkage make the Idle Droop percentage relative, so large droop settings may be required to achieve the desired results.
13. Idle Droop Breakpoint is normally set equal to the actuator output obtained when the engine is unloaded and at low idle. When the output of the control drops below this setting or goes to minimum fuel during rapid engine deceleration, Idle Droop will raise the speed reference. This brings the engine back under control sooner and reduces speed undershoot. Speed undershoot may occur because the time required for the control to return to the new fuel setting is dependent on control dynamics and linkage adjustment.
14. Speed Switch A ON sets the rpm that will turn on Speed Switch A.
15. Speed Switch A OFF sets the rpm that will turn off Speed Switch A.
16. Speed Switch B ON sets the rpm that will turn on Speed Switch B.
17. Speed Switch B OFF sets the rpm that will turn off Speed Switch B.
18. Speed Switch C ON sets the rpm that will turn on Speed Switch C.

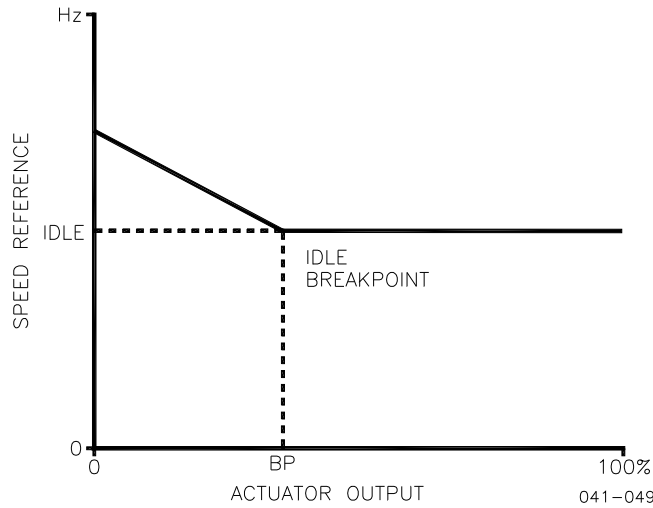


Figure 4-10. Idle Droop

19. Speed Switch C OFF sets the rpm that will turn off Speed Switch C.

The speed switch changes state at the selected speed position. Each switch allows 500 mA to sink to the negative of the power supply when closed.

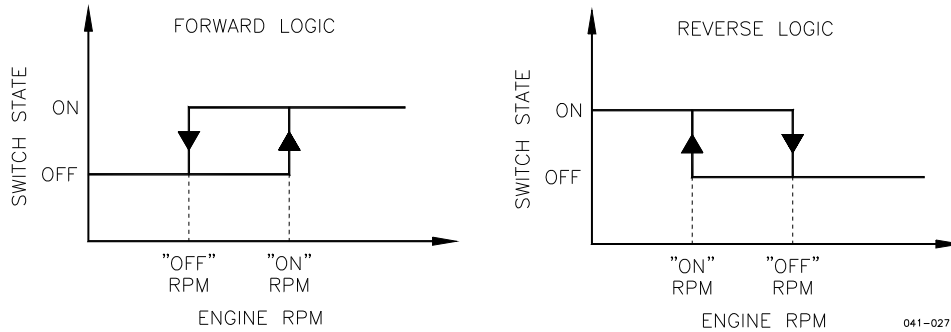


Figure 4-11. Speed Switch Settings

### Menu 4—Limiter Settings

Fuel limiters limit the actuator output from the control. Descriptions of each menu item follow.

1. Maximum Fuel Limit sets the maximum percent actuator output when rated speed is selected. If the actuator linkage is correctly set so the actuator is providing the maximum position stop, 3° in advance of the butterfly valve maximum position, this item may be set at 100%. If the actuator must reach maximum before it reaches its maximum stop, the entry must be below 100%.

**NOTICE**

**Damage to the butterfly valve and possible jamming of the valve in the wide open position is possible if linkage is not designed to reach maximum actuator position at least 3° in advance of maximum butterfly valve position.**

The Maximum limit may be used to limit the horsepower developed in the engine.

2. Transient Limit is used when the maximum fuel limit is controlling the output horsepower of the engine. The transient limit allows overfueling of the engine by the amount tuned into the control. This allows the engine to accelerate to the rated load.
3. Transient Time is the amount of time that the Transient Limit is allowed to operate.
4. Start Fuel Limit is a limit that is in place while the engine is starting. This limit helps reduce smoke on diesel engines and prevents overfueling during the start of gas engines. The limit is removed when the engine reaches Start Speed.
5. Start Ramp is a tunable ramp of the actuator output to ensure starting of cold engines. The control ramps the position of the actuator from the Start Fuel Limit open at a controlled rate until the engine starts. After the engine has started, the fuel limits will be set by the Maximum Fuel Limit or the Torque Limit, whichever is less.
6. Start Speed sets the speed in rpm that will remove the start-fuel limit from the control system. When Start Speed is obtained, the speed ramps to idle or rated speed, depending on the selection made. After start speed is attained, the control uses the Maximum Fuel and Torque limits.
7. Minimum Torque Limit is the percent actuator output allowed when the engine speed is at or below the Lower Limit speed setting (Menu 3). The torque limiter provides a value between Minimum Torque Limit and Breakpoint Torque Limit when engine speed is between these two settings. This sets the torque limit slope below the Breakpoint position.
8. Torque Limit Breakpoint (BP) is the engine speed at which the slope of the torque limiter output changes. The Torque Limit Breakpoint must be set between the Raise and Lower Limits described under Menu 3.
9. (BP) Torque Limit at Breakpoint (BP) is the percent actuator output at the engine speed set by the Torque Limit Breakpoint described above.
10. Maximum Torque Limit is the maximum percent actuator output when the engine speed is at the Raise Limit speed setting. The torque limiter provides a value between the Breakpoint Torque Limit and Maximum Torque Limit when engine speed is between these two settings. This sets the slope above the torque limit breakpoint setting.

Figure 4-12 illustrates the breakpoint and these adjustments.



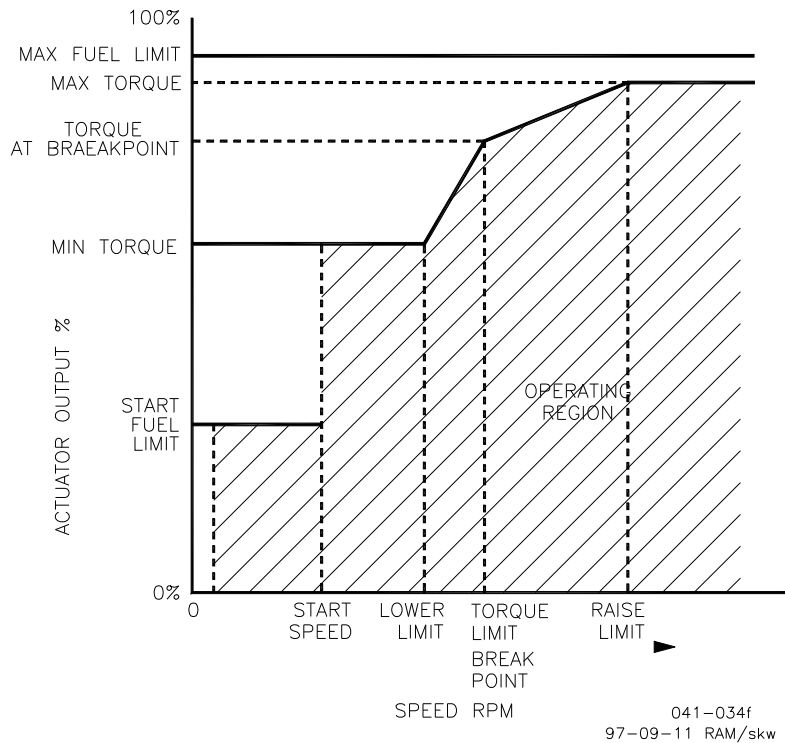


Figure 4-12. Torque Limit Map

## Menu 5—Monitor Menu

Input or output values displayed on the hand held are continuously updated. Descriptions of each menu item follow:

1. Speed displays the current engine speed in rpm.
2. Speed Reference displays the current speed reference in rpm. Note that this may not be the current speed of the engine due to the effect of idle droop, fuel limiters, auxiliary input, or droop.
3. Actuator Output displays the current percent of Actuator output. This is useful for setup of the control fuel limiters, torque limiter, idle droop, and gain breakpoint settings.
4. Aux Input displays the voltage on the Aux Input.
5. Remote Input displays the milliamps on the Remote Speed Setting Input. This is useful for testing and system calibration.
6. Actuator Current provides a readout of the current to the actuator.
7. Actuator Position provides the voltage reading from the position feedback.
8. Run/Stop Switch Status displays the status of the discrete input at terminal 23. Closed indicates 24 Vdc is applied to the input selecting the run position. Open selects minimum fuel or the stop position.

9. Idle/Rated Switch Status displays the status of discrete input at terminal 17. Closed indicates 24 Vdc is applied to the input selecting rated speed and the maximum fuel limit is selected. Open indicates idle speed and the idle fuel limit.
10. Raise Switch Status displays the status of discrete input at terminal 19. Closed indicates 24 Vdc is applied to the input selecting raise speed.
11. Lower Switch Status displays the status of discrete input at terminal 18. Closed indicates 24 Vdc is applied to the input selecting lower speed.
12. Alternate Dynamics Switch Status displays the status of discrete input at terminal 20. Closed indicates 24 Vdc is applied to the input selecting the Alternate Dynamics.
13. Remote Reference Switch Status displays the status of discrete input at terminal 21. Closed enables the remote speed setting at terminals 14 and 15 and disables the Raise and Lower switches.
14. Isoch displays the status of the contacts at terminal 16. Open is droop, closed is in isochronous.
15. Diagnostic indicates the status of the diagnostics switch.
16. Speed Switch A, terminal 3, indicates the on/off position of the switch.
17. Speed Switch B, terminal 4, indicates the on/off position of the switch.
18. Speed Switch C, terminal 5, indicates the on/off position of the switch.
19. Fault Lamp indicates the switch position at terminal 6. This switch is on when a fault has been detected. The system must be turned off and powered back up to extinguish the lamp.

## Menu 6—Configuration Set Points

1. Configuration Key is a code which must be entered before you can change any of the set points on the configuration menu. This helps prevent accidental modification of the set points. The code is factory set to “49”. Use the “rabbit” or “turtle” keys to select the code. The code will be returned to “0” when the menu is exited.
2. Number of Gear Teeth is the number of teeth or holes in the gear or flywheel that drives the speed-sensing device. If the gear is running at camshaft speed (one-half engine speed) then you must enter one-half the number of teeth on the gear. The control requires the number of teeth seen by the MPU per engine revolution.

### **IMPORTANT**

Best control performance will be obtained when sensing speed from a gear rotating at full engine speed. Slower-speed gears (such as the camshaft) provide a lower sampling rate which reduces control response time.

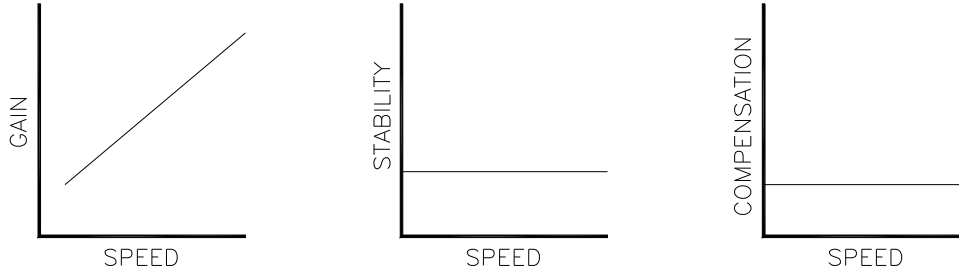
**WARNING** The number of gear teeth is used by the control to convert pulses from the speed-sensing device to engine rpm. To prevent possible serious injury from an overspeeding engine, make sure the control is properly programmed to convert the gear-tooth count into engine rpm. Improper conversion could cause engine overspeed.

3. Dynamics Map selects the mapping algorithm used to map dynamics as a function of engine speed. Figure 4-13 illustrates how dynamics vary as a function of engine speed for each map.
4. Failsafe Function. Use Rabbit or Turtle keys: Up to enable, Down to disable.

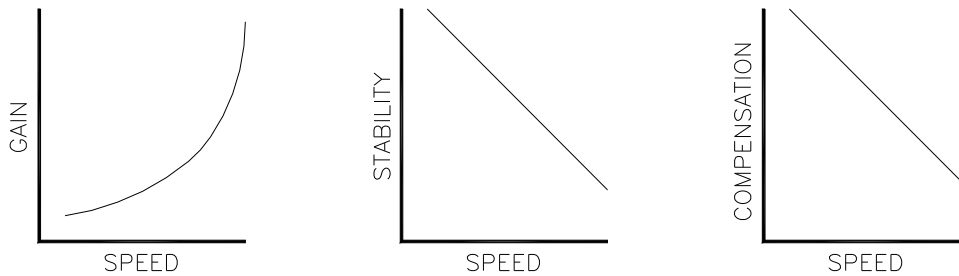
**WARNING** The Failsafe function causes the ProAct control to issue a minimum fuel signal should the MPU signal fail. Should the function be disabled (to permit a fuel position while cranking or for test procedures), it must be enabled again to prevent overspeed should the signal fail while the engine is operating. Engine overspeed can damage equipment and cause personal injury or death.

**Menu 0—Error Menu**

1. Active Errors display errors that the control has detected that are still present. The error must be corrected before operation of the engine. Active errors can be cleared by toggling Run/Stop.



LINEAR DYNAMICS MAP



NON-LINEAR DYNAMICS MAP

027-066  
97-08-22

Figure 4-13. Dynamics Map Curves

2. Logged Errors provides a means of recording errors that the control detects. The error log will be saved, even if power to the control is lost. To clear the error log, press the “hot” (“black square”) key.
3. Self Test Result displays the result of power up diagnostics performed on the microprocessor, data, and program memory. A successful test gives a result of 49. Contact Woodward if the self test result is not 49.

## Conclusion of Test and Calibration Procedures

This completes the calibration instructions. Save the set points by pressing the SAVE key on the Hand Held Programmer. Power down the control for about 10 seconds. Restore power and verify that all set points are as recorded.

### **NOTICE**

To prevent possible damage to the engine resulting from improper control settings, make sure you save the set points before removing power from the control. Failure to save the set points before removing power from the control causes them to revert to the previously saved settings.

Disconnect the Set Point Programmer from the control.

### **WARNING**

Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.

## Chapter 5.

# System Troubleshooting Charts

| Problem   | Cause  | Remedy  |
|---|--|---|
| <p>Prime mover will not start. Actuator not moving to start fuel position.</p> <p><b>IMPORTANT</b></p> <p>If the actuator moves to start position, a problem with the prime mover fuel supply is indicated.</p> | Supply voltage polarity reversed, or no supply voltage.  | Check for supply voltage from terminals 24 (+) to 25 (-). Reverse leads if polarity is incorrect.   |
|   | Actuator not responding to input signal from control.  | <p>If there is a voltage output at control terminals 1 (+) and 2 (-), but the actuator does not move, check the wiring to the actuator for opens or shorts.</p> <p>Check the polarity of the actuator and feedback.</p> <p>Check actuator and linkage for proper installation and operation. Problems may be direction of rotation, linkage, worn components, or improper adjustment.</p> |
|   | Start fuel limit set too low.  | Increase start fuel limit until prime mover starts.   |
|   |  | Increase Start Ramp.  |
|   | Speed setting too low on initial start.  | <p>Speed setting may be lower than cranking speed. Control should be set for rated speed. Increase Rated Speed setting.</p> <p><b>NOTICE</b></p> <p><b>If adjusting Rated Speed does not produce the correct output, return Rated Speed setting to normal start position.</b></p>   |
|   | Idle Speed setting may be set too low.   | Adjust idle speed.  |
| Run/Stop contact open.  | Check terminal 23. Run/Stop contact must be closed for normal operation. Check monitor menu for switch position. |   |

| Problem   | Cause   | Remedy   |
|---|---|--|
| Prime mover will not start. Actuator not moving to start fuel position. (cont.) | Speed sensor signal not clearing failed speed signal circuit. | <p>Check wiring for proper connection. Check shields for proper installation.</p> <p>Speed sensor not spaced properly. Check for at least 1.0 Vac at terminals 10 and 11 during cranking. If less than 1.0 Vac, magnetic pickup may be spaced too far from gear. Make sure there are no metal chips on end of pickup.</p> <p>Check the number of teeth seen by the MPU per engine revolution against the number entered in step 2 of Menu 6.</p> <p>If no voltage is present, magnetic pickup may be open-circuited or shorted. Make resistance check with the leads disconnected from control. Should be 100 to 300 Ω.</p> <p>Check Error Menu 0 for faults.</p> <p><b>⚠ WARNING</b></p> <p>The Failed Speed Signal must be enabled for routine operation of the engine to ensure shutdown and prevent possible life threatening overspeed should the MPU signal be lost at some future time.</p> <p>Check Monitor Menu for Speed When Cranking.</p> <p><b>⚠ WARNING</b></p> <p>Be prepared to make an emergency shutdown when starting the engine, turbine, or other type of prime mover, to protect against runaway or overspeed with possible personal injury, loss of life, or property damage.</p> |
|   | Faulty ProAct control.  | Replace control.   |

| Problem  | Cause  | Remedy  |
|--|--|---|
| Prime mover overspeeds only on starts.                               | Control adjustment.  | Control may be adjusted for sluggish operation causing overspeed on start. Slowly adjust GAIN for fastest stable response. Stability may be adjusted too low. Increase Stability setting.<br><br>Start Fuel Limit may be too high.<br><br>Start Ramp may be too high.<br><br>Start speed may be too low.<br><br>Wrong set of dynamics may have been selected.   |
|  | Linkage/Coupling.  | On diesel installations verify that fuel rack is not binding and linkage is properly adjusted. It may be necessary to determine if the fuel rack is quickly following the actuator.<br><br>On carburetor installations check that the butterfly is not binding.<br><br>Check linkage or coupling adjustment.  |
|  | Overspeed Device.  | Verify proper operation of overspeed protection devices to determine if a shutdown is occurring without an overspeed condition.   |
|  | ProAct control.  | If the control does not cut back the actuator output (Menu 5), the ProAct control may be faulty. If the signal is cut back, look for a problem in the linkage or actuator.  |
| Prime mover overspeeds after operating at rated speed for some time. | Prime mover.   | Check for proper operation of prime mover fuel system. If actuator moves toward minimum fuel during overspeed, problem may not be connected with the governor.  |
| Speed not regulated (hunting).                                       | Incorrect dynamics programmed in control or incorrect dynamics program selected. | Improve dynamics settings or select correct dynamics program.   |
| Los speed is not regulated at idle speed.                            | Actuator and linkage.  | The Idle Speed setting may be below the minimum-fuel position of the actuator or prime mover fuel stop. In this case, the output voltage to the actuator will be zero.<br><br>The engine will be maintained at the minimum-fuel position by the actuator or the prime mover minimum-fuel stop. These conditions indicate that the prime mover minimum-fuel position should be decreased by linkage adjustment (diesel engine) or low-idle set screw (gas engine), or the Idle Speed setting should be raised. If this action does not correct the problem, the control may be faulty. |
| Prime mover does not decelerate when Rated contact is open.          | Faulty Rated contact.  | Check Idle/Rated contact. Remove wire from terminal 17. Prime mover should decelerate.  |
|  | ProAct control ramp circuitry.   | A faulty Rated contact may remain in the accelerate position with the contact open.<br><br>If the Rated contact is operative, loss of idle control may be due to a faulty circuit.  |

| Problem   | Cause  | Remedy   |
|---|--|--|
| Prime mover will not stabilize at rated no-load speed. The instability may occur at no load or it may vary with load. Control may be erratic. | ProAct control.  | Adjust GAIN, Stability, and ACTUATOR COMPENSATION in Menu 1 or 2. Check Gain Breakpoint for the lower speeds.  |
|   | Necessary external wires not properly shielded. (Electrical noise, caused by wiring carrying an ac voltage, stray magnetic fields from transformers, etc., can be picked up by improperly shielded wire. Noise will cause instability if picked up by magnetic pickup, position feedback, auxiliary input, or remote reference lines.) | <p>The following tests will isolate noise and interference.</p> <p>Verify that the switchgear frame, governor chassis, and prime mover have a common ground connection. Temporarily remove the battery-charger cables from the control battery system.</p> <p>If the prime-mover operation is significantly improved by these modifications, replace the wires one at a time to locate the source of the trouble.</p> <p>External wiring may require additional shielding or rerouting from high-current lines or components.</p> <p>If the problem cannot be solved by these checks, it will be necessary to remove the control from the switchgear. Temporarily mount the control next to the prime mover and connect only a battery, magnetic pickup, and actuator to the control (use a separate battery placed next to the prime mover). After starting the prime mover, if necessary, apply load to check stability.</p> <p>If stability occurs when the control is mounted next to the prime mover, return the control to the switchgear. Run new magnetic pickup, actuator feedback, and battery power lines. Shield all wires to the control. Route all wires through conduit or an outer shield. Tie the outer shield to system ground at the end opposite to the control.</p> |
|   | Prime mover may not be receiving fuel as called for by the actuator voltage.   | Check actuator linkage to fuel-controlling mechanism for any lost motion, binding, or excessive loading. Verify a steady fuel pressure of proper value.  |
|   | Prime mover not operating properly.  | Prime mover may be causing speed variations. Control engine manually to determine if instability is in prime mover or governor control. Verify proper adjustment of fuel control linkage.  |
|   | Input voltage low.   | Check supply voltage. It should be at least 18 Vdc, not more than 32 Vdc.  |
| Prime mover will not accept full load.  | Prime mover.   | If droop occurs near the full-load point only, it is possible the prime mover is not producing the power called for by the fuel control, or is being overloaded. Either is indicated if the fuel control is at maximum position.   |
|   | ProAct control.  | <p>Check Max Fuel Limit setting. Increase if required. Check Torque Limiter settings. Increase if required.</p> <p>Check droop setting. Set to 0 if required.</p> <p>Check Aux Input terminals to see if the auxiliaries are out of range. Maximum voltage is 2.5 Vdc.</p> <p>Check linkage from actuator to fuel rack.</p>  |



# Chapter 6.

## Product Support and Service Options

### Product Support Options

If you are experiencing problems with the installation, or unsatisfactory performance of a Woodward product, the following options are available:

1. Consult the troubleshooting guide in the manual.
2. Contact the **OE Manufacturer or Packager** of your system.
3. Contact the **Woodward Business Partner** serving your area.
4. Contact Woodward technical assistance via email ([EngineHelpDesk@Woodward.com](mailto:EngineHelpDesk@Woodward.com)) with detailed information on the product, application, and symptoms. Your email will be forwarded to an appropriate expert on the product and application to respond by telephone or return email.
5. If the issue cannot be resolved, you can select a further course of action to pursue based on the available services listed in this chapter.

**OEM or Packager Support:** Many Woodward controls and control devices are installed into the equipment system and programmed by an Original Equipment Manufacturer (OEM) or Equipment Packager at their factory. In some cases, the programming is password-protected by the OEM or packager, and they are the best source for product service and support. Warranty service for Woodward products shipped with an equipment system should also be handled through the OEM or Packager. Please review your equipment system documentation for details.

**Woodward Business Partner Support:** Woodward works with and supports a global network of independent business partners whose mission is to serve the users of Woodward controls, as described here:

- A **Full-Service Distributor** has the primary responsibility for sales, service, system integration solutions, technical desk support, and aftermarket marketing of standard Woodward products within a specific geographic area and market segment.
- An **Authorized Independent Service Facility (AISF)** provides authorized service that includes repairs, repair parts, and warranty service on Woodward's behalf. Service (not new unit sales) is an AISF's primary mission.
- A **Recognized Engine Retrofitter (RER)** is an independent company that does retrofits and upgrades on reciprocating gas engines and dual-fuel conversions, and can provide the full line of Woodward systems and components for the retrofits and overhauls, emission compliance upgrades, long term service contracts, emergency repairs, etc.

A current list of Woodward Business Partners is available at [www.woodward.com/directory](http://www.woodward.com/directory).

### Product Service Options

Depending on the type of product, the following options for servicing Woodward products may be available through your local Full-Service Distributor or the OEM or Packager of the equipment system.

- Replacement/Exchange (24-hour service)
- Flat Rate Repair
- Flat Rate Remanufacture

**Replacement/Exchange:** Replacement/Exchange is a premium program designed for the user who is in need of immediate service. It allows you to request and receive a like-new replacement unit in minimum time (usually within 24 hours of the request), providing a suitable unit is available at the time of the request, thereby minimizing costly downtime.

This option allows you to call your Full-Service Distributor in the event of an unexpected outage, or in advance of a scheduled outage, to request a replacement control unit. If the unit is available at the time of the call, it can usually be shipped out within 24 hours. You replace your field control unit with the like-new replacement and return the field unit to the Full-Service Distributor.

**Flat Rate Repair:** Flat Rate Repair is available for many of the standard mechanical products and some of the electronic products in the field. This program offers you repair service for your products with the advantage of knowing in advance what the cost will be.

**Flat Rate Remanufacture:** Flat Rate Remanufacture is very similar to the Flat Rate Repair option, with the exception that the unit will be returned to you in “like-new” condition. This option is applicable to mechanical products only.

## Returning Equipment for Repair

If a control (or any part of an electronic control) is to be returned for repair, please contact your Full-Service Distributor in advance to obtain Return Authorization and shipping instructions.

When shipping the item(s), attach a tag with the following information:

- return number;
- name and location where the control is installed;
- name and phone number of contact person;
- complete Woodward part number(s) and serial number(s);
- description of the problem;
- instructions describing the desired type of repair.

## Packing a Control

Use the following materials when returning a complete control:

- protective caps on any connectors;
- antistatic protective bags on all electronic modules;
- packing materials that will not damage the surface of the unit;
- at least 100 mm (4 inches) of tightly packed, industry-approved packing material;
- a packing carton with double walls;
- a strong tape around the outside of the carton for increased strength.

### **NOTICE**

To prevent damage to electronic components caused by improper handling, read and observe the precautions in Woodward manual 82715, *Guide for Handling and Protection of Electronic Controls, Printed Circuit Boards, and Modules*.

## Replacement Parts

When ordering replacement parts for controls, include the following information:

- the part number(s) (XXXX-XXXX) that is on the enclosure nameplate;
- the unit serial number, which is also on the nameplate.

## Engineering Services

Woodward’s Full-Service Distributors offer various Engineering Services for our products. For these services, you can contact the Distributor by telephone or by email.

- Technical Support
- Product Training
- Field Service

**Technical Support** is available from your equipment system supplier, your local Full-Service Distributor, or from many of Woodward’s worldwide locations, depending upon the product and application. This service can assist you with technical questions or problem solving during the normal business hours of the Woodward location you contact.

**Product Training** is available as standard classes at many Distributor locations. Customized classes are also available, which can be tailored to your needs and held at one of our Distributor locations or at your site. This training, conducted by experienced personnel, will assure that you will be able to maintain system reliability and availability.

**Field Service** engineering on-site support is available, depending on the product and location, from one of our Full-Service Distributors. The field engineers are experienced both on Woodward products as well as on much of the non-Woodward equipment with which our products interface.

For information on these services, please contact one of the Full-Service Distributors listed at [www.woodward.com/directory](http://www.woodward.com/directory).

## Contacting Woodward’s Support Organization

For the name of your nearest Woodward Full-Service Distributor or service facility, please consult our worldwide directory published at [www.woodward.com/directory](http://www.woodward.com/directory).

You can also contact the Woodward Customer Service Department at one of the following Woodward facilities to obtain the address and phone number of the nearest facility at which you can obtain information and service.

| <b>Products Used In<br/>Electrical Power Systems</b> | <b>Products Used In<br/>Engine Systems</b> | <b>Products Used In<br/>Industrial Turbomachinery<br/>Systems</b> |
|--|--|---|
| <u>Facility</u> ----- <u>Phone Number</u>            | <u>Facility</u> ----- <u>Phone Number</u>  | <u>Facility</u> ----- <u>Phone Number</u>                         |
| Brazil -----+55 (19) 3708 4800                       | Brazil -----+55 (19) 3708 4800             | Brazil -----+55 (19) 3708 4800                                    |
| China -----+86 (512) 6762 6727                       | China -----+86 (512) 6762 6727             | China -----+86 (512) 6762 6727                                    |
| Germany:   | Germany-----+49 (711) 78954-510            | India -----+91 (129) 4097100                                      |
| Kempen----+49 (0) 21 52 14 51                        | India -----+91 (129) 4097100               | Japan-----+81 (43) 213-2191                                       |
| Stuttgart--+49 (711) 78954-510                       | Japan-----+81 (43) 213-2191                | Korea-----+82 (51) 636-7080                                       |
| India -----+91 (129) 4097100                         | Korea-----+82 (51) 636-7080                | The Netherlands- +31 (23) 5661111                                 |
| Japan-----+81 (43) 213-2191                          | The Netherlands- +31 (23) 5661111          | Poland-----+48 12 295 13 00                                       |
| Korea-----+82 (51) 636-7080                          | United States----+1 (970) 482-5811         | United States----+1 (970) 482-5811                                |
| Poland-----+48 12 295 13 00                          |  |   |
| United States----+1 (970) 482-5811                   |  |   |

For the most current product support and contact information, please visit our website directory at [www.woodward.com/directory](http://www.woodward.com/directory).

### Technical Assistance

If you need to contact technical assistance, you will need to provide the following information. Please write it down here before contacting the Engine OEM, the Packager, a Woodward Business Partner, or the Woodward factory:

#### General

Your Name \_\_\_\_\_

Site Location \_\_\_\_\_

Phone Number \_\_\_\_\_

Fax Number \_\_\_\_\_

---

#### Prime Mover Information

Manufacturer \_\_\_\_\_

Engine Model Number \_\_\_\_\_

Number of Cylinders \_\_\_\_\_

Type of Fuel (gas, gaseous, diesel, dual-fuel, etc.) \_\_\_\_\_

Power Output Rating \_\_\_\_\_

Application (power generation, marine, etc.) \_\_\_\_\_

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#### Control/Governor Information

##### Control/Governor #1

Woodward Part Number & Rev. Letter \_\_\_\_\_

Control Description or Governor Type \_\_\_\_\_

Serial Number \_\_\_\_\_

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##### Control/Governor #2

Woodward Part Number & Rev. Letter \_\_\_\_\_

Control Description or Governor Type \_\_\_\_\_

Serial Number \_\_\_\_\_

---

##### Control/Governor #3

Woodward Part Number & Rev. Letter \_\_\_\_\_

Control Description or Governor Type \_\_\_\_\_

Serial Number \_\_\_\_\_

---

#### Symptoms

Description \_\_\_\_\_

*If you have an electronic or programmable control, please have the adjustment setting positions or the menu settings written down and with you at the time of the call.*

## Appendix. Menu Summary

### Initial Prestart Settings

These tables are provided for the convenience of the ProAct™ user. Each number should be recorded as it is programmed with the Hand Held Programmer. Any changes should be noted so the adjustment can be referenced from its original setting.

#### IMPORTANT

Please refer to application note 51317, *ProAct Digital Speed Control System with Start-up Fuel Limiting*, if this is a fuel-limiting version. Menus 3 and 4 have additional settings.

### Menu 1—Dynamics Settings

| Menu Item          | Default Setting | Gas Engine Prestart Setting | Diesel Engine Prestart Setting | Actual Setting |
|--------------------|-----------------|-----------------------------|--------------------------------|----------------|
| Gain A             | 0.25            | 0.025                       | 0.050                          | _____          |
| Gain A break point | 0%              | 100%                        | 100%                           | _____          |
| Gain B             | 0.25            | 0.025                       | 0.050                          | _____          |
| Gain B break point | 30%             | 100%                        | 100%                           | _____          |
| Gain C             | 0.25            | 0.025                       | 0.050                          | _____          |
| Gain C break point | 60%             | 100%                        | 100%                           | _____          |
| Gain D             | 0.25            | 0.025                       | 0.050                          | _____          |
| Gain D break point | 100%            | 100%                        | 100%                           | _____          |
| Stability          | 0.25 sec.       | 1.0 sec.                    | 1.0 sec.                       | _____          |
| Compensation       | 0.10 sec.       | 0.15 sec.                   | 0.15 sec.                      | _____          |
| Gain Ratio         | 1.00            | 1                           | 1                              | _____          |
| Gain Window        | 60 rpm          | 60 rpm                      | 60 rpm                         | _____          |

### Menu 2—Alternate Dynamics Settings

| Menu Item          | Default Setting | Gas Engine Prestart Setting | Diesel Engine Prestart Setting | Actual Setting |
|--------------------|-----------------|-----------------------------|--------------------------------|----------------|
| Alt Gain A         | 0.10            | 0.025                       | 0.050                          | _____          |
| Gain A break point | 0%              | 100%                        | 100%                           | _____          |
| Alt Gain B         | 0.10            | 0.025                       | 0.050                          | _____          |
| Gain B break point | 30%             | 100%                        | 100%                           | _____          |
| Alt Gain C         | 0.10            | 0.025                       | 0.050                          | _____          |
| Gain C break point | 60%             | 100%                        | 100%                           | _____          |
| Alt Gain D         | 0.10            | 0.025                       | 0.050                          | _____          |
| Gain D break point | 100%            | 100%                        | 100%                           | _____          |
| Alt Stability      | 1.0 sec.        | 1.0 sec.                    | 1.0 sec.                       | _____          |
| Compensation       | 0.20 sec.       | 0.15 sec.                   | 0.15 sec.                      | _____          |
| Alt Gain Ratio     | 1               | 1                           | 1                              | _____          |
| Alt Gain Window    | 60 rpm          | 60 rpm                      | 60 rpm                         | _____          |

## Menu 3—Speed Reference Settings

**IMPORTANT**

Please refer to application note 51317, *ProAct Digital Speed Control System with Start-up Fuel Limiting*, if this is a fuel-limiting version.

| Menu Item              | Default<br>Setting | Actual<br>Setting |
|------------------------|--------------------|-------------------|
| Rated Speed            | 1800 rpm           | _____             |
| Idle Speed             | 1200 rpm           | _____             |
| Raise Limit            | 1890 rpm           | _____             |
| Lower Limit            | 1200 rpm           | _____             |
| Accel Time             | 8 sec.             | _____             |
| Decel Time             | 3 sec.             | _____             |
| Raise Rate             | 2500 rpm/min.      | _____             |
| Lower Rate             | 2500 rpm/min.      | _____             |
| 20 mA Remote Ref.      | 1890 rpm           | _____             |
| 4 mA Remote Ref        | 1710 rpm           | _____             |
| Droop                  | 5%                 | _____             |
| Idle droop             | 0%                 | _____             |
| Idle Droop break point | 0%                 | _____             |
| Speed Switch A On      | 600 rpm            | _____             |
| Speed Switch A Off     | 540 rpm            | _____             |
| Speed Switch B On      | 1200 rpm           | _____             |
| Speed Switch B Off     | 1140 rpm           | _____             |
| Speed Switch C On      | 2000 rpm           | _____             |
| Speed Switch C Off     | 1900 rpm           | _____             |

## Menu 4—Limiter Settings

**IMPORTANT**

Please refer to application note 51317, *ProAct Digital Speed Control System with Start-up Fuel Limiting*, if this is a fuel-limiting version.

| Menu Item          | Default<br>Setting | Actual<br>Setting |
|--------------------|--------------------|-------------------|
| Max Fuel Limit     | 100%               | _____             |
| Transient Limit    | 0%                 | _____             |
| Transient Time     | 0 sec.             | _____             |
| Start Fuel Limit   | 40%                | _____             |
| Start Ramp         | 1%/sec.            | _____             |
| Start Speed        | 400 rpm            | _____             |
| Min Torque Limit   | 50%                | _____             |
| Torque Limit BP    | 1500 rpm           | _____             |
| Torque Limit at BP | 70%                | _____             |
| Max Torque Limit   | 90%                | _____             |

## Menu 6—Configuration Set Points

| Menu Item            | Default<br>Setting | Actual<br>Setting |
|----------------------|--------------------|-------------------|
| Configuration Key    | 0                  | * _____           |
| Number of Gear Teeth | 60                 | _____             |
| Dynamics Map         | Linear             | _____             |
| Failsafe             | Enabled            | _____             |

\*—Set at 49 to change menu tunables

## ProAct Control Menu Summary

### MENU 1—Dynamics Settings

Gain A  
Gain A BP  
Gain B  
Gain B BP  
Gain C  
Gain C BP  
Gain D  
Gain D BP  
Stability  
Compensation  
Gain Ratio  
Window Width

### MENU 2—Alternate Dynamics Settings

Alt Gain A  
Alt Gain A BP  
Alt Gain B  
Alt Gain B BP  
Alt Gain C  
Alt Gain C BP  
Alt Gain D  
Alt Gain D BP  
Alt Stability  
Alt Compensation  
Alt Gain Ratio  
Alt Window Width

### MENU 3—Speed Reference Settings

Rated Speed  
Idle Speed  
Raise Limit  
Lower Limit  
Accel Time  
Decel Time  
Raise Rate  
Lower Rate  
20 mA Remote Ref.  
4 mA Remote Ref  
Droop  
Idle Droop  
Idle Droop BP  
Speed Switch A On  
Speed Switch A Off  
Speed Switch B On  
Speed Switch B Off  
Speed Switch C On  
Speed Switch C Off

### MENU 4—Limiter Settings

Max Fuel Limit  
Transient Over Fuel  
Transient Time  
Start Fuel Limit  
Start Ramp Rate  
Start Speed  
Min Torque Limit  
Torque Limit BP  
Torque Limit at BP  
Max Torque Limit

### MENU 5—Monitor Menu

Speed  
Speed Reference  
Actuator Output  
Aux Input  
Remote Input  
Run/Stop Switch  
Idle Rated Switch  
Raise Switch  
Lower Switch  
Alternate Dynamics Switch  
Remote Reference Switch  
Isoch Switch  
Diagnostic Switch  
Speed Switch A  
Speed Switch B  
Speed Switch C  
Fault Lamp

### MENU 6—Configuration Set Points

\*Configuration Key  
Number of Gear Teeth  
Dynamics Map  
Failsafe Function

Be sure to save any changed set points before removing power from the control.

# ProAct™ Control Specifications

|                          |  |
|--------------------------|--|
| Operating Temperature    | -40 to +85 °C (-40 to +185 °F)   |
| Storage Temperature      | -55 to +100 °C (-67 to +212 °F)  |
| Vibration                | Sine Sweep, 6 hrs/axis, 24-2000 Hz<br>0.5 Oct./min input level 2.5 Gs      |
| Shock                    | US MIL-STD-810C, Method 516.2, Procedure III                               |
| Transit Shock            | US MIL-STD-810C, Method 516.2, Procedure IV                                |
| EMI/RFI:                 |  |
| Conducted Susceptibility |  |
| Frequency (Hz)           | Amplitude (Vrms)   |
| Power Leads— 30-1000     | 3.0  |
| 1000-10 000              | 3.5  |
| 10 000-8 000 000         | 1.5  |
| 8 000 000-1000 000 000   | 1.0  |
| All other leads—         |  |
| 30 000-500 000           | 0.5  |
| 500 000-1 000 000        | 1.0  |
| Radiated Susceptibility: | Control will not fail in an unsafe manner up to 55 V/m, 15 kHz to 1000 MHz |
| Humidity:                | 95% ±5% at 60 °C for 6 hrs<br>50% ±5% at -40 °C for 2 hrs                  |



We appreciate your comments about the content of our publications.

Send comments to: [icinfo@woodward.com](mailto:icinfo@woodward.com)

Please reference publication **04121K**.



PO Box 1519, Fort Collins CO 80522-1519, USA  
1000 East Drake Road, Fort Collins CO 80525, USA  
Phone +1 (970) 482-5811 • Fax +1 (970) 498-3058

Email and Website—[www.woodward.com](http://www.woodward.com)

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as well as authorized distributors and other authorized service and sales facilities throughout the world.**

**Complete address / phone / fax / email information for all locations is available on our website.**

# OPERATION & MAINTENANCE MANUAL



## MITSUBISHI DIESEL ENGINE S12A2

The operator and supervisor are requested to read this Operation and Maintenance Manual carefully before operating the engine or conducting inspection and maintenance.  
Never operate the engine or conduct maintenance work without completely understanding this manual.



January 2011  
Pub. No. 99260-201B0

# FOREWORD

This operation and maintenance manual contains detailed operation, inspection and maintenance information for engines from Mitsubishi Heavy Industries, Ltd. Please be forewarned that there are contents which are overlapping between the chapters.

Please read this manual thoroughly before proceeding with operation, inspection, and maintenance work for correct use and servicing.

Failure to follow directions in this manual may result in serious accidents.

Please observe the contents of the controls which are applied in the countries or areas when using the engines from Mitsubishi Heavy Industries, Ltd.

## LIMITED WARRANTY

If Mitsubishi Heavy Industries, Ltd. examines the returned parts and any failure at manufacturing is found, Mitsubishi Heavy Industries, Ltd. shall repair or exchange the parts.

Mitsubishi Heavy Industries, Ltd.'s warranty is limited to the compensation work of repair or replacement of parts. The warranty coverage is effective for the original purchaser only. Those to whom ownership is later transferred are not provided with the warranty. However the warranty coverage is effective for the ultimate purchaser and each subsequent purchaser for emission-related parts.

- 
- ♦ **Mitsubishi Heavy Industries, Ltd. makes no warranties, either expressed or implied, except as provided in this manual, including, but not limited to, warranties as to marketability, merchantability, fitness for a particular purpose or use, or against infringement of any patent.**
  - ♦ **Mitsubishi Heavy Industries, Ltd. will not be liable for any damages or consequential damages, including, but not limited to, damages or other costs resulting from any abuse, misuse, misapplication of the engine and devices supplied from us.**
  - ♦ **Mitsubishi Heavy Industries, Ltd. will not be liable for any damages or personal injuries resulting from any modification, without our written permission, of the engine and devices supplied from us.**
  - ♦ **Mitsubishi Heavy Industries, Ltd. will not be liable for any damages or production losses caused by the use of fuel, engine oil and/or long life coolant (LLC) that we are not recommended.**
  - ♦ **The owner of the engine is responsible for the performance of the required maintenance listed in this operation manual.**  
**When performing the maintenance, follow the service manual published by Mitsubishi Heavy Industries, Ltd.**  
**Mitsubishi Heavy Industries, Ltd. may deny the warranty coverage if the engine or part has failed due to inadequate or improper maintenance.**
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# EMISSION WARRANTY

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## IMPORTANT

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The following warranty applies to the engines that are approved of the emission regulation of the U.S. Environmental Protection Agency.

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### Warranty Coverage

Mitsubishi Heavy Industries, Ltd. warrants to the first owner and each subsequent purchaser of a new non-road diesel engine that the emission control system of your engine:

- ♦is designed, built and equipped so as to conform at the time of sales with all applicable regulation of the U.S. Environmental Protection Agency. If the vehicle in which the engine is installed is registered in the state of California, a separate California emission regulation also applies.
- ♦is free from the defects in material and workmanship which will cause the engine to fail to meet these regulations within the warranty period.

### Warranty Period

Then its warranty period is 5 years or 3000 hours, whichever comes first.

However, if your engine warranty period is longer than the emission warranty period, the emission warranty period extends to same as the engine warranty period.

Below warranty period shall begin on the date the engine is delivered to the first owner.

### Warranted Parts

Mitsubishi Heavy Industries, Ltd. warrants the parts which will increase the emission of pollutants when they become defective.

The followings are examples.

- ♦Inlet/Exhaust manifold
- ♦Crankcase ventilation system
- ♦Fuel system

### Limited Warranty

It conforms to "[LIMITED WARRANTY](#)" (page ii).

# CALIFORNIA EMISSION CONTROL WARRANTY STATEMENT YOU WARRANTY RIGHTS AND OBLIGATIONS

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## IMPORTANT

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The following warranty applies to the engines that are approved of the emission regulation of the California Air Resources Board (CARB).

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The **California Air Resources Board (CARB)** is pleased to explain the **emission control system warranty** on you 2011 or later engine. In California, new heavy-duty off-road engines must be designed, built, and equipped to meet the State's stringent anti-smog standards. Mitsubishi Heavy Industries, Ltd. must warrant the emission control system on your engine for the periods of time listed below provided there has been no abuse, neglect or improper maintenance of your engine.

Your emission control system may include parts such as the fuel-injection system and the air induction system. Also included may be hoses, belts, connectors and other emission-related assemblies.

Where a warrantable condition exists, Mitsubishi Heavy Industries, Ltd. will repair your heavy-duty off-road engine at no cost to you including diagnosis, parts, and labor.

### **Manufacturer's warranty coverage:**

The **2011** and later heavy-duty off-road engines are warranted for the warranty period. If any emission-related part on your engine is defective, the part will be repaired or replaced by Mitsubishi Heavy Industries, Ltd.

### **Owner's warranty responsibilities**

- ♦As the heavy-duty off-road engine owner, you are responsible for the performance of the **required maintenance listed in your owner's manual**. Mitsubishi Heavy Industries, Ltd. recommends that you retain all receipts covering maintenance on your heavy-duty off-road engine, but Mitsubishi Heavy Industries, Ltd. never deny warranty solely for the lack of receipts or for your failure to ensure the performance of all scheduled maintenance.
- ♦As the heavy-duty off-road engine owner, you should however be aware that Mitsubishi Heavy Industries, Ltd. may deny you warranty coverage if your heavy-duty off-road engine or a part has failed due to abuse, neglect, improper maintenance or unapproved modifications.
- ♦Your engine is designed to operate on diesel fuel only. Use of any other fuel may result in your engine no longer operating in compliance with California's emissions requirements.
- ♦You are responsible for initiating the warranty process. The Air Resources Board suggests that you present your heavy-duty off-road engine to a Mitsubishi Heavy Industries, Ltd. dealer or distributor dealer as soon as problem exists. The warranty repairs will be completed by the dealer or distributor as expeditiously as possible.

If you have any questions regarding your warranty rights and responsibilities, you should contact Mitsubishi Engine North America at **1-630-268-0750**.

**Warranty coverage**

- (a) The warranty period shall begin on the date the engine or equipment is delivered to an ultimate purchaser.
- (b) Mitsubishi Heavy Industries, Ltd. warrants to the ultimate purchaser and each subsequent purchaser of the engine registered in the state of California that the engine is:
- (1) Designed, built and equipped so as to conform with all applicable regulations adopted by the Air Resources Board.
  - (2) Free from defects in materials and workmanship which cause the failure of a warranted part to be identical in all material respects to the parts as described in Mitsubishi Heavy Industries, Ltd.'s application for certification for a period of 5 years or 3,000 hours of operation, whichever occurs first. In the absence of a device to measure hours of use, the engine shall be warranted for a period of 5 years. For all engines rated less than 19 kW, and for constant-speed engines rated under 37 kW with rated speeds higher than or equal to 3,000 min<sup>-1</sup>, the period of 2 years or 1,500 hours of operation, whichever occurs first, shall apply. In the absence of a device to measure hours of use, the engine shall be warranted for a period of 2 years.
- (c) The warranty on emission-related parts shall be interpreted as follows:
- (1) Any warranted part which is not scheduled for replacement as required maintenance in the written instructions required by Subsection (e) shall be warranted for the warranty period defined in Subsection (b) (2). If any such part fails during the period of warranty coverage, it shall be repaired or replaced by Mitsubishi Heavy Industries, Ltd. according to Subsection (4) below. Any such part repaired or replaced under the warranty shall be warranted for the remaining warranty period.
  - (2) Any warranted part which is scheduled only for regular inspection in the written instructions required by Subsection (e) shall be warranted for the warranty period defined in Subsection (b) (2). A statement in such written instructions to the effect of "repair or replace as necessary" shall not reduce the period of warranty coverage. Any such part repaired or replaced under the warranty shall be warranted for the remaining warranty period.
  - (3) Any warranted part which is scheduled for replacement as required maintenance in the written instructions required in Subsection (e) shall be warranted for the period of time prior to the first scheduled replacement point for that part. If the part fails prior to the first scheduled replacement, the part shall be repaired or replaced by Mitsubishi Heavy Industries, Ltd. according to Subsection (4) below. Any such part repaired or replaced under warranty shall be warranted for the remainder of the period prior to the first scheduled replacement point for the part.
  - (4) Repair or replacement of any warranted part under the warranty provisions shall be performed at no charge to the owner at a warranty station.
  - (5) Notwithstanding the provisions of Subsection (4) above, warranty services or repairs shall be provided at all Mitsubishi Heavy Industries, Ltd. distribution centers that are franchised to service the subject engines.
  - (6) The owner shall not be charged for diagnostic labor that leads to the determination that a warranted part is in fact defective, provided that such diagnostic work is performed at a warranty station.
  - (7) Mitsubishi Heavy Industries, Ltd. shall be liable for damages to other engine components proximately caused by failure under warranty of any warranted part.
  - (8) Throughout the engine's warranty period defined in Subsection (b) (2), Mitsubishi Heavy Industries, Ltd. shall maintain a supply of warranted parts sufficient to meet the expected demand for such parts.
  - (9) Any replacement part, as defined in Section 1900(b)(13), Title 13, may be used in the performance of any maintenance or repairs and must be provided without charge to the owner. It is not necessary for replacement parts to be the same brand or by the same manufacturer as the original part sold with the engine. Such use shall not reduce the warranty obligations of the engine manufacturer.

- (10) Add-on or modified parts, as defined in Section 1900(b)(1) and (b)(10), Title 13, that are not exempted by the Air Resources Board may not be used. The use of any non-exempted add-on or modified parts shall be grounds for disallowing a warranty claim made in accordance with this article. The engine manufacturer shall not be liable under this article to warrant failures of warranted parts caused by the use of a non-exempted add-on or modified part.
- (11) The Air Resources Board may request and, in such case, Mitsubishi Heavy Industries, Ltd. shall provide, any documents which describe that Mitsubishi Heavy Industries, Ltd.'s warranty procedures or policies.
- (d) Warranted parts list.
- (1) Fuel metering system
    - (A) Fuel injection system.
    - (B) Air/fuel ratio feedback and control system.
    - (C) Cold start enrichment system.
  - (2) Air induction system
    - (A) Controlled hot air intake system.
    - (B) Intake manifold.
    - (C) Heat riser valve and assembly.
    - (D) Turbocharger/supercharger systems.
    - (E) Charged air cooling systems.
  - (3) Exhaust gas recirculation (EGR) system
    - (A) EGR valve body, and carburetor spacer if applicable.
    - (B) EGR rate feedback and control system.
  - (4) Air injection system
    - (A) Air pump or pulse valve.
    - (B) Valves affecting distribution of flow.
    - (C) Distribution manifold.
  - (5) Catalyst or thermal reactor system
    - (A) Catalytic converter.
    - (B) Thermal reactor.
    - (C) Exhaust manifold.
  - (6) Particulate controls
    - (A) Traps, filters, precipitators, and any other devices used to capture particulate emissions.
    - (B) Regenerators, oxidizers, fuel additive devices, and any other device used to regenerate or aid in the regeneration of the particulate control device.
    - (C) Control device enclosures and manifolding.
    - (D) Smoke puff limiters.
  - (7) Advances oxides of nitrogen (NO<sub>x</sub>) controls
    - (A) NO<sub>x</sub> absorbers.
    - (B) Lean NO<sub>x</sub> catalysts.
    - (C) Selective catalyst reduction.
    - (D) Reductant (urea/fuel) containers/dispensing systems.
  - (8) Positive crankcase ventilation (PCV) system
    - (A) PCV valve.
    - (B) Oil filler cap



(9) Miscellaneous items used in above systems

- (A) Vacuum, temperature, and time sensitive valves and switches.
- (B) Electronic control units, sensors, solenoids, and wiring harnesses.
- (C) Hoses, belts, connectors, assemblies, clamps, fittings, tubing, sealing gaskets or devices, and mounting hardware.
- (D) Pulleys, belts and idlers.
- (E) Emission control information labels.
- (F) Any other part with the primary purpose of reducing emissions or that can increase emission during failure without significantly degrading engine performance.

(e) Mitsubishi Heavy Industries, Ltd. shall furnish with each new engine written instructions for the maintenance and use of the engine by the owner.

**Limited warranty**

Refer to "[LIMITED WARRANTY](#)" (Page ii).

## IMPORTANT INFORMATION

- ♦To avoid the potential hazard, accident prevention activities must be planned methodically and conducted continually by considering all aspect of engine operation, maintenance and inspection. All related personnel, including managers and supervisors, should actively participate, recognize their roles and organize themselves and their work to ensure a safe environment.
- ♦The foremost safety objective is to prevent accidents which may result in injury or death, or equipment damage.
- ♦Always observe laws or regulations of the local or federal/national government.
- ♦Mitsubishi Heavy Industries, Ltd. cannot foresee all potential dangers of the engine, potential danger resulting from human error and other causes, or danger caused by a specific environment in which the engine is used. Since there are many actions that cannot be performed or must not be performed, it is impossible to indicate every caution in this manual or on warning labels. As such, it is extremely important to follow directions in this manual and also to take general safety measures when operating, maintaining and inspecting the engine.
- ♦When the engine is used by individuals whose native language is not English, the customer is requested to provide thorough safety guidance to the operators. Also add safety, caution and operating signs that describe the original warning label statements in the native language of the operators.
- ♦The engine must be operated, maintained and inspected only by qualified persons who have thorough knowledge of engines and their dangers and who also have received risk avoidance training.
- ♦To prevent an accident, do not attempt to carry out any operation other than those described in this manual, and do not use the engine for any unapproved purpose.
- ♦When the ownership of the engine is transferred, be sure to provide this manual with the engine to the new owner. Also inform Mitsubishi Heavy Industries, Ltd. of the name and address of the new owner of the engine.
- ♦This manual is copyrighted and all rights are reserved. No part of this manual, including illustrations and technical references, may be photocopied, translated, or reproduced in any electronic medium or machine readable form without prior written consent from Mitsubishi Heavy Industries, Ltd.
- ♦The contents in this manual are subject to change at any time without notice for improvement of the engine.
- ♦Pictures or illustrations of the product in this manual may differ from those of product you have. Please note that, depending on specifications, items described in this manual may differ from those on your engine in shape, or may not be installed on your engine.
- ♦Please contact a dealer of Mitsubishi Heavy Industries, Ltd. if you need more information or if you have any questions.
- ♦If you lost or damaged this manual, obtain a new copy at a dealer of Mitsubishi Heavy Industries, Ltd. as soon as possible.
- ♦Mitsubishi Heavy Industries, Ltd. recommends the engine owner to install an hour meter on the engine due to monitor correct running intervals and to perform the maintenance at the appropriate timing.

# WARNING INDICATION

The following means are used to call the attention of the operators and maintenance personnel to potential dangers of the engine.

- Warning statements in the manual
- Warning labels affixed on the engine

## Warning Gtatements

The warning statements in this manual describe potential danger in operating, inspecting or maintaining the engine, using the following five classifications to indicate the degree of potential hazard.

Failure to follow these directions could lead to serious accidents which could result in personal injury, or death in the worst case.

Understand the directions well, and handle engines with following directions.



Indicates an immediately hazardous situation which, if not avoided, will result in death or serious injury.



Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.



Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.



Indicates a potentially hazardous situation which, if not avoided, may result in property damage.

Note: Indicates important information or information which is useful for engine operation.

## UB-HG C: A95 GI F9A9BH

Measurements are based on the International System of Units (SI), and they are converted to the metric system units in this manual using the following conversion rates.

- ♦ Pressure :1 MPa = 10.197 kgf/cm<sup>2</sup>
- ♦ Torque:1 N•m = 0.10197 kgf•m
- ♦ Force:1 N = 0.10197 kgf
- ♦ Horsepower:1 kW = 1.341 HP = 1.3596 PS
- ♦ Meter of mercury:1 kPa = 0.75 cmHg
- ♦ Meter of water:1 kPa = 10.197 cmH<sub>2</sub>O (cmAq)
- ♦ Rotation speed:1 min<sup>-1</sup> = 1 rpm
- ♦ Kinetic viscosity:1 mm<sup>2</sup>/s = 1 cSt

## ABBREVIATIONS, STANDARD AND OTHERS

- ♦ API = American Petroleum Institute
- ♦ ASTM = American Society for Testing and Materials
- ♦ ISO = International Organization for Standardization
- ♦ JIS = Japanese Industrial Standards
- ♦ LLC = Long Life Coolant
- ♦ MIL = Military Specifications and Standards
- ♦ MSDS = Material Safety Data Sheet
- ♦ SAE = Society of Automotive Engineers

## Chapter 1

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# Chapter 1 BASIC SAFETY PRECAUTIONS

## Fire and Explosions



### Keep Flames Away

Do not use flames near the engine (in the engine room). Fuel gas vapor or other gas can catch fire and produce dangerous situations.



Wipe off spilled fuel, oil and LLC immediately and thoroughly. Spilled fuel, oil and LLC may ignite and cause a fire.

Store fuel and engine oil in a well-ventilated area.

Make sure that the caps of fuel and engine oil containers are tightly closed.

### Always Switch the Water Heater ON

#### (Emergency generator with water heater)

Always switch the water heater ON (automatic mode) through a whole year.

If the switch is not ON (automatic mode), each cylinder varies considerably in combustion at the starting up the engine. Unburned fuel may explode in the exhaust pipe.

### Keep Engine Surrounding Area Tidy and Clean

Do not leave combustible or explosive materials, such as fuel, engine oil and LLC, near the engine. Such substances can cause fire or explosion.

Remove dust, dirt and other foreign materials accumulated on the engine and surrounding parts thoroughly. Such materials can cause fire or the engine to overheat. In particular, clean the top surface of the battery thoroughly. Dust can cause a short-circuit.

### Ventilation of Engine Room

Always provide adequate ventilation in the engine room. Insufficient air in the room can cause an increase in the engine temperature and a decrease in the output power and performance. It is highly recommended to calculate the required amount of air supply to the engine and install an adequate ventilation system before installing the engine.

### Do Not Open Side Cover Until Engine Cools

Do not attempt to open the side cover of the crankcase before the engine cools down. Wait at least 10 minutes after stopping the engine.

Opening the cover when the engine is hot allows fresh air to flow into the crankcase, which can cause oil mist to ignite and explode.

### Care for Fuel, Oil and Exhaust Gas Leakage

If any fuel, oil or exhaust gas leaks are found, immediately stop the engine and take corrective measures to stop leakage.

Such leakages, if left uncorrected, can cause fuel or engine oil to reach hot engine surfaces or hot exhaust gas to contact flammable materials, possibly leading to personal injury and/or damage to equipment.

### Use Explosion-proof Lighting Apparatus

When inspecting fuel, engine oil, coolant, battery electrolyte, etc., use a flameproof light. An ordinary lighting apparatus may ignite gas and cause it to explode.

### Prevent Electrical Wires From Short-circuiting

Avoid inspecting or servicing the electrical system with the ground cable connected to the battery. Otherwise, a fire could result from short-circuiting. Be sure to disconnect the battery cable from the negative (-) terminal before beginning with the work procedure.

Short-circuits, possibly resulting in fire, may be caused by a loose terminal or damaged cable/wire.

Inspect the terminals, cables and wires, and repair or replace the faulty parts before beginning with the service procedure.

### Keep Fire Extinguishers and a First-aid Kit Handy

Keep fire extinguishers handy, and become familiar with their usage.

Keep a first-aid kit at the designated place where it is easily accessible by anyone at any time.



Establish response procedures to follow in the event of fire or accident. Provide an emergency evacuation route and contact points and means of communication in case of emergency.

## Stay Clear of All Rotating and Moving Parts



### Install Protective Covers Around Rotating Parts

Make sure the protective covers of the engine are correctly installed. Repair any damaged or loose covers. Never remove the covers such as damper cover, camshaft cover, or rocker cover that enclose the revolving parts during operation.



When the engine is coupled to driven equipment, be sure to provide protective covers over the parts such as the connecting belts and couplings that are exposed.

Never remove protective covers.

### Check Work Area for Safety

Before starting the engine, make sure no one is near the engine and tools are not left on or near the engine. Verbally notify persons within the immediate area when starting the engine.

When the starter device is posted with a sign that prohibits startup operation, do not operate the engine.

### Stay Clear of Moving Parts While Engine is Running

Stay away from rotating or sliding parts of the engine while the engine is running. Put objects, which might be easily caught by rotating parts, away from rotating parts.



If any part of the clothing or outfitting is caught by a rotating part, serious bodily injuries could result.

### Lockout and Tagout

Be sure to lockout and tagout before starting inspection and maintenance.

Lockout and tagout are effective methods of cutting off machines and equipment from energy sources.

To accomplish the lockout/tagout, remove the starter switch key, set the battery switch to OFF and attach a "Do Not Run" or similar caution tag to the starter switch.

The starter switch key must be kept by the person who performs inspection and maintenance during the work.

In the case of pneumatic starting type, close the main valve of the air tank and post a tag saying "Do Not Open the Valve" or the like.

### Keep Engine Stopped During Servicing

Be sure to stop the engine before proceeding to inspection and service procedure. Never attempt to make adjustments on the engine parts while the engine is running.

Rotating parts such as belt can entangle your body and cause serious injuries.

### Always Restore Engine Turning Tools After Use

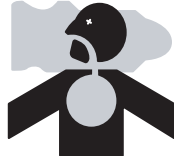
Do not forget to remove the tools which have been used for turning the engine during inspection or servicing, after the procedure is finished. Starting the engine with the turning tools inserted or with the turning gear in engagement can lead to not only engine damage but also personal injuries.

## Be Careful of Exhaust Fume Poisoning

 **WARNING**

### Operate Engine in a Well-ventilated Area

Check the exhaust pipes and where the pipes joint together for gas leaks. Exhaust gas from the engine contains carbon monoxide and other harmful substances. Operating the engine in an poorly-ventilated area can produce gas poisoning.



## Protect Ears From Noise

 **WARNING**

### Wear Ear Plugs

Always wear ear plugs when entering the machine room (engine room). Combustion sound and mechanical noise generated by the engine can cause hearing problems.



## Be Careful of Falling Down

 **WARNING**

### Lift Engine Carefully

To lift the engine, use slings capable of supporting the weight of the engine.

Attach the wire rope to the hangers provided on the engine using a correct sling.

During lifting process, keep the engine in a well-balanced position by taking the center of gravity of the engine into consideration.

The hangers equipped with the engine are designed for lifting the engine only. When mounting generator on the engine, use the special hanger of common bed. Hangers of engine cannot be used. When mounting marine gear on the engine, be sure not to apply the load on the hangers of engine only.

Keep the angle formed by slings attached to hangers within 60°. If the angle exceeds this limit, excessive load could be imposed on the hangers and this could damage the hangers and result in a serious accident. If the wire rope contacts the engine directly, place a cloth or other soft padding to avoid damage to the engine and wire rope.



### Do Not Climb Onto the Engine

Do not climb onto the engine, nor step on any engine parts located on the lateral sides.

To work on parts located on the upper section of engine, use a ladder, stool, etc., that was firmly secured.

Climbing on the engine may not only damage engine parts but also cause falling down from the engine and result in personal injuries.

### Always Prepare Stable Scaffold

When working on the upper part of the engine and other hard-to-reach places, use a stable work platform.

Standing on a decrepit stool or parts box may result in personal injury.

Do not place any unnecessary objects on a work platform.



## Be Careful of Burns



### Do Not Touch the Engine During or Immediately After Operation

To avoid burns, do not touch the engine during or immediately after operation.

A hot engine can cause burns.

To conduct maintenance and inspection work, wait until the engine has cooled sufficiently by checking the temperature gauge.



### Refill Coolant Only After the Coolant Temperature Dropped

When adding coolant, check that the coolant temperature lowers sufficiently with temperature gauge. Adding coolant immediately after the engine stops may result in burns.

### Be careful of burns when changing oil

Wear gloves when draining oil or changing oil filters. If hot oil or parts touch your skin, it may cause burns.

### Never Remove Heat Shields

The inlet and exhaust system, which becomes extremely hot while the engine is operating, is provided with various heat shields. Do not remove these heat shields. If any of these heat shields have been removed owing to unavoidable circumstances during the work, be sure to restore them after the work is completed.

### Be Careful of Opening and Closing Radiator Cap

Never open the radiator cap while the engine is running or immediately after the engine is stopped. To open the cap, stop the engine and allow the coolant temperature to lower sufficiently.

To open the radiator cap, open slowly to discharge the pressure inside the tank. Also to avoid a risk of getting scalded by steam, wear thick rubber gloves or wrap a cloth around the cap.

When closing the radiator cap, be sure to tighten securely.

The coolant is hot while engine is running and immediately after the engine stops. If the cap is opened when the coolant is at operating temperature, steam and hot coolant may blow out and result in burns.

### Do Not Touch High Pressure Injection Fuel

If fuel leaks or sprays out from the high pressure injection pipe, do not touch the fuel.

Fuel in the fuel injection pipes is under high pressure and if the fuel contact your skin, it goes into deep tissues and may result gangrene.

## Be Careful When Handling Fuel, Engine Oil or LLC

### CAUTION

### Use Only Specified Fuel, Engine Oil and LLC

Use fuel, oil and LLC specified in this manual, and handle them carefully.

Use of any other fuel gas, oil or LLC than the specified ones, or improper handling may cause various engine problems and malfunctions.

Obtain the MSDS issued by the oil and LLC suppliers, and follow the directions in the MSDSs for proper handling.

### Handle LLC Carefully

When handling LLC, always wear rubber gloves and a protective face mask. If LLC or cooling water containing LLC comes into contact with your skin or eyes, or if it is swallowed, you would suffer from inflammation, irritation or poisoning.

Should LLC be accidentally swallowed, induce vomiting immediately and seek medical attention. Should LLC enter your eyes, flush them immediately with plenty of water and seek medical attention. If LLC splashes onto your skin or clothing, wash it away immediately with plenty of water.

Keep flames away from LLC. LLC is highly flammable and can easily catch a fire if exposed to a flame.

### Proper Disposal of Waste Oil, LLC and Coolant

Do not discharge waste engine oil, LLC and coolant into sewerage, river, lake or other similar places. Such a way of disposal is strictly prohibited by laws and regulations.

Dispose of waste oil, LLC and coolant and other environmentally hazardous waste in accordance with the applicable law and regulations.

## When Abnormality Occurs

### CAUTION

### Do Not Add Coolant Immediately After a Sudden Stop Due to Overheating

If the engine stops suddenly or if you have no choice but stop the engine suddenly due to overheating, do not add coolant immediately.

Adding water while the engine is hot can damage parts such as cylinder heads due to a sudden drop of temperature. Add coolant gradually after the engine has completely cooled.

### Stop Operation Immediately If You Notice Any Unusual Symptoms

Stop the operation immediately if you notice any unusual noise, odor or vibration during operation. In case of emergency, press the emergency stop button to stop the engine. Contact your local dealer if the cause of problem cannot be located after stopping the generator. Continuous operation neglecting an unusual symptom could cause serious or fatal accident.

### Avoid Immediate Restart After Abnormal Stop

If the engine stops abnormally, do not restart the engine immediately. If the engine stops with an alarm, check and remedy the cause of the problem before restarting. Sustained use of the engine without any remedy could result in serious engine problems.

### Avoid Continuous Engine Operation at Low Oil Pressure

If an abnormal engine oil pressure drop is indicated, stop the engine immediately, and inspect the lubrication system to locate the cause. Continuous engine operation with low oil pressure could cause bearings and other parts to seize.

### If Belt Breaks, Stop Engine Immediately

If the belt breaks, stop the engine immediately and replace the belt. Sustained use of the engine without any remedy could cause defective charge and cooling failure, and result in serious engine problems.

# Battery

 CAUTION

## Handle the Battery Correctly

- Never use flames or allow sparks to generate near the battery. The battery releases flammable hydrogen gas and oxygen gas. Any flames or sparks in the vicinity could cause an explosion.
- Do not use the battery when the battery electrolyte level is below the "LOWER LEVEL" mark. Sustained use of the battery could result in an explosion.
- Do not short the battery terminals with a tool or other metal object.
- When removing battery, always remove the plug from the negative (-) terminal first. When connecting battery, always connect the plug to the positive (+) terminal first.
- Remove all plugs, then charge the battery in a well ventilated area.
- Make sure the cable clamps are securely installed on the battery terminals. A loose cable clamp can cause sparks that may result in an explosion.
- Before servicing electrical components or conducting electric welding, set the battery switch to [Open/OFF] position or remove the plug from the negative (-) terminal to cut off the electrical current.
- Battery electrolyte contains dilute sulfuric acid. Careless handling of the battery can cause the loss of sight and/or skin burns. Also, do not swallow the battery electrolyte.
- Wear protective goggles and rubber gloves when working with the battery (e.g. adding water, charging battery).
- If battery electrolyte is spilled onto the skin or clothing, immediately wash it away with lots of water. Use soap to thoroughly clean.
- The battery electrolyte can cause the loss of sight if splashing into the eyes. If it gets into the eyes, immediately flush it away with plenty of clean water, and seek immediate medical attention.
- If you accidentally swallow battery electrolyte, gargle with plenty of water and then drink lots of water, and seek immediate medical attention.





## Other Cautions



**CAUTION**

### Never Modify Engine

Unauthorized modification of the engine will void our warranty.

Modification of the engine may not only cause engine damage but also produce personal injuries.

If there is a need to modify the engine, contact a dealer of Mitsubishi Heavy Industries, Ltd.

### Observe Safety Rules at Work Site

Observe the safety rules established at your work-place when operating and maintaining the engine.

Do not operate the engine if you are not feeling well, and inform your supervisor of your condition. Operation of the engine with reduced awareness may cause improper operation that could result in accidents.

When working in a team for two or more people, use specified hand signals to communicate among workers.

### Work Clothing and Protective Gear

Wear a hardhat, face shield, safety shoes, dust mask, gloves, ear plugs and other protective gear as needed. When handling compressed air, wear safety goggles, a hardhat, gloves and other necessary protective gear. Working without wearing proper protective gear could result in serious injuries.

### Never Break Seals

To ensure proper engine operation, the fuel control links are sealed to prevent accidental change of the injection volume and rotation speed settings. If the seal is tampered, no guarantee will be provided. If the seal is tampered, the defects shown below can occur.

- Rapid wear of sliding and rotating parts
- Engine damage such as seizing of engine parts
- Considerably increased consumption of fuel and lubricating oil
- Degradation of engine performance due to improper balance between fuel injection volume and governor operation or overrunning of the engine which could result in a serious accident.

### Perform All Specified Pre-operation Inspections and Periodic Inspections

Conduct the pre-operation inspections and periodic inspections as described in this manual.

Failure to conduct the specified inspections may cause various engine problems, damage to parts, and serious accidents.

### Break-in the Engine

To break-in new engines or overhauled engines, operate the engine at a speed lower than the rated speed in a light load condition during the first 50 hours of operation.

Operating new engines or overhauled engines in a severe condition during the break-in period shortens the service life of the engine.

### Warm-up the Engine Before Use

After starting the engine, run the engine at a low idling speed for 5 to 10 minutes for warming-up. Start the work after this operation is completed. Warm-up operation circulates the lubricant around the engine, and thereby, individual engine parts are well lubricated before they are subjected to heavy loads.

Warm-up operation circulates lubricant oil around the engine and contributes to a longer service life and economical operation.

Do not conduct warm-up operation for prolonged period of time. Prolonged warm-up operation causes carbon build-up in the cylinders that leads to incomplete combustion.

### Never Operate the Engine in an Overloaded Condition

If the engine shows an overloaded condition such as black exhaust smoke, reduce the load immediately to operate the engine at an appropriate output and load. Overloading causes not only high fuel consumption but also excessive carbon deposits inside the engine. Carbon deposits cause various problems and will shorten the service life of the engine.



## **Conduct Cooling Operation Before Stopping the Engine**

Before stopping the engine, idle the engine in low gear for 5 to 6 minutes to cool down.

Stopping the engine immediately after high-load operation will cause engine parts to heat up and shorten the service life of the engine.

During cooling operation, check the engine for abnormalities.

## **Do Not Operate Engine Continuously Under Low Load**

When operating the engine with less than 30 % of rated load, limit each operation to an hour. Prolonged warm-up operation causes carbon build-up in the cylinders that leads to incomplete combustion. Operate the engine with a 30 % of rated load or more for over 5 minutes to prevent carbon build-up after one hour continuous operation is conducted.

## **Protection of the Engine Against Water Entry**

Do not allow rainwater, etc. to enter the engine through the air inlet or exhaust openings.

Do not wash the engine while it is operating. Cleaning fluid (water) can be sucked into the engine.

Starting the engine with water inside the combustion chambers can cause the water hammer action which may result in internal engine damage and serious accidents.

## **Conduct Proper Maintenance of Air Cleaner**

Maintain the engine with air cleaner according to the following instructions.

- Never service the air cleaner while the engine is running. The turbocharger may suck particles of foreign materials into the engine and could result in serious accidents.
- Remove the air cleaner slowly to prevent foreign materials accumulated on the element from falling off. After removing the air cleaner, immediately cover the air inlet with plastic sheet or similar means to prevent foreign materials from entering the engine.

## **Use of Tools Optimum for Each Work**

Always keep in mind to select most appropriate tools for the work to be performed and use them correctly. If tools are damaged, replace them with new tools.

## **Avoidance of Prolonged Time of Starter Operation**

Do not use the starter for more than 10 seconds at a time. If the engine does not start, wait for at least 1 minute before cranking again.

Continuous operation of the starter will drain the battery power and cause the starter to seize.

## **Do Not Turn Off the Battery Switch During Operation**

Do not turn off the battery switch during operation.

If the battery switch is turned OFF when the engine is running, not only various meters will stop working but also the alternator may have its diode and transistor deteriorated.

## **Cautionary Instructions for Transporting the Engine**

When transporting the engine on a truck, consider the engine weight, width and height to ensure safety.

Abide by road traffic law, road vehicles act, vehicle restriction ordinance and other pertinent laws.

# Warning Labels



## Maintenance of Warning Labels

Make sure all warning/caution labels are legible.

Clean or replace the warning/caution labels when the description and/or illustration are not clear to read.

For cleaning the warning/caution labels, use a cloth, water and soap. Do not use cleaning solvents, gasoline or other chemicals to prevent the letters from getting blurred or the adhesion from being weakened.

Replace damaged or fractured labels with new ones.

If any engine part on which a warning label is attached is replaced with a new one, attach a new identical warning label to the new part.

To obtain new warning labels, contact a dealer of Mitsubishi Heavy Industries, Ltd.

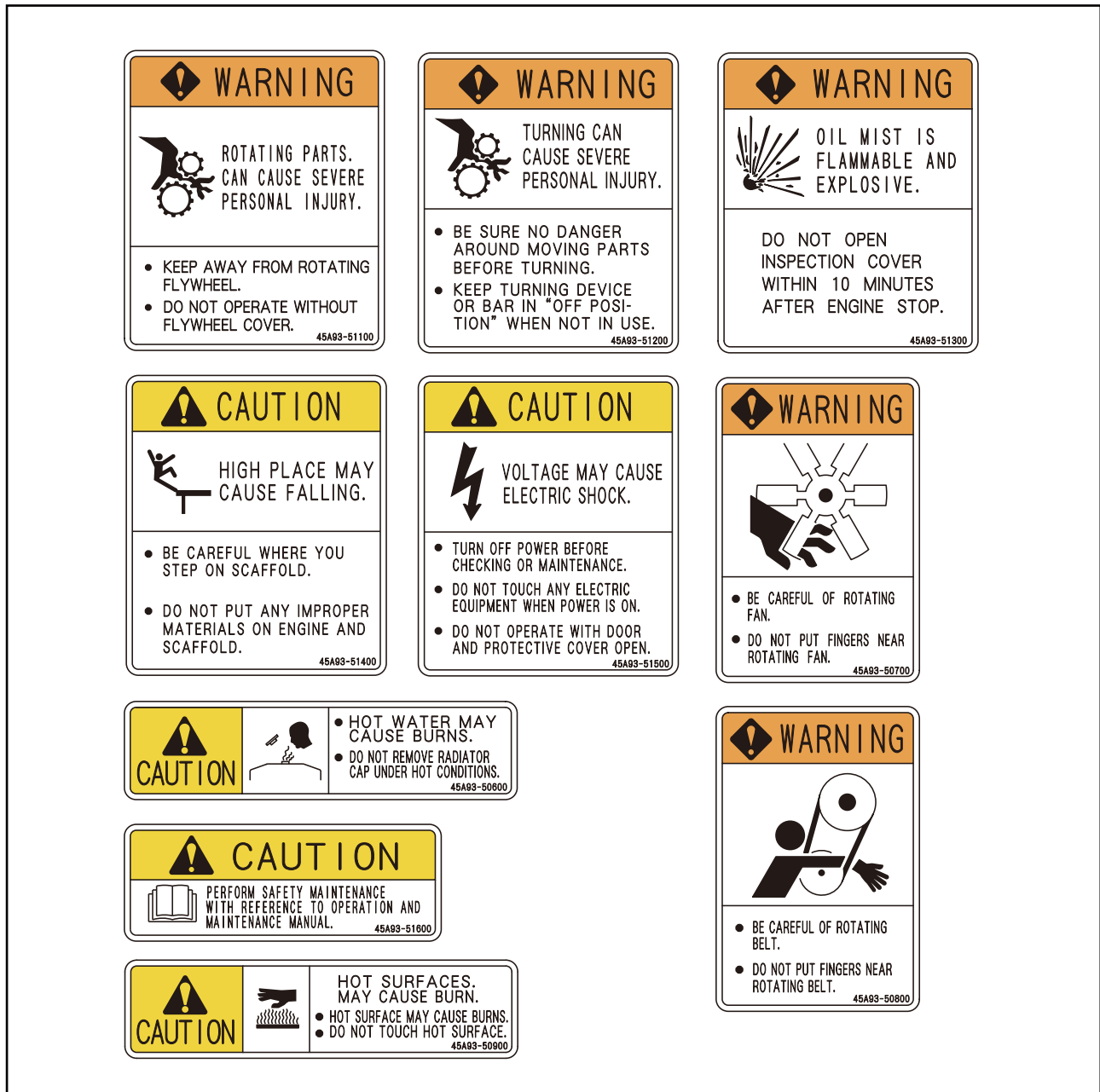


Fig. 1-1 Warning labels

# Chapter 2 NAME OF PARTS

## Engine External Diagrams

### Left Side

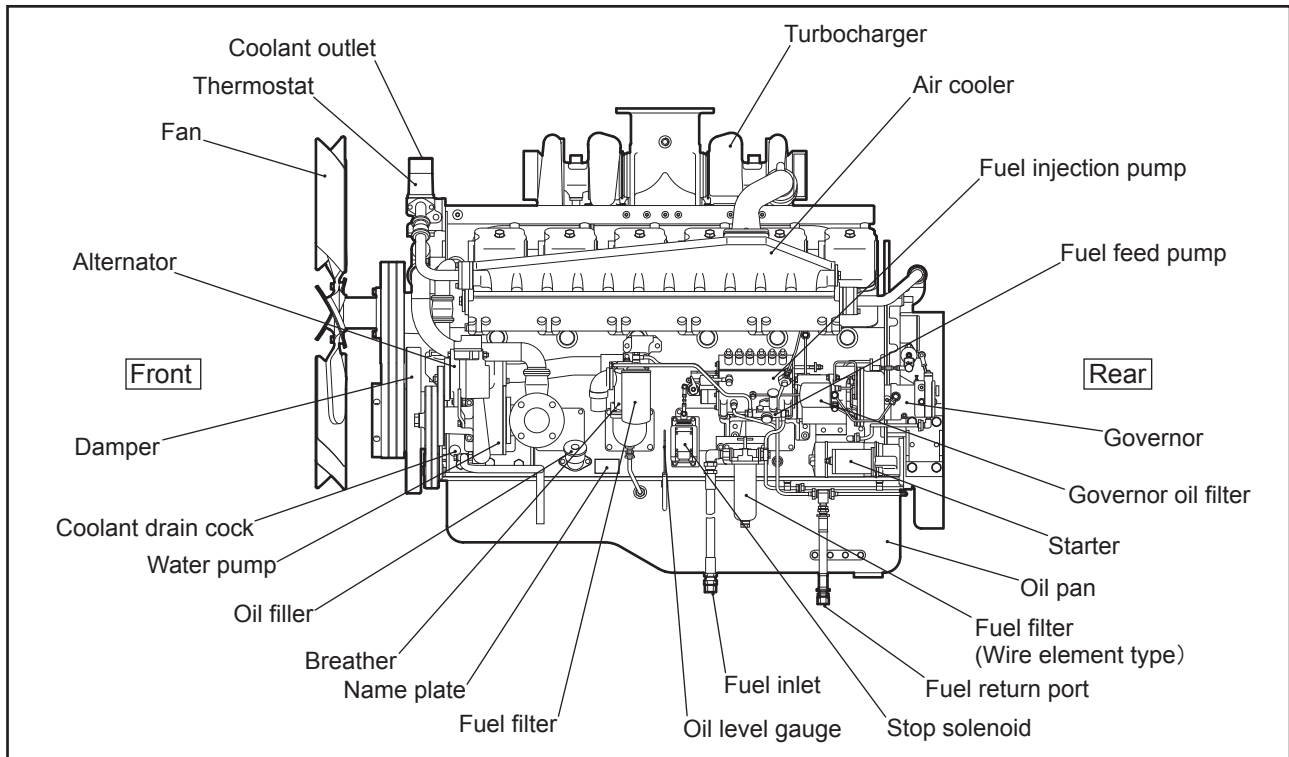


Fig. 2-1 Engine Left Side View

### Right Side

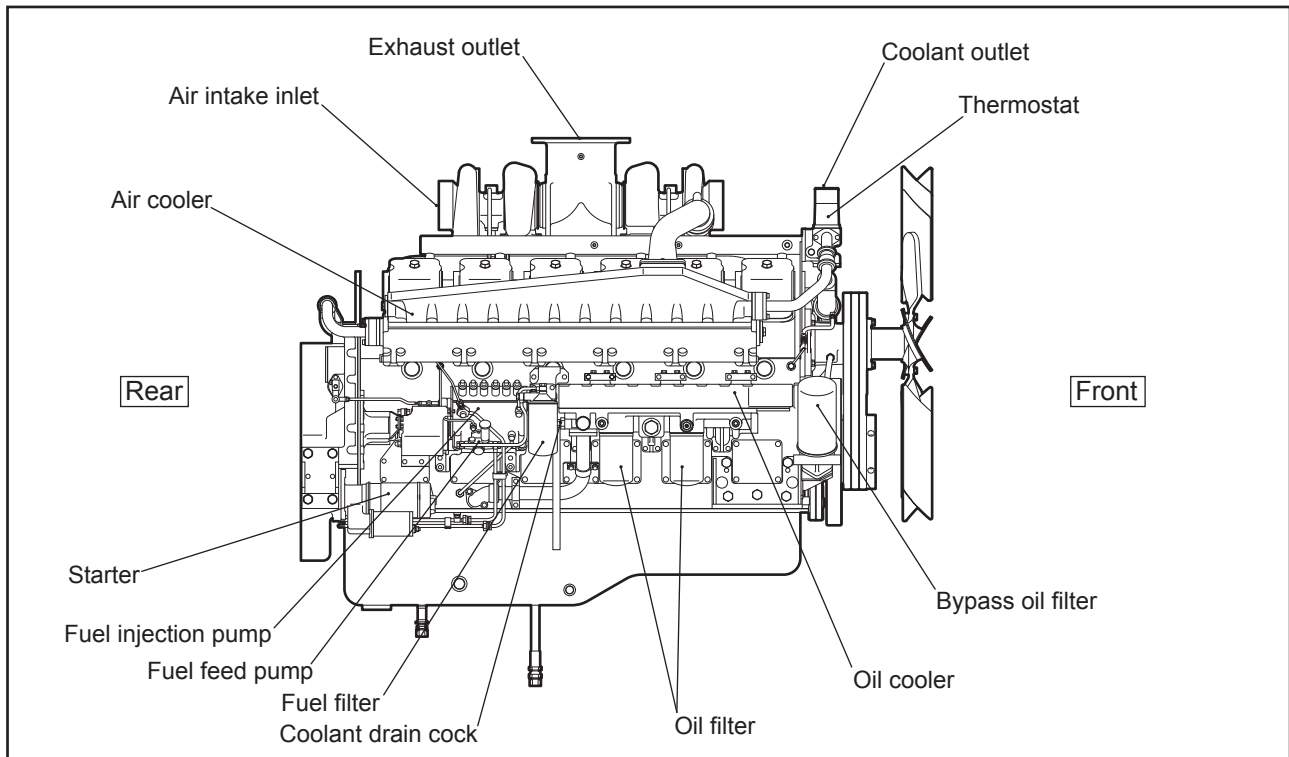


Fig. 2-2 Engine Right Side View

## Equipment and Instrument

The installed equipment and shapes differ on the engine type.

### Start and Stop Instrument

#### Start Switch

When the start switch on the operation panel is pressed, starting system operates to crank the engine.

#### Stop Switch

When the stop switch on the operation panel is pressed, the shutdown cylinder operates and moves the control shaft of the fuel injection pump to the no-injection position to shut down the engine operation.

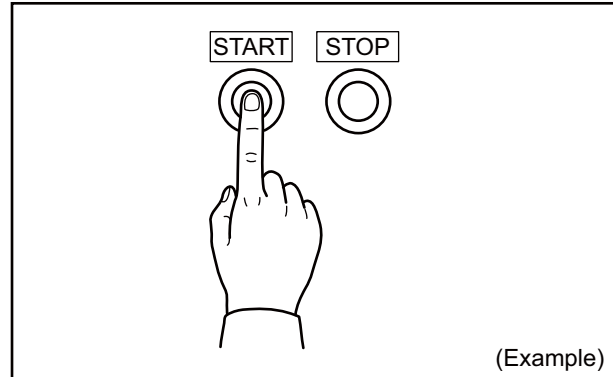


Fig. 2-3 Start Switch and Stop Switch

### Manual Stop Lever

#### CAUTION

When stopping the engine with manual stop lever, keep the manual stop lever at the stop position until the engine completely stops. If release the lever, the engine may restart.

Use the manual stop lever to shut down the engine in the event of an emergency. If the starter switch fails to stop engine operation, use the manual stop lever.

When the manual stop lever, which is located in the fuel control link, is moved in the "STOP" direction, the engine stops.

If the engine continues to operate even after the manual stop lever is moved in the "STOP" direction, cut off the fuel supply to stop the engine.

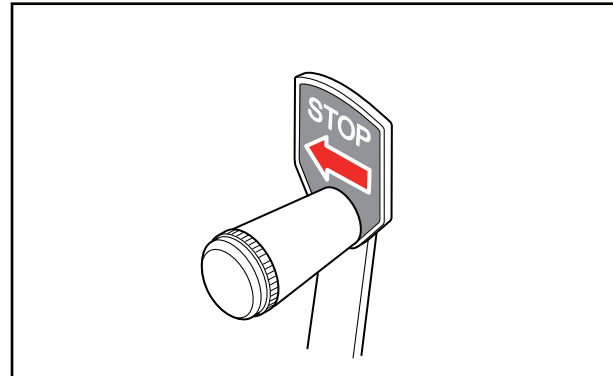


Fig. 2-4 Manual Stop Lever

### Stop Solenoid

The stop solenoid operates for normal shutdown of engine operation. The stop solenoid moves the rack of fuel injection pump to cut the fuel, and consequently stops the engine. Two types of stop solenoids are available.

#### •RUN OFF type

Not energized while the engine is running. Energized by a stop signal to stop the engine.

#### •RUN ON type

Energized while the engine is running, and de-energized by stop signal to stop the engine.

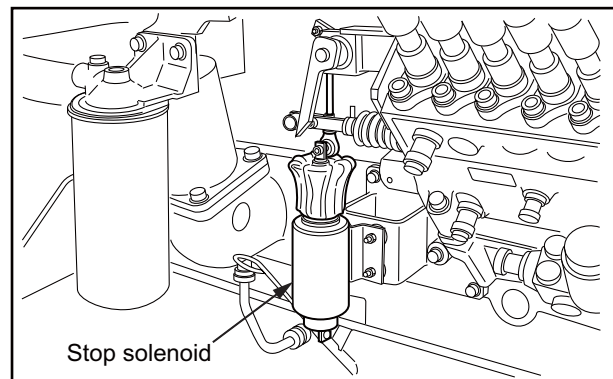


Fig. 2-5 Stop Solenoid

## Instruments

This section describes about devices which transmit signals to necessary instruments of the engine operation. Read carefully and understand functions of each device.

### Oil Pressure Unit

Indicate the oil pressure.

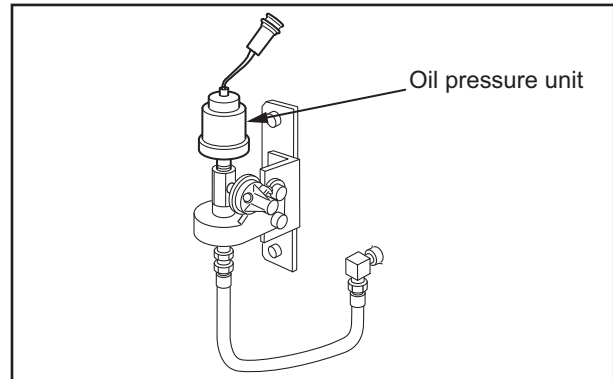


Fig. 2-6 Oil Pressure Unit

### Thermo Unit

Always detect the coolant temperature of engine.

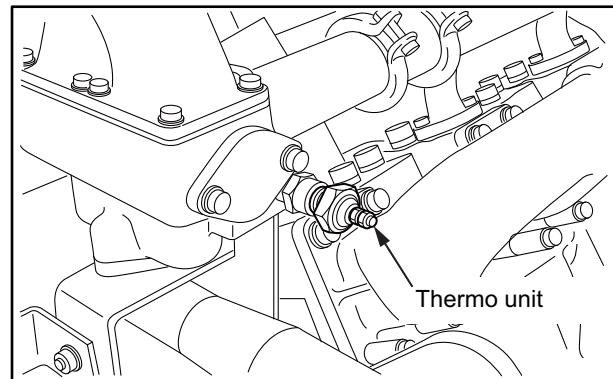


Fig. 2-7 Thermo Unit

### Revolution Detection Pickup

It is installed in the timing gear case, and always detect engine speed.

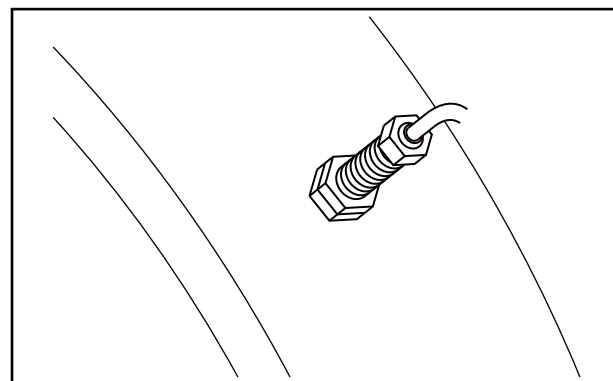


Fig. 2-8 Revolution Detection Pickup

## Engine Protection Devices

The engine protection devices activate an alarm when an abnormality occurs in the engine in order to protect the engine and prevent serious problems and accidents. When a protection device is activated, stop the engine, examine the cause of the abnormality, and take corrective measures. If the cause of the problem is unknown, contact a dealer of Mitsubishi Heavy Industries, Ltd. Protection devices installed on the engine and their types (setting values) and shapes vary depending on the engine specifications.

### Oil Pressure Switch

The oil pressure switch generates an alarm when the engine oil pressure becomes low and reaches the specified pressure.

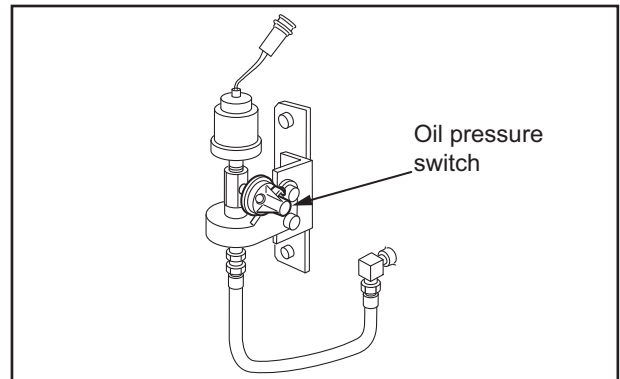


Fig. 2-9 Oil Pressure Switch

### Thermo Switch

The thermo switch generates an alarm when the engine coolant temperature becomes high and reaches the specified temperature.

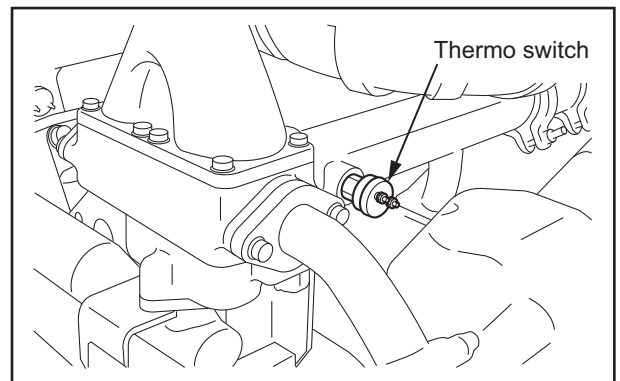


Fig. 2-10 Thermo Switch

### Oil Filter Alarm Switch

The oil filter alarm switch generates an alarm to stop the engine when oil filters become clogged, the difference in pressure between inlet and outlet of oil and reaches the specified value.

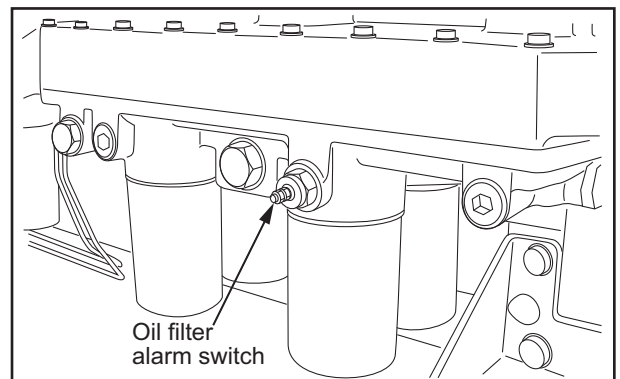


Fig. 2-11 Oil Filter Alarm Switch

## Revolution Detection Pickup

The overrun detection pickup generates an alarm when the engine speed becomes high and reaches the specified engine speed.

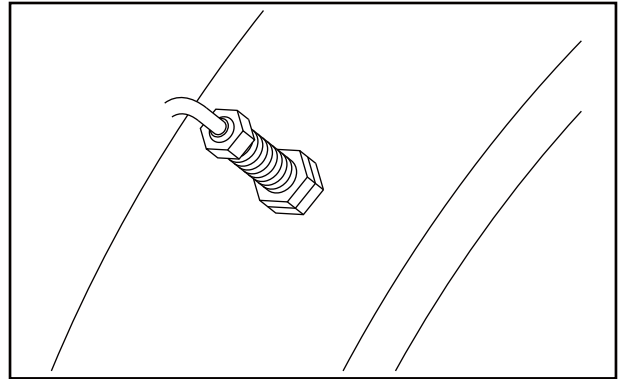


Fig. 2-12 Revolution Detection Pickup

## Air Cleaner Indicator

If the element is clogged, the intake air is decreased and the red signal mark will be displayed. The signal indicates only, and does not generate an alarm. Therefore, the periodic visually inspection is needed. Press the reset button on the top of air cleaner indicator and restore the signal after cleaned the air cleaner indicator or replaced with a new one.

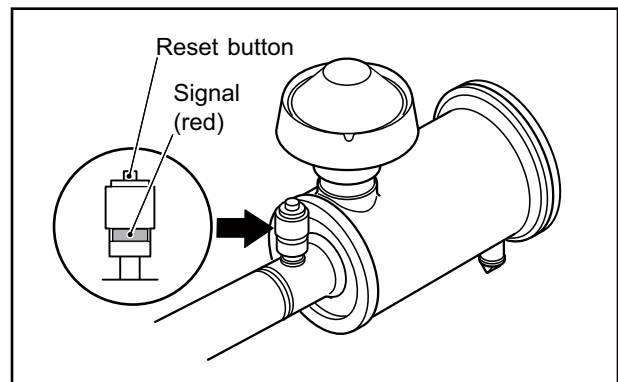


Fig. 2-13 Air Cleaner Indicator

## Operational Environment

### CAUTION

Check that the following contents are performed before the engine is operated. Failure to do so may cause various problems and will shorten the service life of the engine.

- ♦Prevent from spreading water (especially, seawater or rainwater) and entering foreign materials to the air inlet opening.
- ♦Prevent from entering foreign materials to the rotating parts.
- ♦Prevent from attaching water and dust to the electrical system.
- ♦Use the engine at 5 to 40 °C [41 to 104 °F].
- ♦Keep the coolant temperature properly by switching ON the water heater (automatic mode). (Emergency generator with water heater)

## Preparation for Operating New or Overhauled Engine

Before proceeding with operation of a new overhauled engine, conduct the inspections described in this section. For second operation onward, follow the instructions described in the "[Normal Engine Operation](#)" (3-8).

## Preparation of Fuel System

### CAUTION

When handling fuel, make sure there are no open flames or other fire hazards near the engine. Wipe off any spilled fuel completely. Spilled fuel can ignite and cause a fire.

### CAUTION

Do not remove the strainer during fuel tank filling. For fuel to be used, refer to "[FUEL](#)" (4-1).

1. Make sure the insides of the fuel tank and fuel supply pipes to the engine are thoroughly clean.
2. Check the drain valve and air inlet valve is closed at the time.
3. Fill fuel tank with fuel.
4. Remove the fuel feed pipe and drain plug from the fuel inlet of engine, and check the discharged fuel for foreign materials such as dust.
5. Reinstall the drain plug and the fuel feed pipe.
6. Close the drain valve to fill the fuel.
7. Refill fuel tank until fuel level gauge indicates "FULL" level line, after checking the contact of float switch.



## Fuel System - Bleed Air

### **WARNING**

When fuel overflow from the air vent plug, wipe thoroughly. Spilled fuel causes fire hazard.

After bleeding, lock the priming pump securely. If the cap is not locked tightly, the priming pump can be damaged, causing a fuel leak that could lead to a fire.

While feeding fuel with priming pump, bleed air from the location closest to the fuel tank that are the water separator, fuel filter, then the fuel injection pump.

Lock the priming pump according to "Priming Pump Tightening Method".

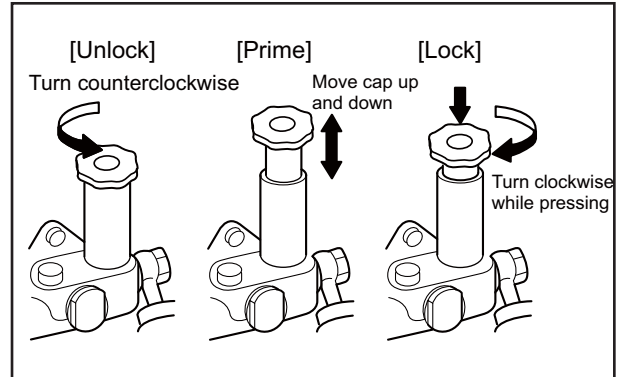


Fig. 3-1 Priming Pump - Handle

## Fuel Filters (Wire-element Type) - Bleed Air

### **CAUTION**

If air vent plugs, the thread portion of the bracket, or sealing washers are damaged, replace them with new ones.

1. Loosen the air vent plug of the fuel filter (wire-element type) about 1.5 turns.
2. Turn the priming pump counterclockwise to unlock, and prime the fuel filter.
3. When the fuel from the air vent plug becomes free from air bubbles, stop priming and tighten the air vent plug to the specified torque.

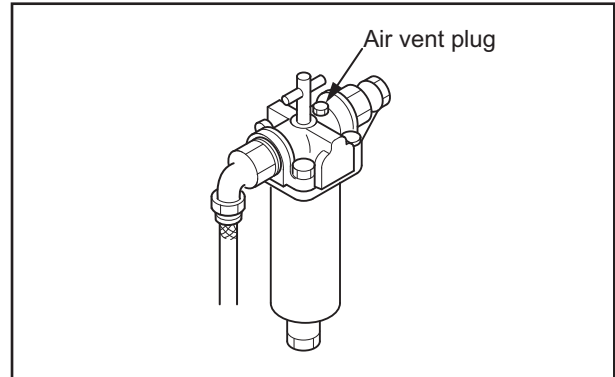


Fig. 3-2 Fuel Filters (Wire-element Type) - Bleed Air

## Fuel Filter - Bleed Air

### **CAUTION**

If air vent plugs, the thread portion of the bracket, or sealing washers are damaged, replace them with new ones.

1. Loosen the air vent plug of the fuel filter about 1.5 turns.
2. Move the priming pump up and down, then feed fuel.
3. When the fuel from the air vent plug becomes free from air bubbles, stop priming and tighten the air vent plug to the specified torque.

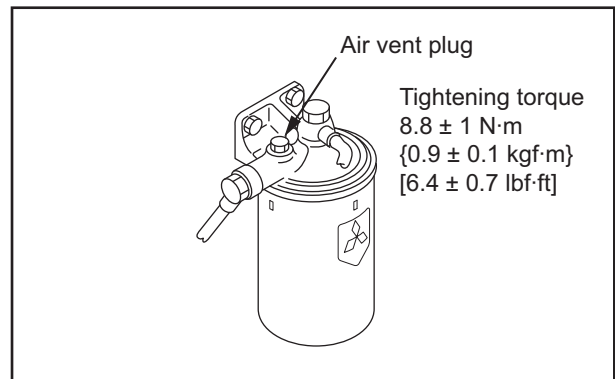


Fig. 3-3 Fuel Filter - Bleed Air

## Fuel Injection Pump - Bleed Air

1. Loosen the air vent plug on the fuel injection pump by rotating about 1.5 turns.
2. Move the priming pump up and down until the fuel flow from the air vent plug is free from air bubbles. Push and turn the priming pump clockwise to lock in the original position when the fuel flows is free from bubbles.
3. Tighten the air vent plug on the fuel injection pump.

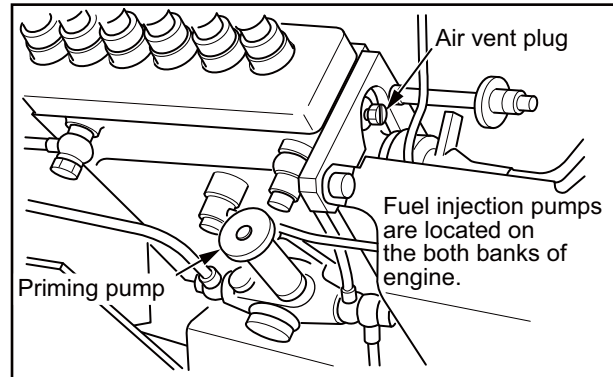


Fig. 3-4 Fuel Injection Pump - Bleed Air

## Priming Pump Tightening Method

### CAUTION

Never fail to tighten the priming pump to the specified angle. If the priming pump is not firmly tightened, internal thread will be worn due to engine vibration, resulting in sudden ejection of the cap to cause fuel flow-out. Or if the priming pump is excessively tightened, the head of the priming pump can be damaged.

1. Gently tighten the priming pump cap by hand until the tightening force suddenly increases.
2. Use a wrench or another appropriate tool to tighten the priming pump  $90 \pm 10^\circ$ .
3. Check the mounting position of head packing.

Note: If the head packing has abnormality such as deformation or scratches, consult a dealer of Mitsubishi Heavy Industries, Ltd., as the priming pump needs to be changed.

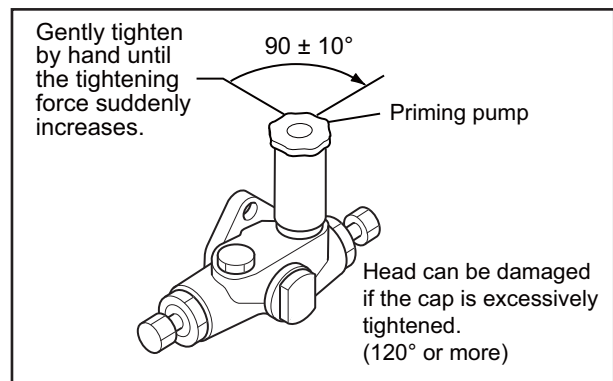


Fig. 3-5 Priming Pump Tightening Method

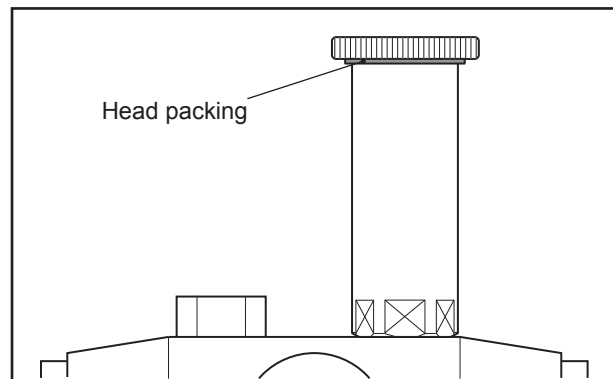


Fig. 3-6 Priming Pump Head Packing

## Preparation of Lubrication System

### Engine Oil - Refill

#### **CAUTION**

Refilling engine oil must be specified level. If the refilling oil goes over the high marks on the oil level gauge, engine oil may blow out. And also, the engine component parts are adversely affected by increasing in oil temperature.

1. Remove the cap from the oil filler.
2. Fill the engine oil pan with specified engine oil to the specified level.

Note: For engine oil, refer to "[ENGINE OIL](#)" (5-1). For engine oil capacity, refer to "[MAIN SPECIFICATIONS](#)" (12-1).

3. Remove the rocker cover, and pour engine oil to the valve mechanism and camshaft oil bath. Pour engine oil to camshaft oil bath from cylinder head side.

Oil capacity per cylinder: 0.8 L [0.21 U.S. gal.]

4. Reinstall the rocker covers.
5. Check the oil level in the oil pan.
6. Pull out the oil level gauge and wipe it clean with a waste cloth.
7. Insert the oil level gauge fully into the oil level gauge guide and then pull it out again.
8. The proper oil level is between the high and low marks on the oil level gauge.  
If the engine oil goes over the high marks on the oil level gauge, open the engine oil drain valve to drain oil.  
If the engine oil is low, refill the specified engine oil.
9. Check the oil pan and other area for oil leaks. Repair the oil leakage if any.
10. While pulling the stop lever, rotate the crankshaft for approx. 10 seconds to turn on the starter. Stop the operation for 1 minute, then, repeat the operation two or three times. Circulate engine oil to each engine parts.

Note: Prepare for the cooling system.

11. Start the engine and run the engine in a no load condition at low idling speed for 5 to 10 minutes.
12. Check the oil level with the oil level gauge again, and add oil to the specified level after leaving the engine stopped for 30 minutes or more.  
For details, refer to "[Test Operation](#)" (3-7).

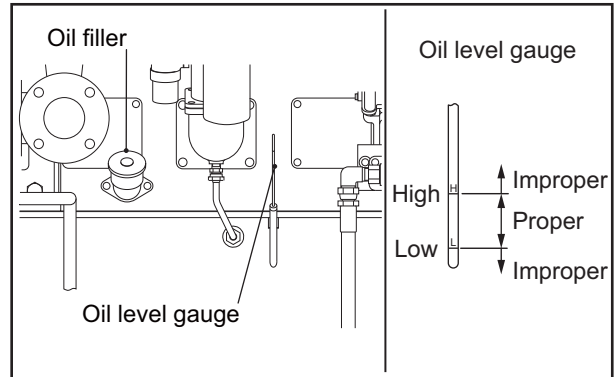


Fig. 3-7 Oil Filler and Oil Level Gauge

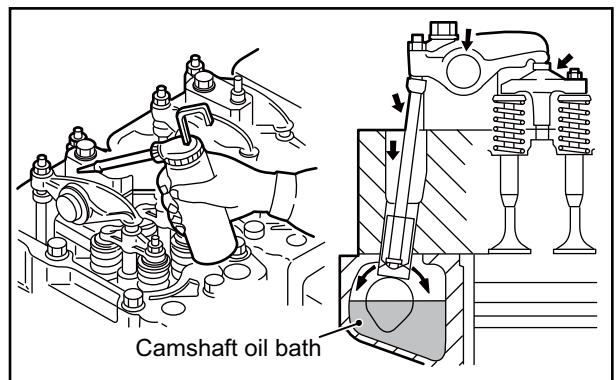


Fig. 3-8 Pouring Engine Oil on Valve Mechanisms and Chamber

## Preparation of Cooling System

### Radiator Cap - Open/Close

#### **WARNING**

When using the engine with radiator cooling system, remove the radiator cap only after the engine has cooled to the room temperature. Place a waste cloth over the cap, and loosen the cap about a half-turn or stand the lever to the upright position to release internal pressure. Opening the radiator cap of coolant expansion tank while the engine is hot causes steam and hot coolant to blow out and can result in skin burns.

Note: If the specification of radiator differs from the contents of this operation manual, follow the manufacturer's operation manual.

### Coolant - Refill

#### **CAUTION**

Always use the coolant having the same concentration.

1. Close the coolant drain cock of engine and water pump securely.
2. Open the coolant filler and add a mixture of water and coolant having the specified concentration.

Note: (a) Determine the quantities of LLC based on the coolant capacity and the LLC concentration chart.

For the coolant, refer to "[COOLANT](#)" (6-1).  
For the coolant capacity, refer to "[MAIN SPECIFICATIONS](#)" (12-1).

(b) For absolute air bleeding, loosen the air vent plug on the upper section of thermostat.

3. Check the heat exchange equipment and other parts for coolant leaks. Repair leakage if found.
4. When coolant reaches the full level, close the coolant filler securely.
5. While pulling the manual stop lever, rotate the crankshaft for approx. 10 seconds using the starter. Stop the operation for approx. 1 minute, then, repeat the operation two or three times to bleed the cooling system.

Note: Prepare for the engine oil system.

6. Check the level of coolant.

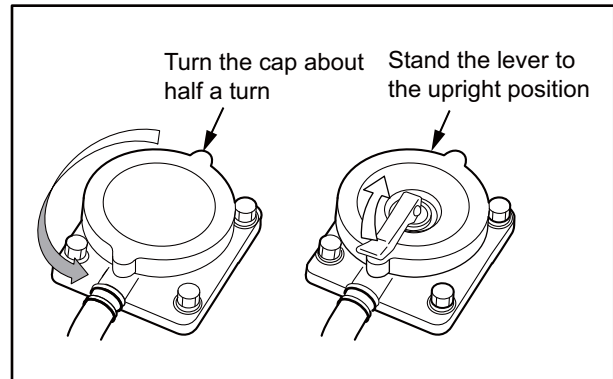


Fig. 3-9 Radiator Cap

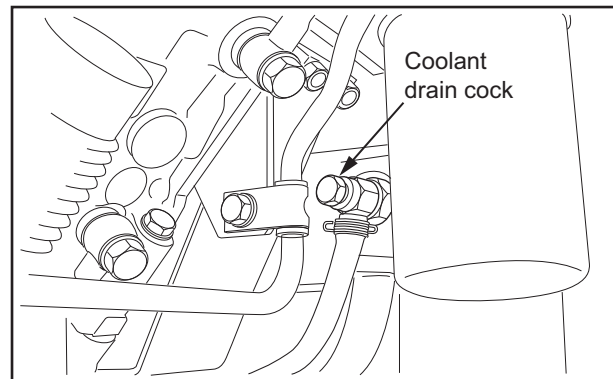


Fig. 3-10 Coolant Drain Cock (Engine)

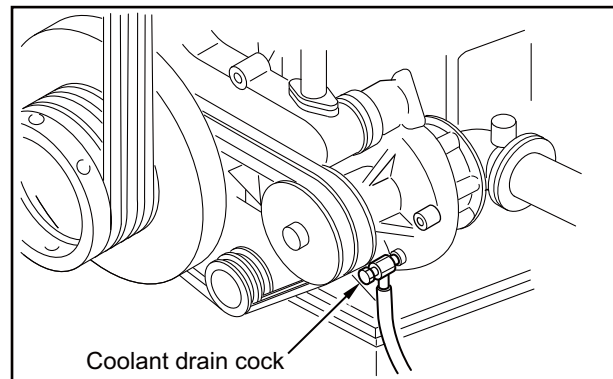


Fig. 3-11 Coolant Drain Cock (Water Pump)

## Preparation of Electrical System

### Battery - Check

**CAUTION**

If battery electrolyte is spilled on your skin or clothes, flush immediately with plenty of water. If battery electrolyte get into your eyes, flush them immediately with plenty of water and then get medical attention.

Do not use open flames or other fire hazards near the battery. When handling the battery, be careful of sparks generated by accidental shorting.

Note: If the specification of battery differs from the contents of this operation manual, follow the manufacturer's operation manual.

### Battery Electrolyte Level - Inspect

Battery electrolyte evaporates during use and the electrolyte level gradually decreases. The proper electrolyte surface level is between the LOWER LEVEL and UPPER LEVEL lines.

For the battery without level lines, the proper electrolyte surface level is about 10 to 15 mm [0.39 to 0.59 in.] above the top of the plates.

If the electrolyte level is low, remove the caps and add distilled water to the proper level.

Note: When adding distilled water, add little by little.

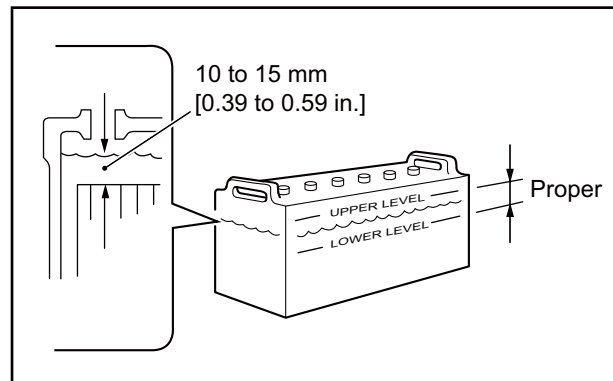


Fig. 3-12 Battery Electrolyte Level - Inspect

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## Test Operation

To conduct a test operation, follow the procedures below.

---

### WARNING

Always switch the water heater ON (automatic mode) through a whole year.

If the switch is not ON (automatic mode), each cylinder varies considerably in combustion at the starting up the engine. Unburned fuel may explode in the exhaust pipe. (Emergency generator with water heater)

---

Before starting the engine, switch the water heater ON (automatic mode) and keep the coolant temperature properly. (Emergency generator with water heater)

Note: For engine operation, refer to "[Normal Engine Operation](#)" (3-8).

## Starting and Stopping

1. Start the engine.
2. Operate the engine at low idling speed under no load for 5 to 10 minutes for a warm-up operation.
3. Stop the engine.

## Inspection

1. Leave the engine be stopped for about 30 minutes.
2. During this period, check the engine and surrounding area for leaks of fuel, engine oil or coolant.
3. At 30 minutes after the engine stop, check the oil level with the oil level gauge. The proper oil level is between the high and low marks on the oil level gauge.
4. If the engine oil goes over the high marks on the oil level gauge, open the engine oil drain valve to drain oil. If the engine oil is low, refill the specified engine oil.
5. Open the coolant filler cap and check the coolant level.
6. If the coolant level is low, add coolant to the specified level.

---

### CAUTION

Always use the coolant having the same concentration.

---

## Normal Engine Operation

This section of the manual covers the procedures for the engine operation in normal condition.

### CAUTION

Should an engine abnormality be observed during operation, stop the engine and correct the problem, or contact a dealer of Mitsubishi Heavy Industries, Ltd.

## Preparations for Operation

Always conduct the following inspection before starting the engine.

### Engine External - Inspect

#### CAUTION

Be sure to keep combustible materials away from the engine, especially from the hot engine parts such as exhaust manifolds, or the battery. Check for fuel and oil leaks. Remove dust from the top surface of the battery. A fire can be caused by combustible materials placed near hot engine parts. If any abnormality is found, be sure to repair it or contact your local dealer.

Inspect the engine exterior as described below.

1. Make sure there is no combustible material near the engine or battery. Also, check to make sure that the engine and battery are clean. If combustible materials or dust are found near the engine or battery, remove them.
2. Check the whole engine for leaks of fuel, engine oil or coolant. If leaks are found, repair the leak, or contact a dealer of Mitsubishi Heavy Industries, Ltd.
3. Visually check bolts and nuts for looseness.
4. Check the electrical wiring including the starters and alternator.
5. Check that valves, plugs or cocks are properly positioned.
  - ♦Fuel feed valve: Open
  - ♦Coolant drain cock (plug): Closed
  - ♦Engine oil drain plug: Closed
  - ♦Air supply valve (air tank): Open

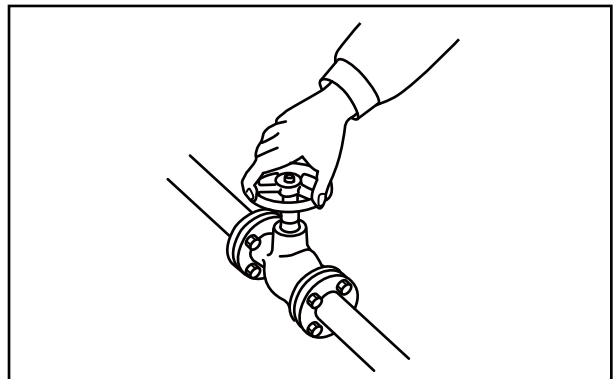


Fig. 3-13 Valves for open/closed position - Check

## Fuel Tank Oil Level - Check

### WARNING

When working around fuel, make sure there are no open flames, heaters or other fire hazards. Wipe off any spilled fuel completely. Spilled fuel can ignite and cause a fire.

### CAUTION

Do not remove the strainer when filling the fuel tank.

If the engine has a float switch and the fuel level is higher the "LOW" level line, the float switch failure may occur. Inspect and repair the float switch.

For fuel to be used, refer to "FUEL" (4-1).

Check that fuel is contained to the specified level in the fuel tank.

If the fuel level is low, refill the tank to the "FULL" level line.

Note: If the specification of fuel tank differs from the contents of this operation manual, follow the manufacturer's operation manual.

## Fuel Control Link - Check

Check fuel control link for smooth movement.

Push the manual stop lever to the fuel increase direction, check the movement of the rack cancel spring.

Then relax your grip on the lever little by little, check that the manual stop lever returns to the no fuel injection position smoothly.

Also check ball joint for looseness and play.

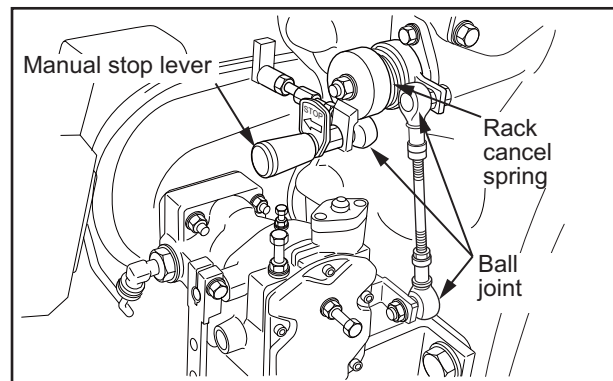


Fig. 3-14 Fuel Control Link - Check

## Engine Oil Level - Check

### CAUTION

Refilling engine oil must be specified level. If the refilling oil goes over the high marks on the oil level gauge, engine oil may blow out.

Always use the same engine oil as the first.

1. Pull out the oil level gauge and wipe oil off the oil level gauge using a clean waste cloth.
2. Insert the oil level gauge fully into the oil level gauge guide and then pull it out again.
3. The proper oil level is between the high and low marks on the oil level gauge. If the engine oil goes over the high marks on the oil level gauge, open the engine oil drain valve to drain oil. If the engine oil is low, refill the specified engine oil.
4. Install the oil filler cap after adding engine oil.
5. Check the oil pan and other area for oil leaks.

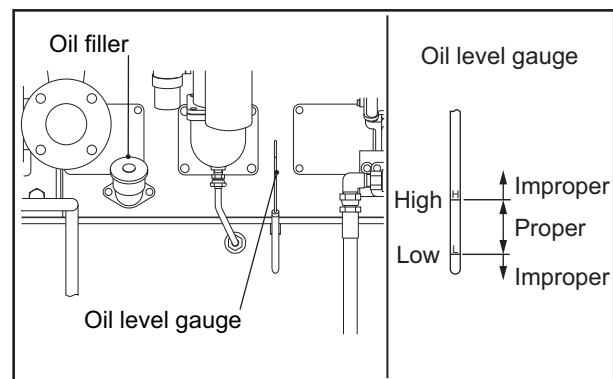


Fig. 3-15 Oil Filler and Oil Level Gauge



## Coolant Level - Check

### CAUTION

Always use the coolant having the same concentration.

If the coolant level is low, add coolant to the specified level.

Note: Determine the quantities of LLC based on the coolant capacity and the LLC concentration chart.

For the coolant, refer to "COOLANT" (6-1). For the coolant capacity, refer to "MAIN SPECIFICATIONS" (12-1).

## Air Cleaner - Check for Clogging

1. Check the air cleaner indicator for the element clogging.
2. If the element is clogged, the red signal mark will be displayed.
3. Immediately clean or replace the air cleaner element when the signal turns red.
4. After checking, press the bottom on top of the indicator to re-set the alarm signal.

Note: (a) For cleaning of the air cleaner element, refer to "Air Cleaner Element - Clean, Check and Replace" (8-22).

(b) If the specification of air cleaner differs from the contents of this operation manual, follow the manufacturer's operation manual.

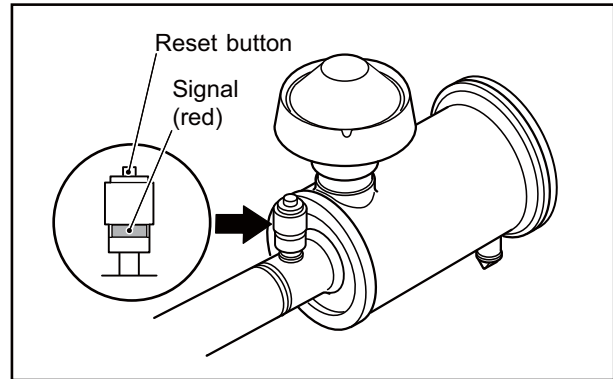


Fig. 3-16 Air Cleaner - Check for Clogging

## Air Tank - Drain Water

### CAUTION

There are 2 places for draining water in the air tank: drain valve on the top of air tank, and drain handle on the bottom of drain separator.

1. Open the drain valve slowly, and check that water in the tank is drained from drain pipe.
2. After water is drained and the air is discharged in the tank, tighten the drain valve firmly.
3. Loosen the drain handle on the bottom of drain separator. Check that water in the drain separator is discharged from the drain pipe.
4. Close the drain handle after draining water firmly.

Note: If the specification of air tank differs from the contents of this operation manual, follow the manufacturer's operation manual.

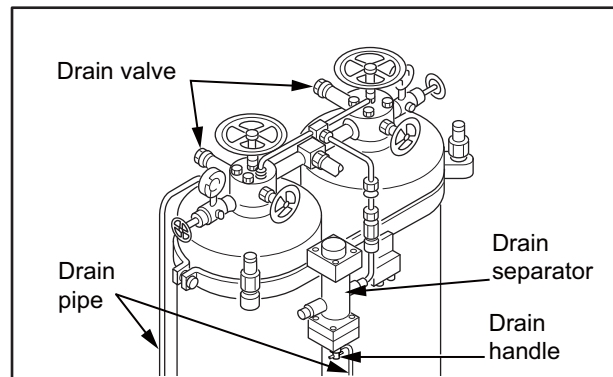


Fig. 3-17 Air Tank - Drain Water

## Air Tank Air Pressure - Check

1. Check the air pressure gauge to see if the air pressure in the air tank conforms to the standard.
2. Open the air pressure gauge valve.
3. Check air pressure in the air tank with air pressure gauge.  
Specified value:  
For air direct starting: 2.94 MPa {30 kgf/cm<sup>2</sup>} [427 psi]  
For air motor: 0.98 MPa {10 kgf/cm<sup>2</sup>} [142 psi]
4. Close the air pressure gauge valve.

Note: If the specification of air tank differs from the contents of this operation manual, follow the manufacturer's operation manual.

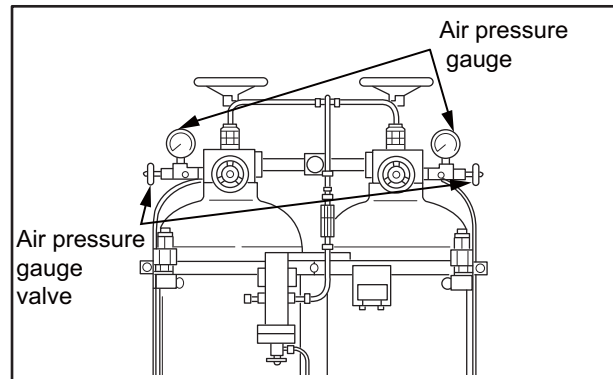


Fig. 3-18 Starting Air Tank Air Pressure - Check

## Temperature of Damper - Check

### Damper temperature management by thermo label

It is recommended to use the thermo label for temperature management of the damper. Check the thermo label before starting engine.

1. Check the thermal part of thermo label is black.
2. Note the highest temperature of thermal part. Note the temperature periodically, and check the abnormality of temperature alteration.

#### CAUTION

If the abnormality of temperature alteration is found, consult a dealer of Mitsubishi Heavy Industries, Ltd.

Note: For damper temperature limit and inspection, refer to "Damper - Inspect" (8-4).

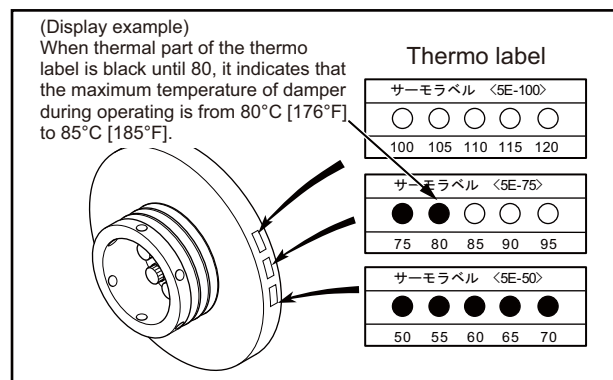


Fig. 3-19 Thermo label of damper

## Start

The starting method varies depending on the application and specifications. Start the engine according to the specified procedure.

---

 **WARNING**

Before starting the engine, check to make sure no one is near the engine and that tools are not left on or near the engine. In a loud voice, notify people in the area when starting the engine.

---

---

**CAUTION**

Do not apply a load to the engine at starting. (Disengage the clutch if equipped.)

Continuous operation of the starter will drain the battery power and cause the starter to seize. Do not use the starter for more than 10 seconds at a time. When the engine does not start, wait for more than 1 minute before cranking again.

---

## Warming-up Operation

---

 **WARNING**

Do not approach rotating parts during operation. Entanglement by rotating parts can result in serious injury.

---

After the engine starts, operate the engine in a no load condition at low idling speed for 5 to 10 minutes to warm-up the engine.

### Checking Engine Oil Pressure

During warm-up operation, check if the oil pressure is in the range of standard value (0.3 MPa {3.1 kgf/cm<sup>2</sup>} [21 psi] or more).

Also, make sure the oil pressure gauge is actuated properly.

### External Inspection During Warm-up

During warm-up operation, walk around the engine and check for fuel, oil, coolant or exhaust gas leaks.

# Run

## Cautions During Operation

### WARNING

Do not approach rotating parts during operation. Entanglement by rotating parts can result in serious injury.

### CAUTION

Do not touch any hot part of the engine such as exhaust pipes during operation or immediately after shut down. A hot engine can cause burns.

### CAUTION

Always provide adequate ventilation in the engine room. If air supply to the engine room is not sufficient, the room temperature rises and can affect engine output and performance.

For the first 50 hours of the new engine or after the overhaul, operate the engine under a light load for break-in operation. Operating the new engine under heavy load or severe conditions during the break-in period can shorten the service life of the engine.

Do not turn the battery switch OFF when the engine is running. Turning off the battery switch during operation not only stops the instrument operations but also may deteriorate the alternator diode and regulator.

Never turn the key to the "START" position during operation. The starter may be damaged.

When operating the engine with a 30 % of rated load or lower, limit each operation to an hour. Prolonged warm-up operation causes carbon build-up in the cylinders that leads to incomplete combustion. Operate the engine with a 30 % of rated load or more for over 5 minutes after continuous operation for an hour to prevent causing carbon build-up.

## Inspection During Operation

Check for abnormal engine noises or vibrations such as knocking or the exterior of engine such as piping joints for leaks.

Carefully check the following items whether there is any abnormality.

Table 3-1 Inspection During Operation

| Item to be inspected                | Criterion/Reference value   |
|-------------------------------------|---|
| Warning indicator lamps/Instruments | Lighting/Numerical anomaly  |
| Engine speed/Frequency              | No large fluctuation  |
| Breather mist volume                | As usual  |
| Exhaust color                       | As usual  |
| Damper temperature                  | 90°C [194°F] or lower   |
| Engine oil pressure                 | 0.39 MPa {4 kgf/cm <sup>2</sup> } [57 psi] or more                      |
| Oil Temperature (oil pan)           | 110 °C [230 °F] or lower  |
| Coolant temperature                 | 70 to 90°C [158 to 194°F]   |
| Exhaust temperature                 | 550°C [1022°F] or lower   |
| Intake air pressure                 | 0.15 to 0.25 MPa {1.5 to 2.5 kgf/cm <sup>2</sup> } [10.85 to 18.08 psi] |

Note: (a) If the engine stops because of decreasing engine oil pressure, be sure to locate the cause of problem and correct it before restarting the engine.

(b) When the thermo switch is activated during normal operation, run the engine with the idle speed at low Rpm for 5 or 6 minutes to cool the engine before stopping the engine. Be sure to locate the cause of problem and correct it before restarting the engine.

## Stop

**CAUTION**

Stopping the engine abruptly while engine parts are hot due to high-speed operation can be a cause for heat up of the engine parts and shorten the engine life. Before stopping the engine, run the engine with the idle speed at low Rpm's for 5 or 6 minutes to cool the engine, and check the engine for abnormalities.

Never accelerate the engine immediately before shutting it down.

Do not restart the engine immediately after abnormal shut down. When the engine stops with alarms, be sure to locate the cause of the problem and correct the problem before restarting the engine. After restarting the operation, check the engine for abnormalities again. If the engine has an abnormality, repair it immediately.

---

Engine stopping method varies depending on the specifications.

To stop the engine, follow the instructions of the equipment.

## Emergency Stop

**CAUTION**

When stopping the engine by pulling the manual stop lever, continue pulling the lever until the engine stops completely. If not, the engine may start again.

---

To perform the emergency stop, pull the manual stop lever to the arrow direction. Continue pulling the lever until the engine stops completely.

Note: When the engine does not stop even if the manual stop lever is pulled, stop fuel supply.

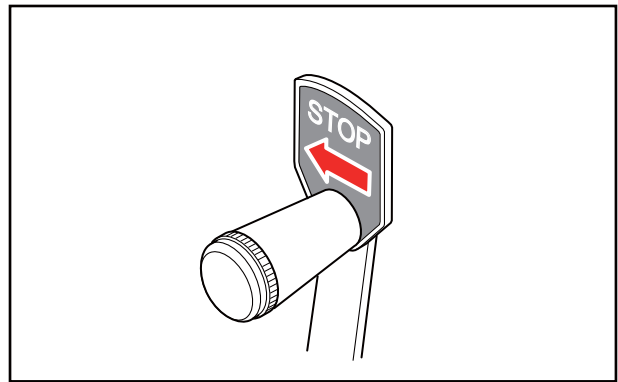


Fig. 3-20 Manual Stop Lever

## Inspection After Stopping

Inspect the engine for fuel, oil or coolant leaks. If any leak is found, repair the leak or contact a dealer of Mitsubishi Heavy Industries, Ltd.

## Recommended Fuel

 **WARNING**

Use a fuel specified in this manual only. Do not refill the fuel tank more than the specified level. Otherwise, fire may result.

Use fuel that meets the values specified in the following Table 4-1 of "Recommended Fuel" and Table 4-2 of "Recommended Limit and Use Limit of Fuel Property".

It is necessary to use fuel that has a pour point suitable for the ambient temperature.

Note: Please use the fuel that meet the control of the countries or areas where the engine is used, if the control is applied.

Table 4-1 Recommended Fuel

| Specification | Classification      |
|---------------|---------------------|
| ISO 8217      | DMX-CLASS           |
| ASTM D975     | No.1-D, No.2-D      |
| BS 2869       | CLASS A1, CLASS A2  |
| DIN 51601     | DIESEL-FUEL         |
| JIS K2204     | TYPE1, TYPE2, TYPE3 |
| EN 590        | DIESEL-FUEL         |

## Handling Fuel

When using fuel from a storage tank, leave it to sit for more than 24 hours so that dust and water can settle at the bottom. Then, use the upper clean fuel.

Fill up the fuel tank or service tank after each operation.

This prevents water from mixing with fuel in the tank and also gives time for dust and water to separate and settle at the bottom of the tank.

Before refilling, clean the areas around the caps thoroughly and remove the caps from the drum and tank. Also clean your hands and the hose before refueling. When using a hand-operated pump, be careful not to pump water or sediment accumulated at the bottom of the storage tank.

Be sure to use a strainer when filling fuel tank. For a complete filtration, it is recommended to use a clean lint-free cloth together with the strainer.

# Fuel Specification

Use fuel which meets the requirements specified in the table below.

Table 4-2 Recommended Limit and Use Limit of Fuel Property

| Item  |                              | Recommended limit  | Use limit  | Test method   |
|---|------------------------------|--|--|---|
| Flash point                                   |                              | 50°C [122°F] or higher<br>(In accordance with the regulation)  |  | JIS K 2265:2007<br>ISO 3769<br>ISO 2719   |
| Distillation                                  | Initial boiling point        | 170°C [338°F] or higher  |  | JIS K 2254:1998<br>ISO 3405   |
|   | 90 % distillate temperature  | 330 to 380°C [626 to 716°F]  |  |   |
| Pour point (PP)                               |                              | 6°C [42.8°F] or lower than ambient temperature   |  | JIS K 2269:1987<br>ISO 3016   |
| Cloud point (CP)                              |                              | Below ambient temperature  |  | JIS K 2269:1987<br>ISO 3015   |
| Cold filter plugging point (CFPP)             |                              | 3 °C [37.4 °F] or lower than ambient temperature   |  | JIS K 2288:2000<br>IP 309/96  |
| Carbon residue (10 % residual oil)            |                              | 0.4 weight % or lower  | 1.0 weight % or lower  | JIS K 2270:2000<br>ISO 6615<br>ISO 10370  |
| Cetane number                                 |                              | 45 or higher   |  | JIS K 2280:1996<br>ISO 5165   |
| Cetane index (new type)                       |                              | 45 or higher   |  | JIS K 2280:1996<br>ISO/DIS 4264   |
| Kinetic viscosity                             |                              | 2.0 mm <sup>2</sup> /s [0.0031 in <sup>2</sup> /s] or more at 30 °C [86 °F]<br>8.0 mm <sup>2</sup> /s [0.0124 in <sup>2</sup> /s] or more at 30 °C [86 °F] |  | JIS K 2283:2000<br>ISO 3104   |
| Sulfur content                                |                              | 0.2 weight % or lower  | 1.0 weight % or lower<br>(Shorten lub. oil change intervals)               | JIS K 2541:2000<br>(The content should be as low as the diesel fuel.)<br>ISO 4260<br>ISO 8754 |
| Water content and sediment                    |                              | 0.1 volume % or lower  |  | JIS K 2275:1996<br>ISO 3733   |
| Ash content                                   |                              | 0.01weight % or lower  | 0.03 weight % or lower   | JIS K 2272:1998<br>ISO 6245   |
| Copper corrosion<br>(3 hrs at 50 °C [122 °F]) |                              | Color change = Copper plate No.3 or less   |  | JIS K 2513:2000<br>ISO 2160   |
| Density at 15 °C [59 °F]                      |                              | 0.83 to 0.87 g/cm <sup>3</sup><br>[49.9424 to 54.3123 lb/ft <sup>3</sup> ]   | 0.80 to 0.87 g/cm <sup>3</sup><br>[49.9424 to 54.3123 lb/ft <sup>3</sup> ] | JIS K 2249:1995<br>ISO 3675   |
| Caulking                                      | 24 hrs at 250 °C<br>[482 °F] | 75 % carbonization or less   | 80 % carbonization or less   | Fed 791B  |
|   | 24 hrs at 230 °C<br>[446 °F] | 55 % carbonization or less   | -  |   |
|   | 48 hrs at 180 °C<br>[356 °F] | Tar-free   | -  |   |
| Aromatics substances (by HPLC)                |                              | 38 % by volume or less   |  | JIS K 2536:2003<br>ISO 3837   |
| Polycyclic aromatic content                   |                              | 8 volume % or lower  |  |   |
| Asphaltene                                    |                              | 0.1 weight % or lower  |  | -   |

Table 4-2 Recommended Limit and Use Limit of Fuel Property

| Item  | Recommended limit   | Use limit                        | Test method   |
|---|---|----------------------------------|---|
| Foreign substances<br>(foreign materials at engine fuel inlet)  | 5.0 mg/liter or less  |                                  | JIS B 9931:2000<br>ISO 4405                                     |
| Lubricity: MWSD (Measured mean Wear Scar Diameter) by HFRR wear test at 60 °C [140 °F] fuel temperature | 460 µm [0.02 in.] or less<br>(calculated wear scar diameter at WS 1.4 kPa {0.0143 kgf/cm <sup>2</sup> } [0.2031 psi]) | -                                | ISO 12156-1   |
| BDF: Biodiesel fuel (FAME: Fatty Acid Methyl Ester)   | BDF quality shall meet JIS K 2390, or ASTM-D 6751 or EN14214,<br>BDF blending of 5 % by volume or less is approved    |                                  | JIS K 2390:2008<br>(FAME for mixing)<br>ASTM D 6751<br>EN 14214 |
| Engine applications   | for regular (prime) use<br>(Regular)  | for emergency use<br>(Emergency) | Selection according to application                              |



## Recommended Engine Oil

**⚠ CAUTION**

Use the engine oils recommended in this manual only. Never use oil other than that specified in this manual. The use of inappropriate or inferior oils will result in sticking of piston rings, seizure between piston and cylinder, or premature wear of bearings and moving parts, and significantly shortens the service life of the engine.

## Engine Oil Grade

Many oil standards, which are established through special engine tests, are available to determine the quality of oil depending on the engines to which they will be applied and on operating conditions. Among those standards, API (American Petroleum Institute) service classifications are mostly used to classify engine oils. SAE specifies the viscosity only, while the API service classification indicates the quality level of engine oil.

For engine lubrication oil, please use API service classification CF or CH-4.

When using the CF class engine oil, it must be certified according to API service classification CF by 2009 and satisfied the following [Table 5-1 Table of Recommended Limit of Engine Oil Properties](#).

When using the CH-4 class engine oil, the sulfur content of fuel must be 0.2 weight % or lower.

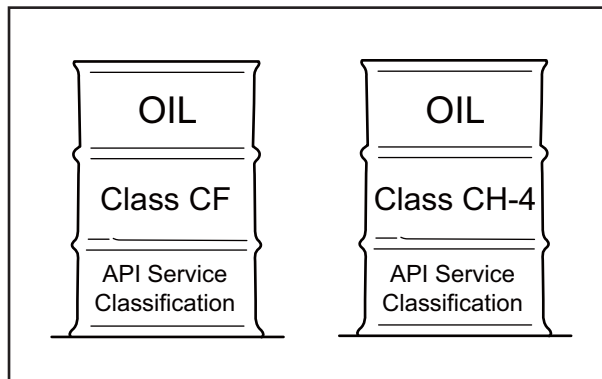


Fig. 5-1 Engine Oil Grade

# Engine Oil Specification

Use engine oil which meets the requirements specified in the table below.

Table 5-1 Table of Recommended Limit of Engine Oil Properties

| Item                             |                          | Unit                    | Recommended limit          | Test method  |                         |
|----------------------------------|--------------------------|-------------------------|----------------------------|--|-------------------------|
| API/JASO                         |                          |                         | CF class *1                | -  |                         |
| SAE viscosity                    |                          | -                       | 15W-40                     | -  |                         |
| Color ASTM                       |                          | -                       | L4.0                       | JIS K 2580<br>ISO 2049                                     |                         |
| Density                          | 15°C [59°F]              | g/cm <sup>3</sup>       | 0.87 to 0.90               | JIS K 2249<br>ISO 3675<br>ISO3838<br>ISO 649-4<br>ISO 91-1 |                         |
| Kinetic Viscosity:               | 40°C [104°F]             | mm <sup>2</sup> /s      | 100 to 110                 | JIS K 2283<br>ISO 3107<br>ISO 2904                         |                         |
|                                  | 150°C [302°F]            |                         | 13.5 to 15.5               |  |                         |
| Viscosity                        |                          | -                       | -                          | JIS K 2283<br>ISO 3107<br>ISO 2904                         |                         |
| Flash point                      |                          | °C [°F]                 | 225 to 250<br>[437 to 482] | JIS K 2265<br>ISO 3679<br>ISO 2719<br>ISO 2592             |                         |
| Base number                      | Hydrochloric acid method | Sulfur contents of fuel | 1.0 weight % or lower      | JIS K 2501<br>ISO 3771<br>ISO 6618<br>ISO 6619<br>ISO 7537 |                         |
|                                  |                          |                         | 0.2 weight % or lower      |  |                         |
|                                  | Perchloric acid method   | Sulfur contents of fuel | 1.0 weight % or lower      |  | 13 or higher (up to 16) |
|                                  |                          |                         | 0.2 weight % or lower      |  | 11 or higher (up to 16) |
| Acid number                      |                          | mgKOH/g                 | 1.5 to 2.0                 | JIS K 2501<br>ISO 3771<br>ISO 6618<br>ISO 6619<br>ISO 7537 |                         |
| Sulfur content                   |                          | %                       | 0.5 or less                | JIS K 2541<br>ISO 4260<br>ISO 8754                         |                         |
| Sulfuric acid ash                |                          | %                       | 2.0 or lower               | JIS K 2272<br>ISO 3987<br>ISO 6245                         |                         |
| Carbon residue content           |                          | %                       | 2.0 or lower               | JIS K 2270<br>ISO 10370<br>ISO 6615                        |                         |
| High temperature shear viscosity | 150°C [302°F]            | mP·aS                   | 3.7 or higher              | JPI-5S-36-91   |                         |
| Pour point                       |                          | °C [°F]                 | -25 [-13] or lower         | JIS K 2269<br>ISO 3015<br>ISO 3016                         |                         |

Table 5-1 Table of Recommended Limit of Engine Oil Properties

| Item                      |                  | Unit | Recommended limit | Test method            |
|---------------------------|------------------|------|-------------------|------------------------|
| Bubbling test<br>*2       | I                | mL   | 10/0              | JIS K 2518<br>ISO 6247 |
|                           | II               |      | 30/0              |                        |
|                           | III              |      | 10/0              |                        |
| Panel caulking test<br>*3 | 300°C<br>[572°F] | mg   | 140 or lower      | FED791-3462            |
|                           | 325°C<br>[617°F] |      | 300 or lower      |                        |

\*1 It must have been certified API service classification CF by 2009.

\*2 Temperature of test I (24°C [75.2°F]), Temperature of test II (93.5°C [200.3°F]), Temperature of test III (24°C [75.2°F] after 93.5°C [200.3°F])

\*3 Temperature of aluminum panel: 300°C [572°F] and 325°C [617°F]

Temperature of engine oil: 100°C [212°F]

Splatter time: 15 seconds

Downtime: 45 seconds

Test time: 8 hours

the properties are the weight of solid product.

## Selection of Oil Viscosity

Use the following chart to select the appropriate oil viscosity according to the ambient temperature.

Excessively high oil viscosity causes power loss and an abnormal rise of oil temperature, while excessively low oil viscosity accelerates wear due to inadequate lubrication, and also causes a decrease in engine output due to leakage of combustion gas.

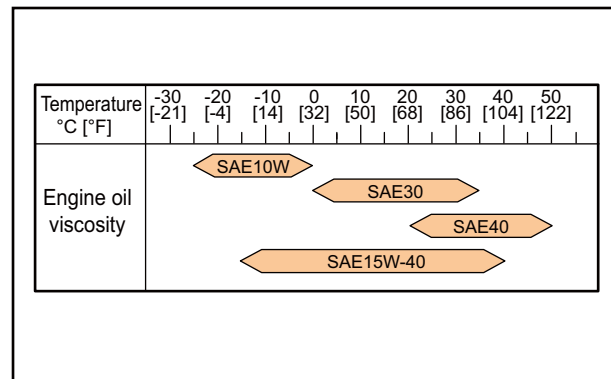


Fig. 5-2 Selection of Oil Viscosity

## Handling Engine Oil

### ⚠ WARNING

Before filling the engine with engine oil, stop the engine and make sure there are no open flames and other fire hazards near the engine. Leaked or spilled oil on hot surfaces or electrical components can cause a fire. Wipe off any spilled oil immediately and thoroughly. After filling oil, securely close the filler cap.

When handling a large amount of engine oil more than the legally specified quantities, be sure to have the work performed by a service station operated under the provision of the law. When removing oil from the engine or oil can, use an oil pump. Do not suck oil using your mouth and a pipe.

Be sure to close the cap on the oil can after use.

Keep oil in a well-ventilated place and out of direct sunlight.

Be sure to obtain the MSDS of the engine oil and follow the instructions of the MSDS.

## Service Limits of Engine Oil

Engine oil degrades through the use and by lapse of time.

The quality of engine oil and fuel, and the operating condition of the engine affect the deterioration of the engine oil. Replace the engine oil in accordance with Chapter 7 MAINTENACE SCHEDULE. However, only if the operating load is stable and engine oil analyze result allows, oil replacement interval may be changed.

Refer to the following table for the determination of engine oil performance. If any of the following properties exceeds the limit, replace the engine oil with new oil.

Table 5-2 Table of engine oil properties

| Properties                   |   | Standard  | Test method                             |
|------------------------------|---|---|---|
| Kinetic Viscosity:           | mm <sup>2</sup> /s [in <sup>2</sup> /s]<br>@100°C [212°F] | +30 % or less rate of change from new oil<br>10 mm <sup>2</sup> /s [0.155 in <sup>2</sup> /s] or more       | JIS K 2283:2007<br>ISO 3107<br>ISO 2909 |
|                              |   | +30 % or less rate of change from new oil<br>-20 % or less rate of change from new oil                      |   |
| Base number                  | mgKOH/g   | 2.0 or more with hydrochloric acid (HCL) method<br>1/2 of new oil or more with perchloric acid (PCA) method | JIS K 2501:2003<br>ISO 3771             |
| Acid number                  | mgKOH/g   | Up to +3.0 of new oil   | JIS K 2501:2003<br>ISO 3771             |
| Water Content                | Vol %   | 0.2 or less   | JIS K 2275:1996<br>ISO 9029             |
| Flash point (open cup)       | °C [°F]   | 180 [356] or higher   | JIS K 2265:2007<br>ISO 3769<br>ISO 2719 |
| Pentane insoluble            | Wt %  | 0.5 or less   | Compliance with ASTM D 893              |
| Pentane insoluble coagulated | Wt %  | 3.0 or less   | Compliance with ASTM D 893              |

# Definition of Properties of Engine Oil

## Kinetic Viscosity

Kinetic viscosity is a basic physical property of engine oil and is considered as the most important aspect when evaluating oil.

Contamination of oil by blow-by gas and deterioration of oil by its natural aging increase the kinetic viscosity and degrade the performance of viscosity, which will cause the deposition of sludge inside the engine and oil filter clogging. Contamination of oil by fuel and sheared molecules of viscosity index improver in oil decrease the viscosity and degrade the performance of viscosity, which will cause insufficient lubrication and friction/wear of engine parts.

## Base Number

Base number shows the ability to neutralize acids such as organic acid due to engine oil oxidation, or sulfurous or sulfuric acid due to the sulfur content of fuel.

Because base number indicates the amount of dispersant detergent in oil, it can be used to estimate consumption of basic dispersant detergent. The ability to disperse sludge declines as dispersant detergent is used up.

## Acid Number

The acid number in oil increases as the organic acid is being derived by the engine oil oxidation, or sulfurous acid or sulfuric acid derived by the combustion of sulfur content of fuel, or the oil becomes contaminated with imperfect combustion products.

An increase in the acid number will result in corrosion or wear of the inner parts of the engine (such as cylinder liners or metal) due to sulfur content, and piston ring seizure due to sludge.

## Water Content

Water in oil promotes corrosion/wear, and decreases lubricity in sliding parts.

## Flash Point

The flash point is lowered by contamination with fuels. Flash point is measured to check the dilution of fuel. The dilution of fuel reduces oil film, and causes insufficient lubrication that will cause friction or wear of engine parts.

## Insoluble

Insoluble includes acid products of engine oil, imperfect combustion products, sludge or soot, metal abrasive particles and dust. Insoluble is an indication of degradation/contamination of oil.

Dispersant detergent, which is an additive in engine oil, absorbs sludge particles, and disperses them as fine particles in oil. Total insoluble density and remaining dispersibility can be obtained by measuring insoluble and coagulated insoluble (chemical specialties which stop action of disperse detergent and collect the sludge dispersed in oil) to understand engine oil contamination level, and thereby, piston ring seizure or premature wear can be prevented before it occurs.

## Engine Oil Analysis Service

For a long term service life of engine, it is recommended to get an engine oil analysis service.

It is a system to understand the availability of the engine oil using in your engine by sampling it with the special sampling tools.

The engine oil analysis service provides the followings:

- ♦The quantity of fine metal powder in engine oil due to abrasion, by which worn parts can be located.
- ♦Water, LLC or salt that should not be in engine oil can be detected.
- ♦Engine oil deteriorating conditions, by which appropriate engine oil renewal intervals, operating conditions, proper inspection and maintenance schedule can be planned.

The engine oil analysis service can diagnose the internal condition of the engine, which is necessary when disassembling the engine. It is highly recommended to take advantage of our engine oil analysis service so that you can learn the engine condition before any malfunction occurs to the engine.

# Chapter 6 COOLANT

Note: In this operation manual, the word "coolant" represents a mixture of water and LLC.

## Recommended Water for Coolant

Use soft water (such as tap water) for the engine cooling system. The water quality must meet the requirements in the Table below. Basically, the water quality should be within the recommended value, however, up to the limit is acceptable.

Table 6-1 Water Quality Standards

| Item                                  | Chemical symbol               | Unit | Recommend value | Limit      | Main adverse effect                 |
|---------------------------------------|-------------------------------|------|-----------------|------------|-------------------------------------|
| pH (25°C [77°F])                      | -                             | -    | 6.5 to 8.0      | 6.5 to 8.5 | Corrosion and rust, scale formation |
| Electrical conductivity (25°C [77°F]) | -                             | mS/m | < 25            | < 40       | Corrosion and rust, scale formation |
| Total hardness                        | CaCO <sub>3</sub>             | ppm  | < 95            | < 100      | Scale formation                     |
| M alkalinity                          | CaCO <sub>3</sub>             | ppm  | < 70            | < 150      | Scale formation                     |
| Chlorine ion                          | Cl <sup>-</sup>               | ppm  | < 100           | < 100      | Corrosion and rust                  |
| Sulfuric acid ion                     | SO <sub>4</sub> <sup>2-</sup> | ppm  | < 50            | < 100      | Corrosion and rust                  |
| Total iron                            | Fe                            | ppm  | < 1.0           | < 1.0      | Scale formation                     |
| Silica                                | SiO <sub>2</sub>              | ppm  | < 30            | < 50       | Scale formation                     |
| Residue from evaporation              | -                             | ppm  | < 250           | < 400      | Scale formation                     |

Note: Other than those above, turbidity must be below 15 mg/liter.

## Long Life Coolant (LLC)

### ⚠ CAUTION

Should coolant or LLC be accidentally swallowed, induce vomiting immediately and seek medical attention. If LLC should enter eyes, flush immediately with plenty of water and seek medical attention.

Be sure to use Mitsubishi Heavy Industries, Ltd. genuine long life coolant (LLC) "GLASSY long life coolant (Ethylene glycol type)" or "PG GLASSY long life coolant (Non-amine type)" as coolant. When using other brand LLCs by necessity, be sure to use the non-amine type LLC that meets the specification in Mitsubishi Heavy Industries, Ltd. Mitsubishi heavy industries disclaims the warranty claims about malfunctions due to the use of LLC that does not meet the following specification.

## Genuine LLC

Mitsubishi Heavy Industries, Ltd. recommends the use of our genuine long life coolant "GLASSY long life coolant (Ethylene glycol type)", and Eco-friendly product "PG GLASSY long life coolant (propylene glycol type)", which are most appropriate coolant for Mitsubishi diesel engines. Be sure to use our Genuine LLC.

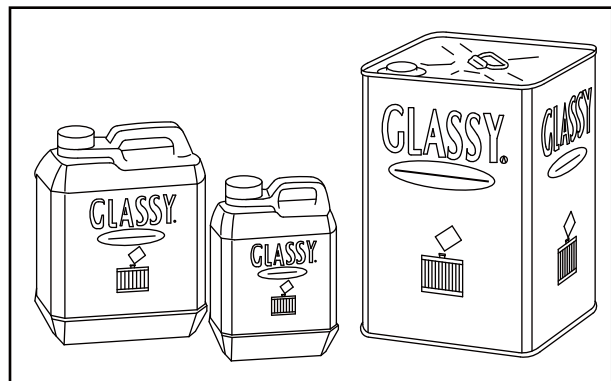


Fig. 6-1 GLASSY - LLC

## Other Brand LLCs

### CAUTION

Never mix Mitsubishi Heavy Industries, Ltd. genuine LLC with other brand LLCs. Mixing with other brand LLCs degrades the performance of the Mitsubishi Heavy Industries, Ltd. genuine LLC.

When using LLC other than Mitsubishi Heavy Industries, Ltd. genuine long life coolant (LLC) "GLASSY long life coolant (Ethylene glycol type)" or "PG GLASSY long life coolant (propylene glycol type)", be sure to use the LLC which meets specification in Mitsubishi Heavy Industries, Ltd.

The quality and performance of commercially available LLCs as well as their component variations are the responsibility of LLC suppliers.

Before purchasing commercial LLC, be sure to discuss the suitability of LLC with the LLC supplier.

Use all-season LLC (non-amine type) only. Do not use antifreeze alone instead of LLC.

## Standard for Other Brand LLC

When using other brand LLCs by necessity, be sure to use the LLC that meets the following specification. Mitsubishi heavy industries, Ltd. disclaims the warranty claim concerning malfunctions caused by the use of LLC that does not meet the following specification.

### General Demands of LLC

- ♦ LLC must be a homogeneous liquid without sediment.
- ♦ When the LLC is diluted to 30 to 60% density, the LLC shall not cause troubles such as corrosion and precipitation deposits in the engine cooling system.
- ♦ LLC shall be mixed with other LLC that satisfies this specification, and shall not separate elements each other, and shall not decrease the performance each other.
- ♦ LLC shall not allow the container to be corroded, and shall not has precipitation products etc. even if LLC is left in the container for 6 months.
- ♦ LLC shall not has extraction products etc. even if LLC is kept in -20 to -25°C [-4 to -13°F].
- ♦ The validity term of the quality that provides with this specification is 2 years after it delivers with the indoor normal temperature keeping.



## LLC Specification

LLC shall be examined according to JIS K2234, Section 7 (Test method), and satisfy this requirements. General matters and the specimen sampling shall comply with JIS K2234.

Table 6-2 LLC Specification

| Property  |  | Standard   |   |                          |
|---|--|--|---|--------------------------|
| Appearance  |  | No precipitation   |   |                          |
| Density   |  | Minimum 1.112 g/cm <sup>3</sup> [69.4199 lb/ft <sup>3</sup> ] (20/20°C) [68/68°F] (Stock solution) |   |                          |
| Water content   |  | Maximum 5.0 weight % (Stock solution)  |   |                          |
| Frozen temperature  | 30 vol %                                 | Maximum -14.5°C [6°F]  |   |                          |
|   | 50 vol %                                 | Maximum -34.0°C [-29°F]  |   |                          |
| Boiling temperature   |  | 155°C [311°F] or higher (Stock solution)   |   |                          |
| pH  |  | 7.0 to 11.0 (30 vol %)   |   |                          |
| Bubbling character (ASTM D3306-01)  | 30 vol %                                 | 4.0 ml or less   |   |                          |
|   | 33 <sup>1</sup> / <sub>3</sub> vol %     | 150 ml [0.032 gal] or less, Disappearance of bubble within 5 seconds.                              |   |                          |
| Hard water adaptability   |  | 1.0 or less (50 vol %)   |   |                          |
| Metallic causticity (88±2°C [190.4±35.6°F], 336±2 Hr, 30 vol % (E.G), 50 vol % (P.G)) | Metal specimen                           | Mass change  | Aluminum  | ±0.30 mg/cm <sup>2</sup> |
|   |  |  | Cast iron   | ±0.15 mg/cm <sup>2</sup> |
|   |  |  | Steel   | ±0.15 mg/cm <sup>2</sup> |
|   |  |  | Brass   | ±0.15 mg/cm <sup>2</sup> |
|   |  |  | Solder  | ±0.30 mg/cm <sup>2</sup> |
|   |  |  | Copper  | ±0.15 mg/cm <sup>2</sup> |
|   | Appearance of the specimen after testing |  | No visible signs of corrosion on the surface excluding the area contacting to spacer. However, discoloration is acceptable. |                          |
|   | Bubbling during the test                 |  | Not bubbling overflow   |                          |
|   | Properties of liquid after the test      | pH   |   | 6.5 to 11.0              |
|   |  | pH change  |   | ±1.0                     |
| Precipitation   |  | 0.5 vol % or less  |   |                          |
| Appearance of liquid  |  | No remarkable discoloration, separation and gel generation.  |   |                          |

Table 6-2 LLC Specification

| Property  |  |  | Standard  |   |
|---|--|--|---|---|
| Circulation metallic causticity<br>(98±2°C<br>[208.4±35.6°F],<br>1000 Hr,<br>30 vol %<br>(E.G)<br>50 vol %<br>(P.G) | Metal specimen                                   | Mass change                              | Aluminum, Cast iron, Steel, Brass, Solder, Copper<br>±0.30 mg/cm <sup>2</sup>   |   |
|   |  | Appearance of the specimen after testing |   | No visible signs of corrosion on the surface excluding the area contacting to spacer. However, discoloration is acceptable. |
|   | Properties of liquid after the test              | pH                                       |   | 7.0 to 9.0  |
|   |  | pH change                                |   | ±1.0  |
|   |  | Pre-alkalinity change                    |   | ±15 %   |
|   |  | Precipitation                            |   | 1.0 vol % or less   |
|   |  | Appearance of liquid                     |   | No remarkable discoloration, separation and gel generation.   |
| Density of ion  | Fe, Cu, Al, Zn, Pb, NH <sub>4</sub> <sup>+</sup> | 10 ppm or less                           |   |   |
| Circulation metallic causticity<br>(88±3°C<br>[190.4±37.4°F],<br>1000±2 Hr,<br>30 vol %<br>(E.G)                    | Metal specimen                                   | Mass change                              | Aluminum  | ±0.60 mg/cm <sup>2</sup>  |
|   |  |  | Cast iron   | ±0.30 mg/cm <sup>2</sup>  |
|   |  |  | Steel   | ±0.30 mg/cm <sup>2</sup>  |
|   |  |  | Brass   | ±0.30 mg/cm <sup>2</sup>  |
|   |  |  | Solder  | ±0.60 mg/cm <sup>2</sup>  |
|   |  |  | Copper  | ±0.30 mg/cm <sup>2</sup>  |
|   | Appearance of the specimen after testing         |  | No visible signs of corrosion on the surface excluding the area contacting to spacer. However, discoloration is acceptable. |   |
|   | Properties of liquid after the test              | pH                                       |   | 6.5 to 11.0   |
|   |  | pH change                                |   | Maximum ±1.0  |
|   |  | Appearance of liquid                     |   | No remarkable discoloration, separation and gel generation.   |
| Condition of parts  | Pump seal  |  | Free from any malfunction, liquid leak and abnormal noise during operation.   |   |
|   | Inside of pump case and blade                    |  | Free from remarkable corrosion  |   |
| Rubber adaptability<br>(30 vol %, 115°C [239°F], 360 Hr)  | Silicon  | Tensile strength change                  |   | -60 to 0 %  |
|   |  | Elongation change                        |   | -40 to +20 %  |
|   |  | Volume change                            |   | 0 to +40 %  |
|   |  | Hardness change                          |   | -20 to +10 %  |
|   | Acrylonitrile butadiene rubber                   | Tensile strength change                  |   | 0 to +10 %  |
|   |  | Elongation change                        |   | -15 to +15 %  |
|   |  | Volume change                            |   | 0 to +40 %  |
|   |  | Hardness change                          |   | -10 to 0 %  |
|   | Ethylene propylene diene monomer                 | Tensile strength change                  |   | 0 to +10 %  |
|   |  | Elongation change                        |   | -30 to 0 %  |
|   |  | Volume change                            |   | 0 to +10 %  |
|   |  | Hardness change                          |   | -10 to 0 %  |

Table 6-2 LLC Specification

| Property   | Standard    |
|--|-------------|
| Storage stability vol % (30 vol %, room temperature, 6 Hr) | 0.3 or less |

## Maintenance of LLC

### ⚠ CAUTION

Should coolant or LLC be accidentally swallowed, induce vomiting immediately and seek medical attention. If LLC should enter eyes, flush immediately with plenty of water and seek medical attention.

LLC is toxic. Never dispose of coolant containing LLC drained from engine into regular sewage. For disposal of used coolant, consult LLC distributor.

## Replacement Intervals of LLC

### CAUTION

Be sure to renew LLC (coolant) at the intervals specified in this manual.

Failure to renew LLC may cause malfunctions due to performance degradation of preventing rust and cavitation.

When a coolant mixed with the LLC recommended by our company is used, replace coolant every 8000 hours or 2 years, whichever comes first.

## LLC Concentration

Keep the LLC concentration of 30 % (GLASSY) and 40 % (PG GLASSY) on any temperature conditions. LLC of less than 30 % concentration does not provide sufficient corrosion protection. If the LLC concentration is lower than 10 %, it may accelerate corrosion.

When adding coolant, do not add plain water. Always use coolant with the same LLC concentration.

Table 6-3 Recommended LLC Concentration

| Item                  | Type      | Appearance | Lowest ambient temperature |                          |                           |                           |
|-----------------------|-----------|------------|----------------------------|--------------------------|---------------------------|---------------------------|
|                       |           |            | -10°C [14°F]<br>or above   | -20°C [-4°F]<br>or above | -30°C [-22°F]<br>or above | -45°C [-49°F]<br>or above |
| LLC concentration (%) | GLASSY    | Green      | 30                         | 40                       | 50                        | 60                        |
|                       | PG GLASSY | Red        | 40                         | 55                       | 70                        | -                         |

Note: (a) If the outside air temperature is -30°C [-22°F] or lower, use "GLASSY."

(b) The concentration above is based on Mitsubishi Heavy Industries, Ltd. genuine LLC "GLASSY long life coolant (Ethylene glycol type)" or "PG GLASSY long life coolant (Non-amine type)."

For determining the accurate LLC concentration, refer to the instructions for the LLC used.

## Importance of LLC

Today's trend is toward smaller and lighter engines offering greater output, lower fuel consumption and lower exhaust emission levels.

Conditions to which engine coolant is subjected, therefore, are becoming severer due to longer operating hours, higher coolant temperature and higher coolant circulating speed.

Many different materials such as steel, aluminum, copper, solder and rubber are used in the cooling system, and they are also subjected to the severe conditions described above. Those materials have different ionization characteristics, and this difference accelerates corrosion through the medium of engine coolant. To prevent such a problem, it is necessary to use the LLC having the additive that prevents rust.

## Characteristics of LLC Additive and Important Notes

LLC contains several chemicals in such proportions as to produce chemical reactions that suppress corrosion (ionization) of engine parts in contact with the coolant. LLC loses its effectiveness by hours of use as well as lapse of time.

Moreover, if the chemicals in LLC are not maintained, certain chemicals in the LLC become rapidly used up and result in dissolution of metals instead of protecting metals from corrosion. Consequently, other corrosion preventing chemicals react with dissolving metals and accelerate corrosion. This condition generates more severe corrosion than when plain soft water is used. This is a typical problem caused by the use of inappropriate LLC.

## Examples of Abnormalities Caused by LLC (Amine Type)

### Pitting of Iron Parts

Amines are generally effective in suppressing the rusting of ferrous metals, but they are said to cause problems for copper parts.

Dissolved copper (copper corrosion) in the cooling system deposits on iron parts and the copper deposits cause corrosion and then pitting on iron parts that have a high ionization characteristics due to galvanic or local-cell action.

### Corrosion of Aluminum Parts

Silicate is highly effective in protecting aluminum against rusting. However, it is unstable in a solution in which the pH is 9 or lower, and can turn to gel and precipitate in the solution. For this reason, the pH is usually specified to be about 10 to ensure a high alkaline level.

This means, after silicate is used up, the high alkalinity causes chemical attacks on aluminum. To prevent this problem, proper maintenance of the coolant is required. For case example, rapid wear of mechanical seals in the water pump due to secondary effects of silicate gel formed. Corrosion of aluminum parts after silicate is consumed.

### Pitting and Clogging of the Heat Exchange Equipment

When LLC deteriorates or when its concentration in the coolant is too low, the anti-corrosion performance of LLC lowers and results in the corrosion of metals. Brass and solder tend to corrode faster than other metals, and corrosion of these metals is said to cause water leakage and clogs. Example: Holes and clogs in heat exchange equipment.

# **Chapter 7 MAINTENANCE SCHEDULE**

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## **How to Use the Maintenance Schedule**

Periodic inspection not only extends the service life of the engine but also serves to ensure safe operation. Be sure to conduct inspections and maintenance according to the maintenance schedule.

The maintenance schedule shows the standard service intervals. If you notice any abnormalities such as abnormal noise, black exhaust smoke, white exhaust smoke, extremely high temperature of exhaust gas, abnormal vibration, and fuel, oil or exhaust gas leakage, make sure to conduct the inspection and maintenance work, regardless of recommended service intervals in the "Maintenance schedule."

Note: Appropriate service intervals vary depending on the usage and operating conditions as well as consumption of fuel, oil and coolant. Check the operating record of the engine to determine the most appropriate service intervals. (Feel free to consult a dealer of Mitsubishi Heavy Industries, Ltd. regarding service intervals.)

Service the items at multiples of the original requirement. For example, at 1000 service hours, also service those items listed under every 250 service hours and every 50 service hours.

### **Periodic Maintenance Chart**

Appropriate service intervals vary depending on the engine specifications. Perform all daily inspection and maintenance items in an accordance with the following 3 categories.

#### **Periodic Maintenance Chart for Regular Use Engine**

When the engine is used as a regular use engine, perform the periodic inspection and maintenance in accordance with the "Periodic Maintenance Chart for Engine in Regular Use".

#### **Periodic Maintenance Chart for Emergency Engine**

When the engine is used as an emergency engine, perform the periodic inspection and maintenance in accordance with the "Periodic Maintenance Chart for Emergency Engine". Due to the nature of application, an engine for emergency use is subject to demanding operating conditions such as a quick startup and immediate supply of power. In addition, it must operate reliably in the event of an emergency. Therefore, be sure to perform the daily inspection and also conduct the following operation for maintenance purposes. Once every week: Operate the engine under no load (for 3 to 5 minutes). (When operating the engine for the adjustment of peripheral devices, limit the operating time to 10 minutes.) Once every month: Operate the engine under load (for 15 to 30 minutes with more than 1/2 load). If the engine cannot be operated under load every month, operate the engine under load (more than 1/2 load) for more than 2 hours. During the engine maintenance operation, check the ease of startup, oil pressure, and exhaust color and vibration.

#### **Periodic maintenance chart for general purpose engine**

If the engine is used for different purposes other than the above usage, do maintenance according to the "Periodic Maintenance Chart for General-Purpose Power Supply Engine".

## **General Definition of Engine**

### **General Definition of Regular Use Engine**

An engine operated with a constant base load for the purpose of generating electric power, which is used independently or in combination with commercial power supply. An engine operated under a fluctuating load throughout a day for supplying rated electric power in lieu of commercial power.

### **General definition of emergency engine**

An engine used for emergency power generation such as main power supply and commercial power supply.

### **General Definition of General-purpose Engine**

An engine used for a purpose other than power generation - for example, to drive a pump, as the main engine for a ship, and for an industrial vehicle - and operated under constant or cyclically varying load and speed.

# Periodic Maintenance Chart for Regular Use Engine

Table 7-1 Periodic Maintenance Chart for Regular Use Engine

| Interval and service item                              |  | Refer-<br>ence<br>page |
|--|--|------------------------|
| Every 50 service hours or every month                  | Fuel Tank - Drain Water*1  | 8-6                    |
|  | Water Separator - Drain Water*1  | 8-7                    |
|  | Fuel Filters (Wire-element Type) - Drain Water   | 8-9                    |
| First 50 service hours for a new or overhauled engine  | Bolts and Nuts on the Engine - Retighten   | *2                     |
|  | Engine Oil, Oil Filter and Bypass Oil Filter - Replace<br>It is recommended to check the engine oil characteristics at the same time. The oil filters must be replaced when the filter alarm lights. | 8-13                   |
| Every 250 service hours                                | Engine Oil, Oil Filter and Bypass Oil Filter - Replace<br>It is recommended to check the engine oil characteristics at the same time. The oil filters must be replaced when the filter alarm lights. | 8-13                   |
| First 250 service hours for a new or overhauled engine | Valve Clearance - Inspect and Adjust<br>(Check Valve Mechanism at the Same Time.)  | *2                     |
| Every 1000 service hours                               | Inside of Fuel Filters (Wire-element Type) - Clean   | 8-9                    |
|  | Fuel Filter - Replace  | 8-10                   |
|  | Water Separator Element - Inspect and Replace  | -                      |
|  | Gauze Filter - Clean   | 8-8                    |
|  | Belt and Belt Tension - Inspect and Adjust   | 8-2                    |
| Every 2000 hours                                       | Fuel Tank - Drain Water (Replace Parts as Necessary) *1  | 8-6                    |
|  | Valve Clearance - Inspect and Adjust<br>(Check Valve Mechanism at the same Time.)  | *2                     |
|  | Fuel Injection Timing - Inspect and Adjust   | *2                     |
|  | Fuel Injection Nozzle - Nozzle Tip Replacement<br>(Check the Spray Condition and Adjust the Fuel Injection Pressure After Replacement)   | *2                     |
|  | Checking Movement of the Rack (During operation) of the Fuel Injection Pump (Including the Governor)   | *2                     |
|  | Fuel Pipe - Inspect  | 8-12                   |
|  | Oil Pipe - Inspect   | 8-16                   |
| Every 4000 service hours                               | Top End of the Engine - Overhaul<br>Remove the cylinder head, and inspect and service the combustion chambers.   | *2                     |
|  | Turbocharger - Inspect   | 8-20                   |
|  | Damper - Inspect   | 8-4                    |
|  | Starter - Inspect  | 8-25                   |
|  | Protection Devices Operation - Inspect   | *2                     |
|  | Unit Seal and Oil Seal of Water Pump - Replace   | *2                     |
|  | Checking LLC Concentration Level in the Coolant  | *2                     |



Table 7-1 Periodic Maintenance Chart for Regular Use Engine

|   | Interval and service item  | Reference page |
|---|--|----------------|
| Every 8000 hours                          | Engine - Major Overhaul<br>Disassemble engine, clean, check and change major parts.<br>[Parts to be changed at major overhaul.]<br>Inlet and exhaust valves, inlet and exhaust valve seats, valve rotators, valve cotters, rocker arm adjusting screws, valve push rods, bridge caps, camshaft bushings, camshaft expansion plugs, main bearings, cylinder liners, main bearing cap bolts and washers, piston rings, connecting rod bearings, damper, crankcase thrust plate and consumable items (gaskets, oil seals, O-rings, etc.)<br>[At second overhaul, replace the following parts in addition to the parts listed above] ><br>Cylinder head bolts, valve guides, valve bridge guides, valve bridges, valve springs, tappets, camshaft thrust plates, pistons, piston pins, connecting rod bolts, connecting rod bushings, rocker bushings, fuel pipe assembly, oil pipe assembly | *2             |
|   | Fuel Injection Pump - Inspect and Test (Replace Parts as Necessary)  | *2             |
|   | Governor - Inspect and Test (Replace Parts as Necessary)   | *2             |
|   | Protective Devices - Repair or Replace<br>High coolant temperature, low oil pressure, overspeeding, starting failure, water supply failure, undervoltage, overvoltage, overcurrent, low coolant level in tank, low fuel level in tank, low air pressure in tank, etc.  | *2             |
|   | Auxiliary Devices Operation - Check<br>Water heater, oil heater, oil priming pump, fuel transfer pump, governor motor, etc.  | *2             |
| Every 8000 service hours or every 2 years | Coolant - Change   | 8-17           |
| As required                               | Fuel System - Bleed Air *1   | 3-2            |
|   | Radiator Fins - Check and Clean  | 8-19           |
|   | Air Cleaner Element - Clean, Check and Replace   | 8-22           |
|   | Cleaning the Inside of the Engine Breathers  | *2             |
|   | Stop Solenoid - Inspect or Replace   | *2             |
|   | Couplings - Inspect or Replace *1  | *2             |
|   | Inspecting the Vibration-isolating Rubber *1   | *2             |

\*1 If it is not a item supplied from Mitsubishi Heavy Industries, maintain the part following the manufacture's operation manual as required.

\*2 Items require special tools or large equipment. For the servicing of those items, contact a dealer of Mitsubishi Heavy Industries, Ltd.

# Periodic Maintenance Chart for Emergency Engine

Table 7-2 Periodic Maintenance Chart for Emergency Engine

| Interval and service item |   | Refer-<br>ence<br>page |
|---------------------------|---|------------------------|
| Every week                | Engine External - Inspect (Check for leakage of fuel, oil and coolant)  | 3-8                    |
|                           | Fuel Tank Oil Level - Check *1  | 3-9                    |
|                           | Engine Oil Level - Check  | 3-9                    |
|                           | Coolant Level - Check   | 3-10                   |
|                           | Air Tank Air Pressure - Check (Air motor type or direct inlet type)   | 3-11                   |
|                           | Water Leakage of Aircooler - Inspect  | -                      |
|                           | Operating the Engine for Maintenance<br>(Operate the Engine Under No Load for 5 to 10 Minutes)<br>Check for ease of starting, color of exhaust smoke, abnormal vibration, abnormal noise, abnormal smell and gauge indication (oil pressure gauge, coolant temperature gauge, oil temperature gauge, exhaust temperature gauge, tachometer, etc.)   | -                      |
| Every month               | Engine Oil for Mixing of Fuel and Water - Inspect   | 8-15                   |
|                           | Clean Fuel Filter (Wire Element Type) - Turn Handle One or Two Times  | -                      |
|                           | Fuel Control Link - Check   | 3-9                    |
|                           | Battery Electrolyte Level - Inspect *1  | 3-6                    |
|                           | Air Tank - Drain Water  | 3-10                   |
|                           | Air Compressor Oil Level - Inspect and Refill   | -                      |
|                           | Conducting Engine Maintenance Operation<br>(Operate the Engine With More Than 1/2 Load for 15 to 30 Minutes)<br>Check for ease of starting, color of exhaust smoke, abnormal vibration, abnormal noise, abnormal smell and gauge indication (oil pressure gauge, coolant temperature gauge, oil temperature gauge, exhaust temperature gauge, tachometer, etc.)<br>Check fuel injection pump and the movement and rack of governor, check temperature of damper, check damper visually. | -                      |
| Every 6 months            | Checking LLC Concentration Level in the Coolant   | *2                     |
|                           | Cleaning the Inside of the Coolant Tank *1  | -                      |

Table 7-2 Periodic Maintenance Chart for Emergency Engine

| Interval and service item |                           | Reference page   |      |
|---------------------------|---------------------------|--|------|
| Every one year            | Basic engine              | Belt and Belt Tension - Inspect and Adjust                                     | 8-2  |
|                           |                           | Bolts and Nuts on the Engine - Check and Retighten                             | *2   |
|                           |                           | Damper - Inspect   | 8-4  |
|                           |                           | Valve Clearance - Inspect and Adjust (Check valve mechanism at the same time.) | *2   |
|                           |                           | Inspecting the Vibration-isolating Rubber *1                                   | *2   |
|                           |                           | Foundation Bolts - Inspect *1  | *2   |
|                           |                           | Couplings - Inspect or Replace *1  | *2   |
|                           | Fuel system               | Fuel Tank - Drain Water *1   | 8-6  |
|                           |                           | Water Separator - Drain Water *1   | 8-7  |
|                           |                           | Fuel Filters (Wire-element Type) - Drain Water                                 | 8-9  |
|                           |                           | Fuel Injection Nozzle Spray Condition and Spray Pressure - Inspect and Adjust  | *2   |
|                           |                           | Fuel Injection Timing - Inspect and Adjust                                     | *2   |
|                           |                           | Fuel Pipe - Inspect  | 8-12 |
|                           | Engine Lubricating system | Oil Pipe - Inspect   | 8-16 |
|                           |                           | Engine Oil Properties - Analyze  | *2   |
|                           |                           | Engine Oil Pressure (Maintenance Operation) - Inspect and Adjust               | *2   |

Table 7-2 Periodic Maintenance Chart for Emergency Engine

| Interval and service item  |   |  | Refer-<br>ence<br>page |      |
|--|---|--|------------------------|------|
| Every one year   | Cooling system  | Water Pump - Inspect   | *2                     |      |
|  |   | Solenoid Valve and Pressure Reducing Valve of the Cooling System - Inspect, Disassemble and Clean  | *2                     |      |
|  |   | Strainer (Including With Ball Tap) of Cooling Water - Inspect, Disassemble and Clean   | *2                     |      |
|  |   | Coolant Properties (when Only Soft Water is Used) - Inspect (Change Coolant According to the Analysis Results)   | *2                     |      |
|  | Air intake system   | Air Cleaner Element - Clean, Check and Replace   | 8-22                   |      |
|  | Electrical system   | Starter - Inspect  | 8-25                   |      |
|  |   | Alternator - Inspect   | 8-25                   |      |
|  |   | Specific Gravity of Battery Electrolyte - Check  | 8-24                   |      |
|  |   | Air Heater - Inspect   | -                      |      |
|  | Air starter system  | Air Strainer - Drain Water and Clean   | 8-26                   |      |
|  |   | Air Tank - Inspect Safety Valve Operation  | 8-27                   |      |
|  |   | Air Starter Valve - Inspect  | *2                     |      |
|  |   | Solenoid Valve and Pressure Reducing Valve - Inspect and Clean   | *2                     |      |
|  |   | Air Distribution Valve - Inspect   | *2                     |      |
|  |   | Air Compressor Belt Tension - Inspect  | *2                     |      |
|  | Auxiliary Devices Operation - Check *1<br>High coolant temperature, low oil pressure, overspeeding, starting failure, water supply failure, undervoltage, overvoltage, overcurrent, low coolant level in tank, low fuel level in tank, low air pressure in tank, etc. |  | *2                     |      |
|  | Auxiliary Devices Operation - Check<br>Engine control, fuel transfer pump, governor motor, room ventilating fan, solenoid, storage pump, water tank ball tap, water heater, oil heater, oil priming pump, etc.  |  | *2                     |      |
|  | Every 2 years   | Engine Oil, Oil Filter and Bypass Oil Filter - Replace<br>It is recommended to check the engine oil characteristics at the same time. The oil filters must be replaced when the filter alarm lights. |                        | 8-13 |
|  |   | Inside of Fuel Filters (Wire-element Type) - Clean   |                        | 8-9  |
|  |   | Fuel Filter - Replace  |                        | 8-10 |
| Water Separator Element - Replace                                      |   | 8-7  |                        |      |
| Gauze Filter - Clean   |   | 8-8  |                        |      |
| Fuel Control Link Ball Joint - Inspect<br>(Replace parts as necessary) |   | 8-11   |                        |      |
| Coolant - Change   |   | 8-17   |                        |      |
| Thermostat - Inspect   |   | *2   |                        |      |
| Turbocharger - Inspect   |   | 8-20   |                        |      |
| Exhaust Muffler - Drain Water *1                                       |   | 8-20   |                        |      |
| Air Compressor Overhaul (Air Motor Type or Direct Inlet Type)          |   | *2   |                        |      |

Table 7-2 Periodic Maintenance Chart for Emergency Engine

| Interval and service item   |  | Reference page |
|-----------------------------|--|----------------|
| Every 4 years               | Top End of the Engine - Overhaul<br>Remove the cylinder head, and inspect and service the combustion chambers. (If the abnormalities of first and second cylinders are found, inspect all cylinders. ) | *2             |
|                             | Checking Oil Cooler for Contamination, Clogging and Leakage  | *2             |
|                             | Checking Oil Pump for Discoloration and Other External Defects   | *2             |
|                             | Governor Oil Filter - Change   | 8-16           |
|                             | Fuel Tank - Clean *1   | 8-6            |
|                             | Fuel Injection Pump - Inspect and Test (Replace Parts as Necessary)  | *2             |
|                             | Governor - Inspect and Test (Replace Parts as Necessary)   | *2             |
|                             | Radiator Fins - Check and Clean  | 8-19           |
|                             | Rubber Hose - Replace  | *2             |
|                             | Air Cleaner Element - Clean, Check and Replace   | 8-22           |
|                             | Protective Devices - Repair or Replace *1<br>Oil pressure gauge, coolant temperature gauge, oil temperature gauge, exhaust temperature gauge, tachometer   | *2             |
| Every 8 years               | Engine - Major Overhaul<br>Disassemble engine, clean, check and change major parts.  | *2             |
|                             | Damper - Replace   | *2             |
|                             | Oil Pump - Repair or Replace   | *2             |
|                             | Fuel Injection Nozzle - Nozzle Tip Replacement<br>(Check the Spray Condition and Adjust the Fuel Injection Pressure After Replacement)   | *2             |
|                             | Rubber Parts and O-rings - Replace   | *2             |
|                             | Unit Seal and Oil Seal of Water Pump - Replace   | *2             |
|                             | Turbocharger - Disassemble and Inspect   | *2             |
|                             | Aircooler - Disassemble and Clean  | *2             |
|                             | Vibration-isolating Rubber - Repair or Replace *1  | *2             |
|                             | Couplings - Repair or Replace *1   | *2             |
|                             | Protective devices - Repair or replace *1  | *2             |
|                             | Protective devices - Repair or replace *1  | *2             |
|                             | Stop Solenoid - Inspect or Replace *1  | *2             |
|                             | Ball Tap of Water Tank - Repair or Replace *1  | *2             |
| Other Consumables - Replace | *2   |                |

\*1 It is not a item supplied from Mitsubishi Heavy Industries, Ltd., however, please maintain the part regularly to use the engine securely and effectively.

\*2 Items require special tools or large equipment. For the servicing of those items, contact a dealer of Mitsubishi Heavy Industries, Ltd.

# Periodic Maintenance Chart for General Purpose Engine

Table 7-3 Periodic Maintenance Chart for General Purpose Engine

| Interval and service item                              |   | Reference page |
|--|---|----------------|
| Every 50 service hours or every month                  | Fuel Control Link Ball Joint - Inspect  | 8-11           |
|  | Air Strainer - Drain Water and Clean (Air motor type or direct inlet type)  | 8-26           |
|  | Air Tank - Drain Water (Air motor type or direct inlet type)  | 3-10           |
| First 50 service hours for a new or overhauled engine  | Bolts and Nuts on the Engine - Retighten  | *2             |
|  | Engine Oil, Oil Filter and Bypass Oil Filter - Replace<br>It is Recommended to Check the Engine Oil Characteristics at the Same time.<br>The Oil Filters Must be Replaced When the Filter Alarm Lights. | 8-13           |
| Every 250 service hours or every 1 year                | Engine Oil, Oil Filter and Bypass Oil Filter - Replace<br>The Oil Filters Must be Replaced When the Filter Alarm Lights.  | 8-13           |
|  | Governor Oil Filter - Change  | 8-16           |
|  | Belt and Belt Tension - Inspect and Adjust  | 8-2            |
|  | Radiator Fins - Check and Clean *1  | 8-19           |
|  | Exhaust Muffler - Drain Water *1  | 8-20           |
|  | Air Tank - Inspect Safety Valve Operation   | 8-27           |
| First 250 service hours for a new or overhauled engine | Valve Clearance - Inspect and Adjust<br>(Check valve mechanism at the same time.)   | *2             |
| Every 1000 service hours or every 2 years              | Fuel Filter - Replace   | 8-10           |
|  | Water Separator Element - Replace *1  | 8-7            |
|  | Gauze Filter - Clean  | 8-8            |
|  | Air Strainer - Drain Water and Clean (Air motor type or direct inlet type)  | 8-26           |
|  | Zinc Rod - Replace  | *2             |
| Every 2000 service hours or every 3 years              | Bolts and Nuts on the Engine - Retighten  | *2             |
|  | Valve Clearance - Inspect and Adjust<br>(Check valve mechanism at the same time.)   | *2             |
|  | Fuel Injection Timing - Inspect and Adjust  | *2             |
|  | Fuel Pipe - Inspect   | 8-12           |
|  | Oil Pipe - Inspect  | 8-16           |
|  | Fuel Injection Nozzle - Nozzle Tip Replacement<br>(Check the spray condition and adjust the fuel injection pressure after replacement)  | *2             |
|  | Protection Devices Operation - Inspect<br>(High water temperature, low oil pressure, overspeed)   | *2             |

Table 7-3 Periodic Maintenance Chart for General Purpose Engine

| Interval and service item                 |  | Reference page |
|---|--|----------------|
| Every 4000 service hours or every 5 years | Top End of the Engine - Overhaul<br>Remove the Cylinder Head, and Inspect and Service the Combustion Chambers. | *2             |
|   | Fuel Control Link Ball Joint - Inspect   | 8-11           |
|   | Damper - Inspect   | 8-4            |
|   | Air Cleaner - Clean  | *2             |
|   | Heat Exchanger - Wash  | *2             |
| 8000 hours                                | Engine - Major Overhaul<br>Disassemble Engine, Clean, Check and Change Major Parts.                            | *2             |
|   | Fuel Injection Pump - Inspect and Test (Replace parts as necessary)  | *2             |
|   | Governor - Inspect and Test (Replace parts as necessary)   | *2             |
|   | Protective Devices - Repair or Replace   | *2             |
|   | Auxiliary Devices Operation - Check  | *2             |
| Every 8000 service hours or every 2 years | Coolant - Change   | 8-17           |
| As required                               | Fuel System - Bleed Air  | 3-2            |
|   | Air Cleaner Element - Clean, Check and Replace *1  | 8-22           |

\*1 If it is not a item supplied from Mitsubishi Heavy Industries, maintain the part following the manufacture's operation manual as required.

\*2 Items require special tools or large equipment. For the servicing of those items, contact a dealer of Mitsubishi Heavy Industries, Ltd.

# Chapter 8 PERIODIC INSPECTION AND MAINTENANCE PROCEDURES

## Basic Engine

### Engine External - Inspect

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 **CAUTION**

Be sure to keep combustible materials away from the engine, especially from the hot engine parts such as exhaust manifolds, or the battery. Check for fuel and oil leaks. Remove dust from the top surface of the battery. A fire can be caused by combustible materials placed near hot engine parts. If any abnormality is found, be sure to repair it or contact your local dealer.

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Inspect the engine exterior as described below.

1. Make sure there is no combustible material near the engine or battery. Also, check to make sure that the engine and battery are clean. If combustible materials or dust are found near the engine or battery, remove them.
2. Check the electrical wiring for such components as the starter and alternator for looseness.
3. Check the whole engine for leaks of fuel, engine oil or coolant. If leaks are found, repair or contact your local dealer.
4. Check that valves, plugs or cocks are properly positioned.
  - ♦Fuel feed valve: Open
  - ♦Coolant drain cock (plug): Closed
  - ♦Engine oil drain plug: Closed



## Belt and Belt Tension - Inspect and Adjust

### CAUTION

If defects such as cuts or surface separations are found during inspection, replace the belt.

Keep oil and grease away from the belt. They may cause the belt to slip and shorten the service life.

Excessive belt tension can cause rapid wear of the alternator bearing and shorten the service life of the belt.

Adjust the belt tension accurately by following the procedures below.

### Belt - Inspect

1. Inspect the belt visually for separation or damage. If any abnormality is found, replace the belt with a new one.
2. Inspect belt tension (deflection) and pressing force.

#### V-belt

Push the belt downward at the midway between pulleys with approximately 98 to 147 N {10 to 15 kgf} [22.05 to 33.05 lbf]. If the deflection is 10 to 15 mm [0.39 to 0.59 in.], the tension is correct. If the deflection of belt is not within the standard, adjust the belt tension.

#### Ribbed belt

Refer to Table 8-1 "[Ribbed Belt Tension Force](#)", adjust the pressing force if it is not average level when pushing the belt downward till 15 mm [0.59 in.] at the midway between pulleys with gauge.

### Belt Tension (Alternator Side) - Adjust

1. Remove the belt cover.
2. Loosen all retaining bolts of the alternator and adjusting plate.
3. Insert a bar between the alternator and crankcase and use leverage to move the alternator to have proper belt tension.
4. After adjusting, tighten all retaining bolts of the alternator and adjusting plate.
5. Install the belt cover.

### Belt Tension (Fan Side) - Adjust

1. Loosen all fan bracket retaining bolts.
2. Loosen the lock nut of adjusting bolt.
3. Turn the adjusting bolt to adjust the belt tension.
4. After adjusting deflection, fix the lock nut.
5. Tighten all retaining bolts of the fan bracket.

### Belt Tension (Water Pump Side) - Adjust

1. Remove the belt cover.
2. Loosen all slide plate retaining bolts.
3. Loosen the lock nut of adjusting bolt, and turn the adjusting bolt. Then, adjust the belt tension.
4. After adjusting, fix the slide plate and adjusting bolt.
5. Install the belt cover.

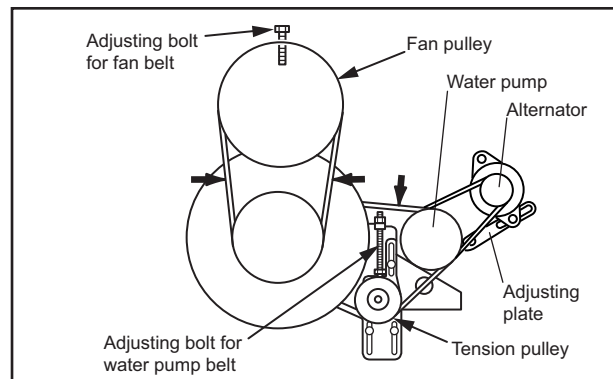


Fig. 8-1 Adjusting the Belt Tension

Table 8-1 Ribbed Belt Tension Force

| Item                      | Number of ribs | Belt direct distance (mm)         |                                   |                                   |                                 |                                 |
|---------------------------|----------------|-----------------------------------|-----------------------------------|-----------------------------------|---------------------------------|---------------------------------|
|                           |                | Up to 300                         | 300 or more<br>Up to 400          | 400 or more<br>Up to 500          | 500 or more<br>Up to 600        | 600 or more                     |
| When attaching a new belt | 3              | 74 N {7.55 kgf }<br>[16.64 lbf]   | 49 N {5.00 kgf }<br>[11.02 lbf]   | 37 N {3.77 kgf }<br>[8.31 lbf]    | 29 N {2.96 kgf }<br>[6.53 lbf]  | 25 N {2.55 kgf }<br>[5.62 lbf]  |
|                           | 4              | 88 N {8.97 kgf }<br>[19.78 lbf]   | 59 N {6.02 kgf }<br>[13.27 lbf]   | 44 N {4.49 kgf }<br>[9.90 lbf]    | 35 N {3.57 kgf }<br>[7.87 lbf]  | 29 N {2.96 kgf }<br>[6.53 lbf]  |
|                           | 5              | 103 N {10.50 kgf }<br>[23.15 lbf] | 69 N {7.04 kgf }<br>[15.52 lbf]   | 51 N {5.20 kgf }<br>[11.46 lbf]   | 41 N {4.18 kgf }<br>[9.22 lbf]  | 34 N {3.47 kgf }<br>[7.65 lbf]  |
|                           | 6              | 118 N {12.03 kgf }<br>[26.52 lbf] | 79 N {8.06 kgf }<br>[17.77 lbf]   | 59 N {6.02 kgf }<br>[13.27 lbf]   | 47 N {4.79 kgf }<br>[10.56 lbf] | 39 N {3.98 kgf }<br>[8.77 lbf]  |
|                           | 7              | 132 N {13.46 kgf }<br>[29.67 lbf] | 88 N {8.97 kgf }<br>[19.78 lbf]   | 66 N {6.73 kgf }<br>[14.84 lbf]   | 53 N {5.40 kgf }<br>[11.90 lbf] | 44 N {4.49 kgf }<br>[9.90 lbf]  |
|                           | 8              | 147 N {14.99 kgf }<br>[33.05 lbf] | 98 N {9.99 kgf }<br>[22.02 lbf]   | 74 N {7.55 kgf }<br>[16.64 lbf]   | 59 N {6.02 kgf }<br>[13.27 lbf] | 49 N {5.00 kgf }<br>[11.02 lbf] |
|                           | 9              | 162 N {16.52 kgf }<br>[36.42 lbf] | 108 N {11.01 kgf }<br>[24.27 lbf] | 81 N {8.26 kgf }<br>[18.21 lbf]   | 65 N {6.63 kgf }<br>[14.62 lbf] | 54 N {5.51 kgf }<br>[12.15 lbf] |
|                           | 10             | 176 N {17.95 kgf }<br>[39.57 lbf] | 118 N {12.03 kgf }<br>[26.52 lbf] | 88 N {8.97 kgf }<br>[19.78 lbf]   | 71 N {7.24 kgf }<br>[15.96 lbf] | 59 N {6.02 kgf }<br>[13.27 lbf] |
|                           | 11             | 191 N {19.48 kgf }<br>[42.95 lbf] | 127 N {12.95 kgf }<br>[28.55 lbf] | 96 N {9.79 kgf }<br>[21.58 lbf]   | 76 N {7.75 kgf }<br>[17.09 lbf] | 64 N {6.53 kgf }<br>[14.40 lbf] |
|                           | 12             | 206 N {21.01 kgf }<br>[46.32 lbf] | 137 N {13.97 kgf }<br>[30.80 lbf] | 103 N {10.50 kgf }<br>[23.15 lbf] | 82 N {8.36 kgf }<br>[18.43 lbf] | 69 N {7.04 kgf }<br>[15.52 lbf] |
| Reused                    | 3              | 51 N {5.20 kgf }<br>[11.46 lbf]   | 34 N {3.47 kgf }<br>[7.65 lbf]    | 26 N {2.65 kgf }<br>[5.84 lbf]    | 21 N {2.14 kgf }<br>[4.72 lbf]  | 17 N {1.73 kgf }<br>[3.81 lbf]  |
|                           | 4              | 62 N {6.32 kgf }<br>[13.93 lbf]   | 41 N {4.18 kgf }<br>[9.22 lbf]    | 31 N {3.16 kgf }<br>[6.97 lbf]    | 25 N {2.55 kgf }<br>[5.62 lbf]  | 21 N {2.14 kgf }<br>[4.72 lbf]  |
|                           | 5              | 72 N {7.34 kgf }<br>[16.18 lbf]   | 48 N {4.89 kgf }<br>[10.78 lbf]   | 36 N {3.67 kgf }<br>[8.09 lbf]    | 29 N {2.96 kgf }<br>[6.53 lbf]  | 24 N {2.45 kgf }<br>[5.40 lbf]  |
|                           | 6              | 82 N {8.36 kgf }<br>[18.43 lbf]   | 55 N {5.61 kgf }<br>[12.37 lbf]   | 41 N {4.18 kgf }<br>[9.22 lbf]    | 33 N {3.37 kgf }<br>[7.43 lbf]  | 27 N {2.75 kgf }<br>[6.06 lbf]  |
|                           | 7              | 93 N {9.48 kgf }<br>[20.90 lbf]   | 62 N {6.32 kgf }<br>[13.93 lbf]   | 46 N {4.69 kgf }<br>[10.34 lbf]   | 37 N {3.77 kgf }<br>[8.31 lbf]  | 31 N {3.16 kgf }<br>[6.97 lbf]  |
|                           | 8              | 103 N {10.50 kgf }<br>[23.15 lbf] | 69 N {7.04 kgf }<br>[15.52 lbf]   | 51 N {5.20 kgf }<br>[11.46 lbf]   | 41 N {4.18 kgf }<br>[9.22 lbf]  | 34 N {3.47 kgf }<br>[7.65 lbf]  |
|                           | 9              | 113 N {11.52 kgf }<br>[25.40 lbf] | 75 N {7.65 kgf }<br>[16.87 lbf]   | 57 N {5.81 kgf }<br>[12.81 lbf]   | 45 N {4.59 kgf }<br>[10.12 lbf] | 38 N {3.87 kgf }<br>[8.53 lbf]  |
|                           | 10             | 123 N {12.54 kgf }<br>[27.65 lbf] | 82 N {8.36 kgf }<br>[18.43 lbf]   | 62 N {6.32 kgf }<br>[13.93 lbf]   | 49 N {5.00 kgf }<br>[11.02 lbf] | 41 N {4.18 kgf }<br>[9.22 lbf]  |
|                           | 11             | 134 N {13.66 kgf }<br>[30.12 lbf] | 89 N {9.08 kgf }<br>[20.02 lbf]   | 67 N {6.83 kgf }<br>[15.06 lbf]   | 54 N {5.51 kgf }<br>[12.15 lbf] | 45 N {4.59 kgf }<br>[10.12 lbf] |
|                           | 12             | 144 N {14.68 kgf }<br>[32.36 lbf] | 96 N {9.79 kgf }<br>[21.58 lbf]   | 72 N {7.34 kgf }<br>[16.18 lbf]   | 58 N {5.91 kgf }<br>[13.03 lbf] | 48 N {4.89 kgf }<br>[10.78 lbf] |

The pressing force when pressing the belt downward till 15 mm [0.59 in.] at the midway of the belt direct distance.

## Damper - Inspect

### Damper - Check Visually

#### CAUTION

When installing a damper protective cover to the engine, do not use a cover that encloses the damper. It may cause serious engine problems because the damper deteriorates by heat or not deliver enough its performance.

Check the vibration damper for oil leakage, scratches, deformation, discoloration and peeling of paint. Check carefully for swelling on the cover (use a scale), oil leaks from the shim, discoloration and peeling of paint due to heat.

Note: If defects are found in the damper, contact a dealer of Mitsubishi Heavy Industries, Ltd.

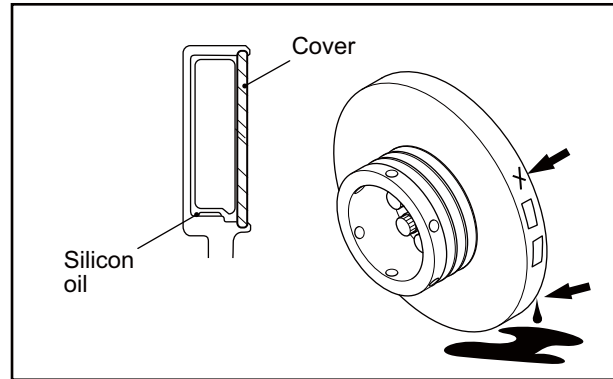


Fig. 8-2 Damper - Check Visually

### Damper Temperature Management

For making damper function well, heat of damper must be dissipated from its surface to prevent excessive damper heating. Mitsubishi inspects each engine before shipment to ensure proper operating temperature of the vibration damper. However, the vibration damper temperature varies depending on ambient conditions. Therefore, observe the following suggestions and provide sufficient ventilation for the vibration damper and equipment.

1. Make sure the temperature of the outside damper surface does not exceed the temperature that described in the following table when operating the engine with rated power for an hour.

Table 8-2 Damper Temperature Management

| Type of damper        | Continuous   | Standby       |
|-----------------------|--------------|---------------|
| Viscous damper        | 90°C [194°F] | 100°C [212°F] |
| Viscous rubber damper | 80°C [176°F] | 90°C [194°F]  |

2. When installing a safety cover to damper, check ventilation carefully and make sure the damper temperature remains below the temperature specified above, with the cover in place.
3. It is recommended to use the thermo label for the temperature management of damper in regular use engine.

### Thermo Label - Handle

The white thermal part of thermo label becomes black when reaching the specified value.

Note: The thermal part that becomes black once does not return to white. Therefore, if the engine stops and then the temperature of damper drops, the thermo label continues indicating the maximum temperature while engine is running.

1. Attach a thermo label to the periphery or front end of damper.
2. Note the maximum temperature to check the thermal part of thermo label when engine stops. Note the temperature periodically, and check the abnormality of temperature alteration.

Note: (a) When the temperature of thermo label increased, identify the abnormality of engine or other cause. Then, reattach new thermo label, and check the change of temperature.

(b) If the temperature indication of thermo label comes close to the limit temperature of damper or the abnormality is found in change of temperature, contact a dealer of Mitsubishi Heavy Industries, Ltd.

(c) For damper temperature limit and inspection, refer to "Damper - Inspect" (8-4).

Table 8-3 Thermo Label for Temperature Management

| Part Name            | Part No.                                  | Temperature measuring range    |
|----------------------|---|--------------------------------|
| Thermo label 100-120 | 32522-04211<br>20 labels set: 32522-04200 | 100 to 120°C<br>[212 to 248°F] |
| Thermo label 75-95   | 32522-04111<br>20 labels set: 32522-04100 | 75 to 95°C<br>[167 to 203°F]   |
| Thermo label 50-70   | 32522-04311<br>20 labels set: 32522-04300 | 50 to 70°C<br>[122 to 158°F]   |

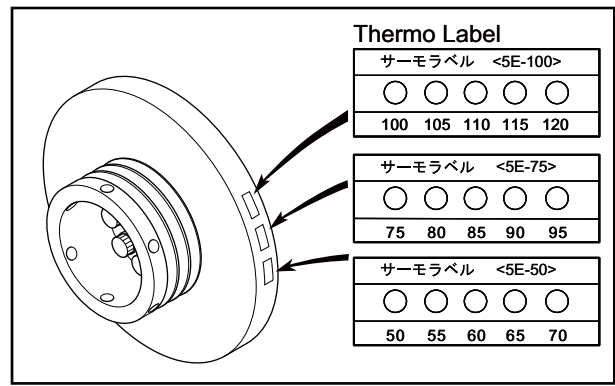


Fig. 8-3 Damper Temperature Management

# Fuel System

## Fuel System - Inspect

**WARNING**

When handling fuel, make sure there are no open flames or other fire hazards near the engine. Wipe off any spilled fuel completely. Spilled fuel can ignite and cause a fire.

## Fuel Tank - Clean

**CAUTION**

For fuel to be used, refer to "FUEL" (4-1).

1. Close the fuel feed valve to cut off the fuel supply to the engine.
2. Place a drip tray under the drain cock.
3. Drain all fuel in the tank from drain cock on the bottom of fuel tank.
4. Clean the inside of fuel tank.
5. Add fuel to the fuel tank.
6. Open the fuel feed valve, and bleed air for the fuel system.

Note: (a) For bleeding fuel system, refer to "Fuel System - Bleed Air" (3-2).

(b) If the specification of fuel tank differs from the contents of this operation manual, follow the manufacturer's operation manual.

## Fuel Tank - Drain Water

If fuel gets mixed with particles of foreign material such as dust, dirt, or water, it can cause not only decrease of output but also malfunctions of the fuel system. To avoid such a problem, drain fuel tank as described below.

1. Prepare the oil pan (capacity of 2 L [0.5 U.S. gal.] or more) under the drain cock of fuel tank.
2. Open the drain cock of fuel tank and drain fuel at least 1 to 2 liters.
3. Make sure that water and particles of foreign material discharged with fuel. Close the drain cock.

Note: If the specification of fuel tank differs from the contents of this operation manual, follow the manufacturer's operation manual.

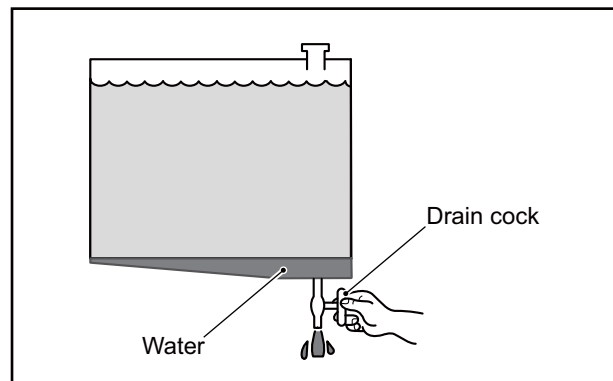


Fig. 8-4 Fuel Tank - Drain Water

## Water Separator - Drain Water

1. Prepare a plate, and place it under the drain cock of water separator.
2. Open the drain cock, and drain water in the water separator.
3. Close the all drain cocks after draining.

Note: If the specification of water separator differs from the contents of this operation manual, follow the manufacturer's operation manual.

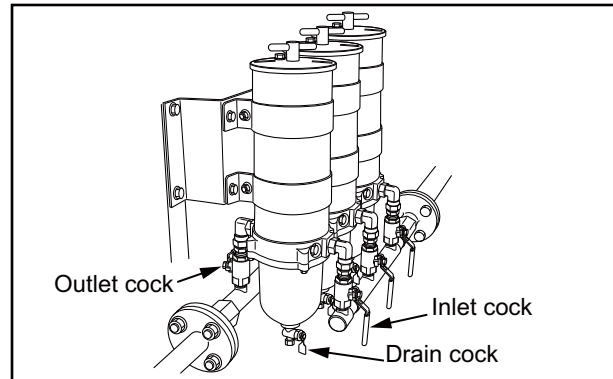


Fig. 8-5 Water Separator - Drain Water

## Water Separator Element - Replace

**WARNING**

Open the inlet valve slowly to prevent overflowing fuel. Wrap a cloth around the water separator before the fuel may spill.

1. Close the inlet cock and outlet cock.
2. Turn the T-handle, and remove the water separator cover.
3. Open the drain cock, and drain fuel in the water separator.
4. Close the all drain cocks after draining.
5. Replace the element with a new one.
6. Fill the water separator with fuel.
7. Attach the water separator cover, and tighten the T-handle.
8. Open the inlet cock and outlet cock.
9. After replacing the element, open the fuel feed valve to the engine, then bleed air from the fuel system.

Note: (a) For bleeding fuel system, refer to ["Fuel System - Bleed Air" \(3-2\)](#).

- (b) If the specification of water separator differs from the contents of this operation manual, follow the manufacturer's operation manual.

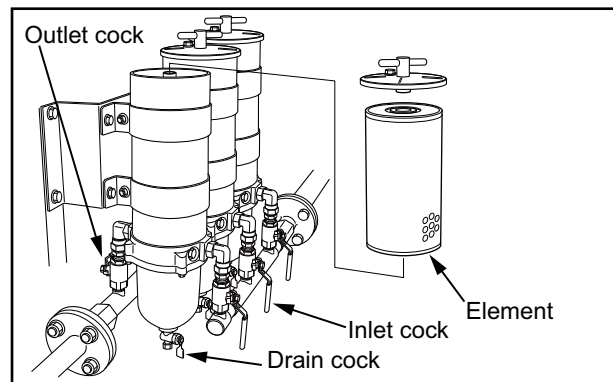


Fig. 8-6 Water Separator Element - Replace

## Gauze Filter - Clean

If the gauze filter is clogged, the fuel supply becomes insufficient, resulting in decrease in power output or engine stall.

1. Remove the eye bolt at the inlet port of fuel feed pump.
2. Using a screw driver, remove the gauze filter that is fitted inside the eye bolt.
3. Soak the gauze filter in the fuel, and clean it with a brush.
4. After cleaning, install the gauze filter into the eye bolt using a screw driver.
5. Install the eye bolt to the fuel feed pump.
6. Bleed the air from the fuel filter.

Note: For bleeding the fuel filter, refer to "[Fuel Filter - Bleed Air](#)" (3-2).

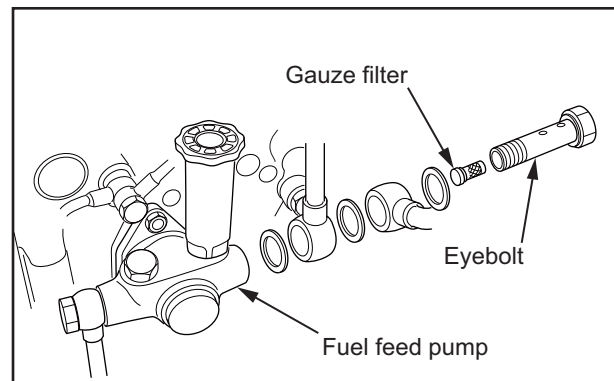


Fig. 8-7 Gauze Filter - Clean

## Fuel Filters (Wire-element Type) - Drain Water

### ⚠ WARNING

When working around fuel, make sure there are no open flames, heaters or other fire hazards. Wipe off any spilled fuel completely. Spilled fuel can ignite and cause a fire.

### CAUTION

Check that the thread of the filter case and drain plug, or sealing washers. If damaged, replace them with new ones.

1. Close the fuel feed valve to cut off the fuel supply to the engine.
2. Prepare a drip pan, and place it under the fuel filters.
3. Turn the handle at the top of the fuel filter to remove dust and other particles from the element.
4. Remove the drain plug and the sealing washer to discharge sediment from the filter.
5. Reinstall the drain plug and the sealing washer.
6. Bleed air from the fuel filter.

Note: For bleeding the fuel filter, refer to "[Fuel Filter - Bleed Air](#)" (3-2).

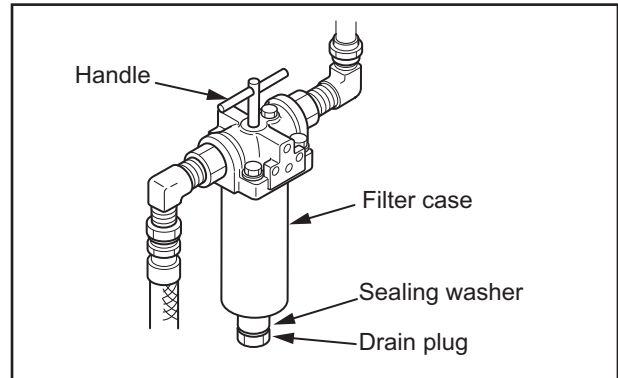


Fig. 8-8 Fuel Filters (Wire-element Type) - Drain Water

## Inside of Fuel Filters (Wire-element Type) - Clean

### ⚠ CAUTION

Check that the thread of the filter case and drain plug, or sealing washers. If damaged, replace them with new ones.

1. Close the fuel feed valve to cut off the fuel supply to the engine.
2. Clean the area around the fuel filters.
3. Prepare a drip pan, and place it under the fuel filters.
4. Drain fuel by removing the drain plug and the sealing washer.
5. Remove the filter case by loosening the mounting bolt at the top of the filter.
6. Remove dust and other particles from the element using the soft brush with diesel fuel.
7. Also clean inside of the case.
8. Reinstall the drain plug, the sealing washer and the filter case to the original position.
9. Bleed air from the fuel filter.

Note: For bleeding the fuel filter, refer to "[Fuel Filter - Bleed Air](#)" (3-2).

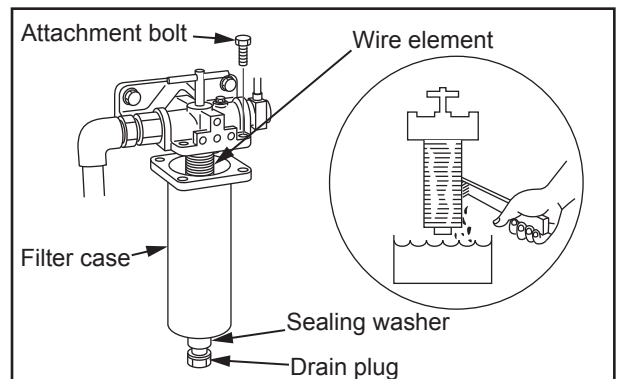


Fig. 8-9 Inside of Fuel Filters (Wire-element Type) - Clean



## Fuel Filter - Replace

1. Clean the area around the fuel filters.
2. Prepare a drip pan, and place it under the fuel filters.
3. Using a filter wrench, remove the fuel filters.
4. Wipe off fuel on the fuel filter cartridge mounting surface of the filter bracket with a waste cloth.
5. Check new fuel filters for proper seating of the gasket.

**WARNING**

Do not use a filter with the dented case. Filter damage or fuel leakage may occur and it can cause fire hazard.

6. Apply clean fuel to the gasket of the new fuel filter.
7. Install the fuel filter to the filter bracket. When the gasket contacts the mounting surface of the filter bracket, further rotate 3/4 to a full turn.

**CAUTION**

Do not use a filter wrench to install the fuel filter.  
Do not dent or scratch the fuel filter surfaces.

8. After installing the new fuel filter, bleed the fuel filter.

Note: For bleeding the fuel filter, refer to "[Fuel Filter - Bleed Air](#)" (3-2).

9. Start the engine and run it at idle speed for several minutes.
10. Make sure that there is no fuel leak during the engine operation. If fuel leakage is found, loosen the fuel filter and check the gaskets for damage. If there is no damage, retighten the fuel filter.

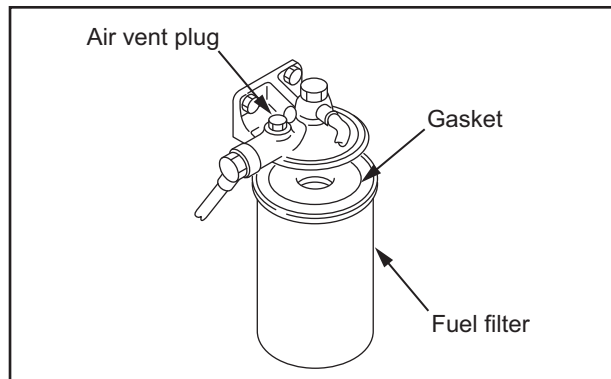


Fig. 8-10 Fuel Filter - Replace

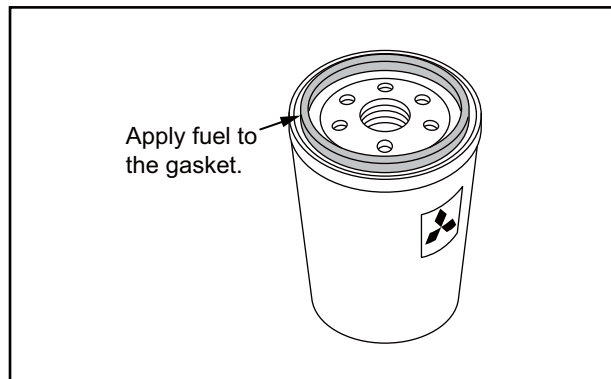


Fig. 8-11 Fuel Filter

## Fuel Control Link Ball Joint - Inspect

Check ball joint in the fuel control link for play. If the amount of play is 0.1 mm [0.004 in.] or more, replace the ball joint with the new one.

### CAUTION

If the sealed ball joints are found loosened, contact a dealer of Mitsubishi Heavy Industries, Ltd. If the seal on the ball joint is broken, the warranty is invalidated.

If the ball joints are integrated in the control link, replace the control link when the ball joints have loosened. When installing ball joints, be sure to tighten the nuts firmly.

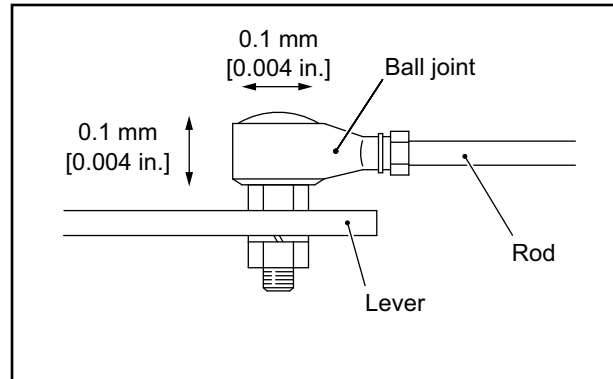


Fig. 8-12 Ball Joints For Looseness - Inspect

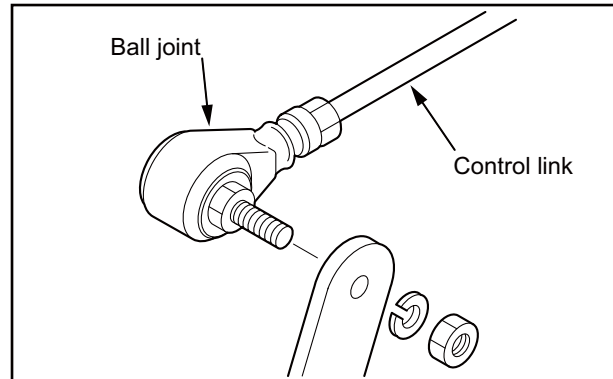


Fig. 8-13 Fuel Control Link - Remove

## Fuel Pipe - Inspect

### High Pressure Fuel Injection Pipe and Clamp Seat - Inspect and Replace

#### Visual Inspection in Every 2000 Service Hours

Check clamp seat cracks and wear, or high pressure fuel injection pipe wear. If defective, replace the clamp seat with a new one. Replace the high pressure fuel injection pipe with a new one as needed.

#### In Every Major Overhaul

Replace clamp seat with a new one. Also, check high pressure fuel injection pipe wear. If defective, replace the high pressure fuel injection pipe with a new one.

#### In Every Other Major Overhaul

Replace all clamp seats and high pressure fuel injection pipes with new ones.

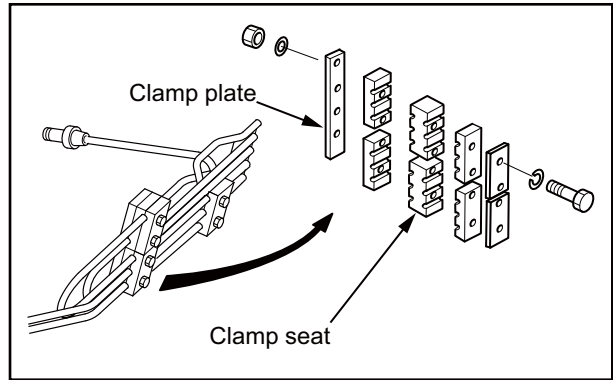


Fig. 8-14 High Pressure Fuel Injection Pipe and Clamp Seat - Inspect and Replace

### Low Pressure Fuel Pipe and Clip - Inspect

#### Visual Inspection in Every 2000 Service Hours

Loosen clamp fixing bolt and check clip wear and pipe metal contact with clamp. If defective, replace the pipe assembly with a new one.

#### In Every Other Major Overhaul

Replace the pipe assembly with a new one.

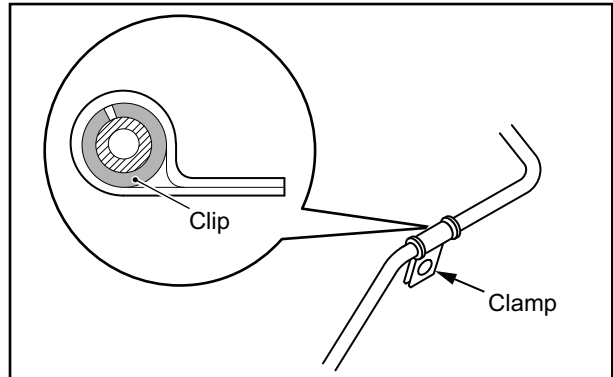


Fig. 8-15 Low Pressure Fuel Pipe and Clip - Inspect

## Lubricating System

### Engine Oil, Oil Filter and Bypass Oil Filter - Replace

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 **CAUTION**

When draining engine oil, check that the oil temperature is low.

When draining oil or changing the oil filter, wear gloves. Hot engine oil and parts may cause burns.

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**CAUTION**

Do not dump waste oil. It is forbidden by law. For disposal of waste oil, consult a dealer of Mitsubishi Heavy Industries, Ltd.

Change the engine oil, oil filter and bypass oil filter at the same time.

Also checking and analyzing the oil properties is recommended when changing the engine oil.

Do not reuse the oil filter element, as it is a paper type. When replacing filters, always replace gasket with new ones.

---

### Engine Oil - Drain

After stopping the engine, drain the engine oil from the engine oil drain port of oil pan.

## Engine Oil - Refill

### **CAUTION**

Refilling engine oil must be specified level. If the refilling oil goes over the high marks on the oil level gauge, engine oil may blow out.

1. Remove the cap from the oil filler.
2. Fill the engine oil pan with specified engine oil to the specified level.

Note: For engine oil, refer to "ENGINE OIL" (5-1). For engine oil capacity, refer to "MAIN SPECIFICATIONS" (12-1).

3. Check the oil level in the oil pan as follows:
4. Pull out the oil level gauge and wipe it clean with a waste cloth.
5. Insert the oil level gauge fully into the oil level gauge guide and then pull it out again.
6. The proper oil level is between the high and low marks on the oil level gauge.  
If the engine oil goes over the high marks on the oil level gauge, open the engine oil drain valve to drain oil. If the engine oil is low, refill the specified engine oil.
7. Install the oil filler cap after adding engine oil.
8. Check the oil pan and other area for oil leaks. Repair the oil leakage if any.
9. While pulling the stop lever, rotate the crankshaft for approx. 10 seconds to turn on the starter. Stop the operation for 1 minute, then, repeat the operation two or three times. Circulate engine oil to each engine parts.

Note: Prepare for the cooling system.

10. Check the oil level with the oil level gauge again, and add oil to the specified level.

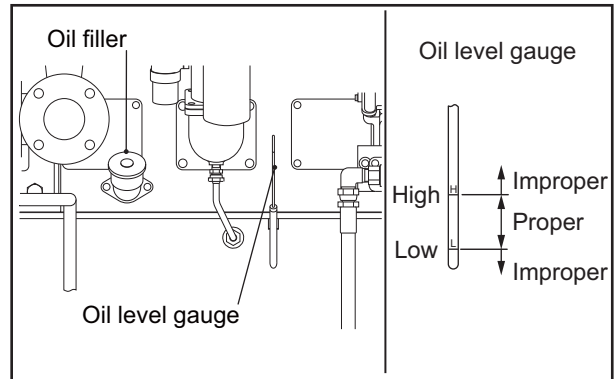


Fig. 8-16 Oil Filler and Oil Level Gauge

## Oil Filter and Bypass Oil Filter - Replace

### WARNING

Do not use a filter with the dented case. Filter damage or oil leakage may occur and it can cause fire hazard.

### CAUTION

Do not use a filter wrench to install the oil filter and bypass oil filter.

Do not dent or scratch the oil filter surfaces.

1. Clean around the oil filters.
2. Prepare drip pans, and place them under oil filters and a bypass oil filter.
3. Using a filter wrench, remove oil filters and a bypass oil filter.

Note: Disconnect the removed oil filters and a bypass oil filter, and check elements for metal particles. If metal particles are found, contact a dealer of Mitsubishi Heavy Industries, Ltd.

4. Thoroughly wipe off oil on the oil filter mounting surface of the filter bracket with a cloth.
5. Check the new oil filters and a bypass filter for proper seating of gasket.
6. Apply clean engine oil to gasket.
7. Install oil filters and a bypass oil filter to the filter bracket. When the gasket contacts the mounting surface of the filter bracket, further rotate 3/4 to a full turn.

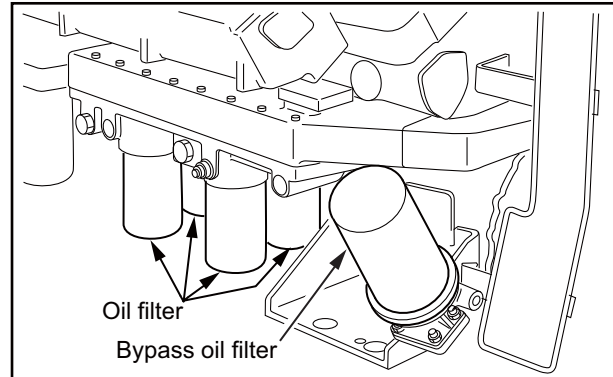


Fig. 8-17 Oil Filter and Bypass Oil Filter - Replace

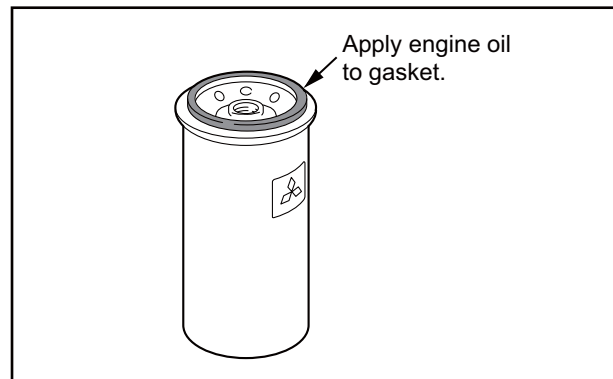


Fig. 8-18 Oil Filter

## Engine Oil for Mixing of Fuel and Water - Inspect

### CAUTION

If the engine continues to operate with engine oil mixed with fuel or water, the engine oil viscosity decreases and this can cause serious accidents such as seizing of bearings.

Sample 1 to 2 L [0.26 to 0.53 U.S. gal.] of engine oil, and check for abnormal odor and discoloration to determine the mixing of fuel and water.

If fuel is mixed with the engine oil, the oil will smell like fuel.

If water is mixed with the engine oil, the oil will be milky white.

If fuel or water is detected in the engine oil, find the cause of the problem, and repair. If the problem cannot be corrected easily, contact a dealer of Mitsubishi Heavy Industries, Ltd.

## Governor Oil Filter - Change

### WARNING

When draining oil or changing the oil filter, wear gloves. Hot engine oil and parts may cause burns.

1. Prepare a drip pan and place it under the governor oil filter.
2. Using a filter wrench, remove the governor oil filter.
3. Prepare a new governor oil filter, and clean the gasket.
4. Apply clean engine oil to the gasket.
5. Screw the governor oil filter onto the filter bracket by hand.
6. Remove the plug from filter bracket, and pour engine oil until the filter is filled with out.
7. Install the plug after refilling engine oil.
8. Operate the priming pump or wing pump to circulate engine oil. Check to make sure oil does not leak from filter mounting surface. If oil leaks, tighten the filter again.

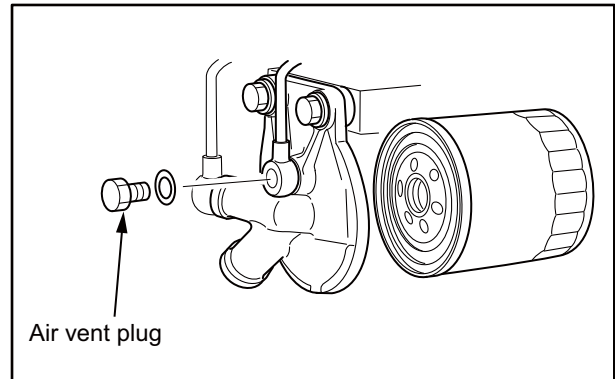


Fig. 8-19 Governor Oil Filter - Change

## Oil Pipe - Inspect

### Oil Pipe and Clip - Inspect and Replace Visual Inspection at Overhaul

Loosen clamp fixing bolt and check clip wear and pipe wear. If defective, replace the pipe assembly with a new one.

### In Every Other Major Overhaul

Replace the pipe assembly with a new one.

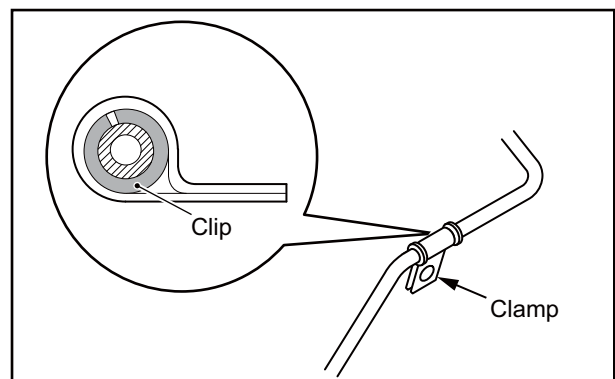


Fig. 8-20 Oil Pipe and Clip - Inspect and Replace

# Cooling System

## Coolant - Change

### CAUTION

The service life of LLC is 2 years. Be sure to change coolant at least once every 2 years.

### Radiator Cap - Open/Close

#### WARNING

When using the engine with radiator cooling system, remove the radiator cap only after the engine has cooled to the room temperature. Place a waste cloth over the cap, and loosen the cap about a half-turn or stand the lever to the upright position to release internal pressure. Opening the radiator cap of coolant expansion tank while the engine is hot causes steam and hot coolant to blow out and can result in skin burns.

Note: If the specification of radiator differs from the contents of this operation manual, follow the manufacturer's operation manual.

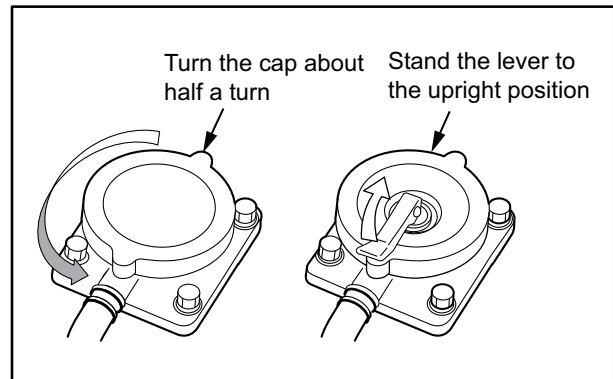


Fig. 8-21 Radiator Cap

### Coolant - Drain

1. When draining coolant immediately after engine operation, idle the engine in low gear for 5 to 6 minutes to lower the coolant temperature to 70 to 80 °C [158 to 176 °F].
2. Open the coolant inlet.
3. Place coolant receiving cans under the drain cocks and plugs, and open the coolant drain cocks and plugs to drain the coolant.

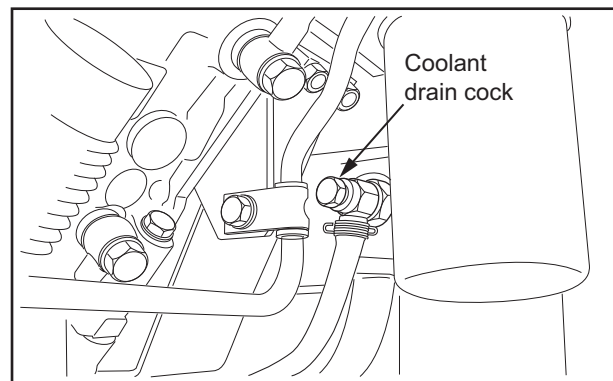


Fig. 8-22 Coolant Drain Cock (Engine)



## Cooling System - Clean

### CAUTION

Clean the cooling system when operating the engine or heat exchange equipment first time, or restarting the engine after storage with coolant drained.

1. Close coolant drain cocks and plugs.
2. Pour in a cleaning solution (a solution that is non-corrosive to rubber and metals) in the cooling system, and operate the engine at 800 to 900 min<sup>-1</sup> for about 15 minutes, then drain the cleaning solution.
3. Close coolant drain cocks and plugs.
4. Pour in fresh water, and operate the engine at 800 to 900 min<sup>-1</sup> for about 10 minutes.  
Repeat the above rinsing steps until the draining water becomes clear and clean.

## Coolant - Refill

### CAUTION

Always use the coolant having the same concentration.

1. Close coolant drain cocks and plugs firmly.
2. Open the coolant filler and add a mixture of water and coolant having the specified concentration.  
Note: Determine the amounts of LLC and water to be added by using the LLC concentration chart.  
For the coolant, refer to "COOLANT" (6-1). For the coolant capacity, refer to "MAIN SPECIFICATIONS" (12-1).
3. Check the heat exchange equipment and other parts for coolant leaks. If a coolant leak is found, repair it.
4. When coolant reaches the full level, close the coolant filler securely.
5. While pulling the manual stop lever, rotate the crankshaft for approx. 10 seconds using the starter. Stop the operation for 1 minute, then, repeat the operation two or three times to bleed the cooling system.  
Note: Prepare for the engine oil system.
6. Check the level of coolant.

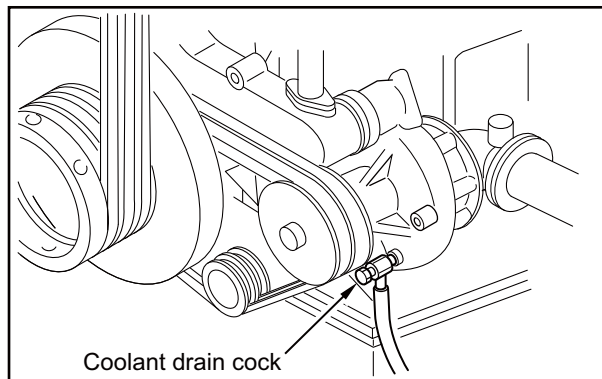


Fig. 8-23 Coolant Drain Cock (Water Pump)

## Radiator Fins - Check and Clean

**CAUTION**

When handling compressed air, wear safety goggles, a hardhat, gloves and other necessary protective gear. Working without wearing proper protective gear could result in serious injuries.

Check the radiator fins for holes and cracks.

To clean the radiator fins, blow compressed air from the opposite direction of the normal air flow.

Note: If the specification of radiator differs from the contents of this operation manual, follow the manufacturer's operation manual.

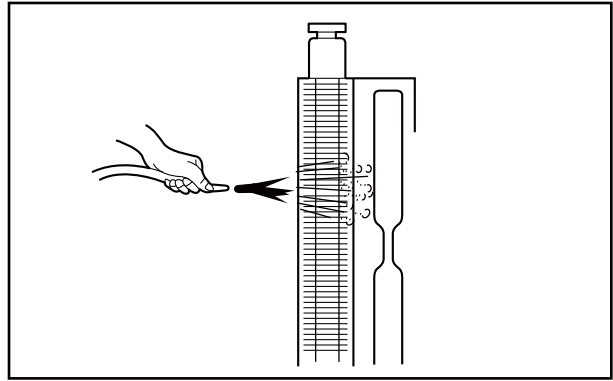


Fig. 8-24 Radiator fins - Clean

## Inlet and Exhaust Systems

### Turbocharger - Inspect

**CAUTION**

Check the turbocharger when the engine is cold. Also, make sure that the compressor wheel is not rotating before inspecting the turbocharger.

**CAUTION**

If the color of the exhaust gas is abnormal, also inspect the turbocharger.

Disconnect the pipe from the air inlet side. Hold the compressor wheel nut by hand and turn the wheel to check for looseness or rotation smoothness. Replace the turbocharger if any abnormal movement is found.

Note: When removing and inspecting turbocharger, contact a dealer of Mitsubishi Heavy Industries, Ltd.

Also, inspect that there is any discoloration or damage on the compressor wheel fins.

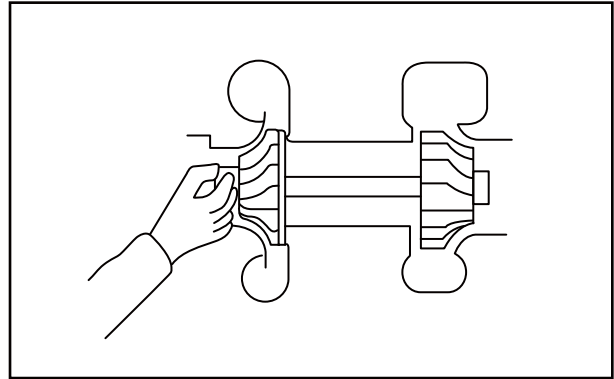


Fig. 8-25 Turbocharger - Inspect

### Exhaust Muffler - Drain Water

**CAUTION**

The exhaust muffler is very hot immediately after operation. Never touch the exhaust muffler by hand. Work must be conducted after the exhaust muffler cools at the room temperature.

Remove the drain plug and allow water to drain from the exhaust muffler.

Note: If the specification of exhaust muffler differs from the contents of this operation manual, follow the manufacturer's operation manual.

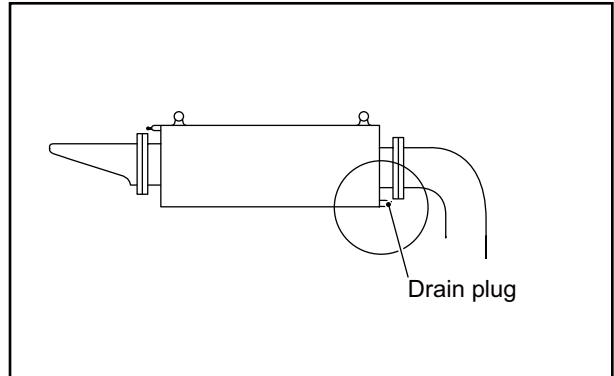


Fig. 8-26 Draining Water From the Exhaust Muffler

## Air Cleaner - Check for Clogging

1. Check the air cleaner indicator for the element clogging.
2. If the element is clogged, the red signal mark will be displayed.
3. Immediately clean or replace the air cleaner element when the signal turns red.

Note: (a) For cleaning of the air cleaner element, refer to "Air Cleaner Element - Clean, Check and Replace" (8-22).

- (b) If the specification of air cleaner differs from the contents of this operation manual, follow the manufacturer's operation manual.

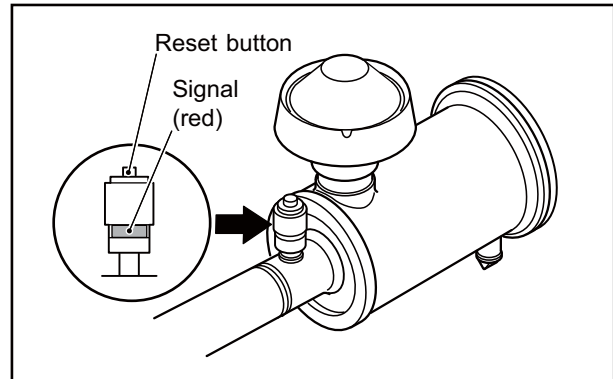


Fig. 8-27 Air Cleaner - Check for Clogging

## Air Cleaner Element - Clean, Check and Replace

### CAUTION

When handling compressed air, wear safety goggles, a dust mask, a hardhat, gloves and other necessary protective gear. Working without wearing proper protective gear could result in serious injuries.

### CAUTION

Never perform maintenance on the air cleaner while the engine is running. Servicing the pre-cleaner while the engine is running can cause particles of foreign material to enter the engine and result in rapid wear of parts, leading to a shorter service life of the engine. Never tap, hit or wash the air cleaner element.

If defects such as cuts, pinholes or local wear are found in the element, or if the air cleaner indicator shows a red sign soon after the cleaned element is installed, change it for new one. Remove the air cleaner slowly to prevent foreign materials accumulated on the element from falling off.

After removing the air cleaner, immediately cover the air inlet with plastic sheet or similar means to prevent foreign materials from entering the engine.

1. Remove the air cleaner cap and wing bolt.
2. Remove the air cleaner element from the body.
3. Blow compressed air (0.69 MPa {7 kgf/cm<sup>2</sup>} [100 psi] or lower) onto the inside surface of the element to remove foreign materials.
4. To remove dust stuck on the air cleaner element, blow dry compressed air onto the outside surface from a distance.

Blow compressed air on the inside surface toward the outside along the pleats. Then, blow compressed air on the outside and inside surface again.

5. After cleaning, hold the air cleaner element near a light bulb to illuminate the inside, to check for defects such as cuts, pinholes or local wear.
6. If any defect is found, replace the air cleaner element with a new one.
7. Reassemble the air cleaner element as it was.

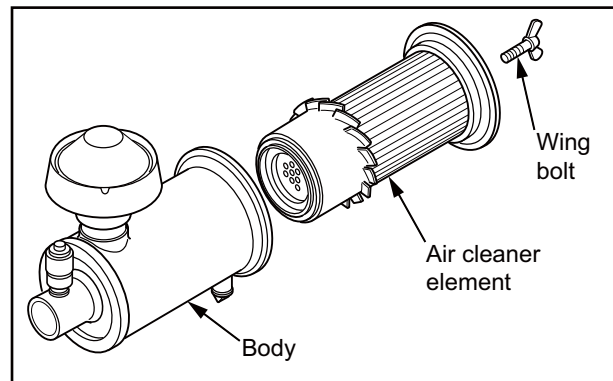


Fig. 8-28 Air Cleaner Element - Remove

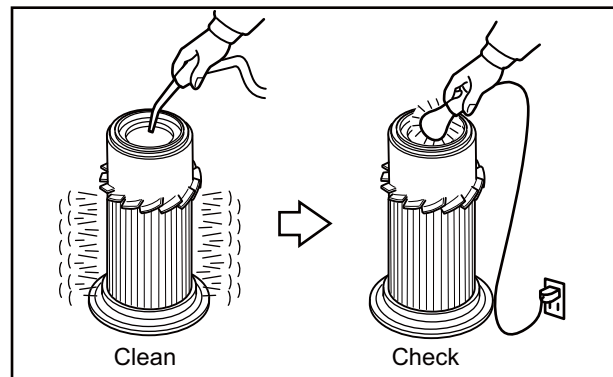


Fig. 8-29 Air Cleaner Element - Clean and Check

8. After cleaning or replacing the air cleaner element, press the reset button to reset the indicator.

Note: If the specification of air cleaner differs from the contents of this operation manual, follow the manufacturer's operation manual.

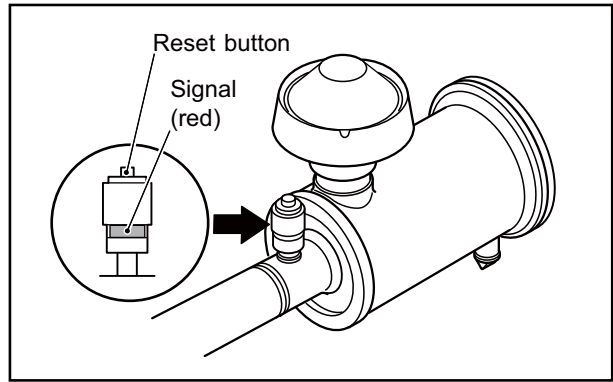


Fig. 8-30 Air Cleaner - Check for Clogging

# Electrical System

## Battery - Check

**CAUTION**

If battery electrolyte is spilled on your skin or clothes, flush immediately with plenty of water. If battery electrolyte get into your eyes, flush them immediately with plenty of water and then get medical attention.

Do not use open flames or other fire hazards near the battery. When handling the battery, be careful of sparks generated by accidental shorting.

Note: If the specification of battery differs from the contents of this operation manual, follow the manufacturer's operation manual.

### Battery Electrolyte Level - Inspect

Battery electrolyte evaporates during use and the electrolyte level gradually decreases. The proper electrolyte surface level is between the LOWER LEVEL and UPPER LEVEL lines.

For the battery without level lines, the proper electrolyte surface level is about 10 to 15 mm [0.39 to 0.59 in.] above the top of the plates.

If the electrolyte level is low, remove the caps and add distilled water to the proper level.

Note: When adding distilled water, add little by little.

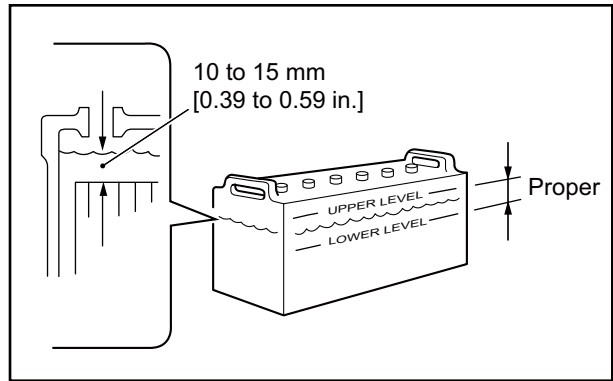


Fig. 8-31 Battery Electrolyte Level - Inspect

### Specific Gravity of Battery Electrolyte - Check

If the specific gravity measured at 20°C [68°F] is lower than 1.22, then charge the electrolyte.

Table 8-4 Specific gravity of electrolyte

| Specific gravity at 20 °C [68 °F] | Condition     | Remedy |
|-----------------------------------|---------------|--------|
| From 1.26 to 1.28                 | Fully charged | -      |
| From 1.22 to 1.26                 | Charged       | Charge |
| Less than 1.22                    | Discharged    | Charge |

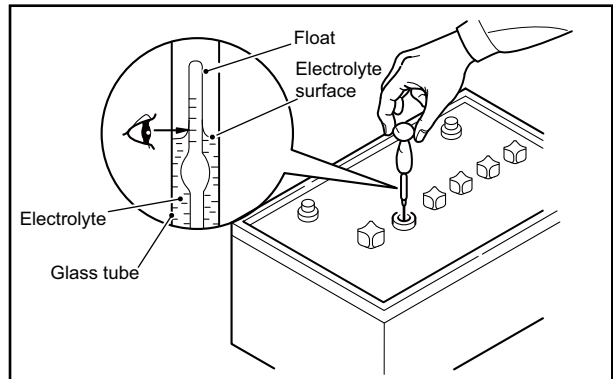


Fig. 8-32 Specific Gravity of Battery Electrolyte - Check

## Starter - Inspect

Visually check the starter for damage.

Note: If the starter is defective, consult a dealer of Mitsubishi Heavy Industries, Ltd.

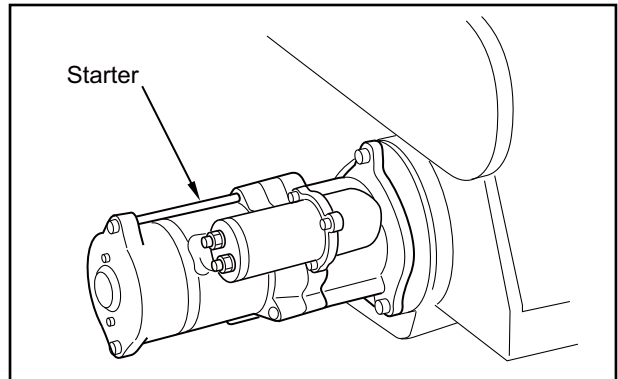


Fig. 8-33 Starter - Inspect

## Alternator - Inspect

Visually check the alternator for damage.

Remove the belt, and turn the pulley by hand to make sure that it rotates smoothly.

Note: If the alternator is defective, consult a dealer of Mitsubishi Heavy Industries, Ltd.

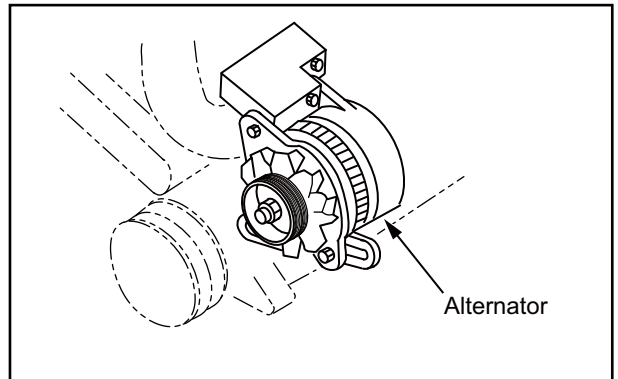


Fig. 8-34 Alternator - Inspect



## Air Starter System

### Air Strainer - Drain Water and Clean

#### **CAUTION**

When opening the drain valve of air strainer, open it slowly. High pressured air is in the pipe only even if the air tank valve is closed. Do not open it suddenly.

1. Close the handle for starting of the air tank.
2. Remove the drain plug of air starter strainer and drain water from the air strainer.
3. Remove the cap and remove the filter from the cap.
4. Clean the filter with diesel fuel, then blow compressed air to dry.
5. Reassemble the air strainer as it is.
6. Open the starting air handles slowly.

Note: If the specification of air tank strainer differs from the contents of this operation manual, follow the manufacturer's operation manual.

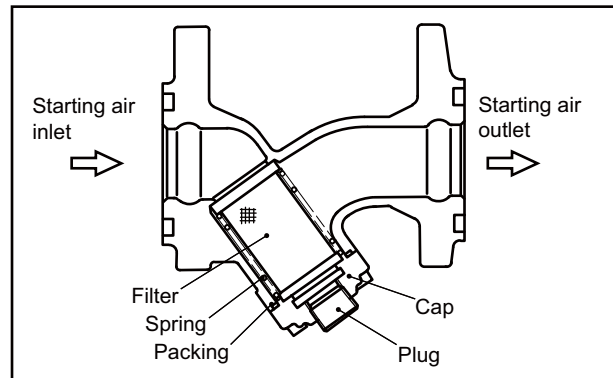


Fig. 8-35 Air Strainer - Drain Water and Clean

### Air Tank - Drain Water

#### **CAUTION**

There are 2 places for draining water in the air tank: drain valve on the top of air tank, and drain handle on the bottom of drain separator.

1. Open the drain valve slowly, and check that water in the tank is drained from drain pipe.
2. After water is drained and the air is discharged in the tank, tighten the drain valve firmly.
3. Loosen the drain handle on the bottom of drain separator. Check that water in the drain separator is discharged from the drain pipe.
4. Close the drain handle after draining water firmly.

Note: If the specification of air tank differs from the contents of this operation manual, follow the manufacturer's operation manual.

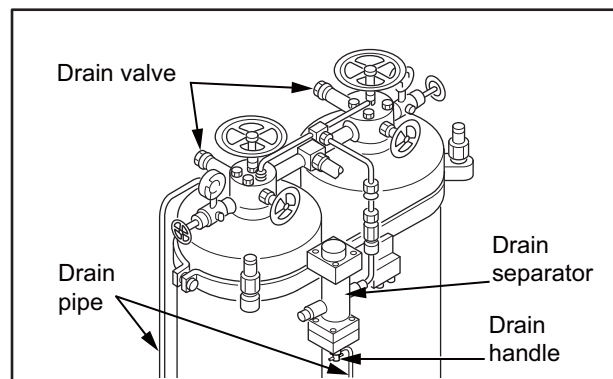


Fig. 8-36 Air tank - Drain water

## Air Tank - Inspect Safety Valve Operation

1. Open the inlet valve of air tank and air pressure gauge valve.
2. Fill air with the air compressor.
3. Check to make sure the safety valve opens to relieve pressure when the air pressure value in the tank is over the standard.  
Pressure in the air tank: 2.94 MPa{30 kgf/cm<sup>2</sup>} [427 psi]  
Safety valve operating pressure (open): 3.14 MPa {32 kgf/cm<sup>2</sup>} [455 psi]  
Safety valve operating pressure (close): 2.84 MPa {29 kgf/cm<sup>2</sup>} [412 psi]
4. If defective in safety valve operation, contact a dealer of Mitsubishi Heavy Industries, Ltd.

Note: If the specification of air tank differs from the contents of this operation manual, follow the manufacturer's operation manual.

# Chapter 9 LONG-TERM STORAGE

## CAUTION

If the engine has been left unattended for 3 months or more, the internal engine parts can rust, and that may cause damage to the engine.

When storing the engine for an extended period of time, be sure to follow the steps below.

## Storing the Engine in an Inoperable Condition for 3 Months or More

### Preparation for Storage

1. Drain the engine oil in-use, and pour rust-preventive oil (NP-10-2).
2. Prepare a fuel mixture containing 50% rust-preventive fuel (NP-9), and fill the fuel tank with it.
3. Run the engine at low idling speeds for 5 to 10 minutes.
4. Immediately before stopping the engine, spray volatile corrosion inhibitor (VCI) through the inlet port to prevent rust on the air intake system.
5. Stop the engine, and drain the fuel mixture from the fuel tank.
6. Apply rust-preventive oil (NP-3) liberally on the exposed sections of mechanical surfaces.
7. Seal the air inlet, exhaust outlet, breather and other openings with an adhesive cloth tape.
8. Loosen the belt.
9. Wrap adhesive cloth tape on the terminals of the starters and alternator, and seal the openings. Cover these sections with polyethylene sheet or processed polyethylene paper, and place desiccants in the polyethylene covers.
10. Disconnect the cables from the battery terminals, and charge the battery. Clean the terminals, apply a thin coat of grease to the terminals, and store the battery in a cool and dry room.
11. Cover the whole engine.

Note: (a) Store the engine in a well-ventilated and dried indoor area.

(b) It is not necessary to drain coolant since it contains LLC. (LLC must be specified concentration. For LLC concentration, refer to "[LLC Concentration](#)" (6-6).)

(c) Post a sign at an easily noticeable place to warn that the fuel tank must be filled with fuel before operating the engine for the first time after storage.

### Recommended Rust-preventive Oil and Corrosion Inhibitor

Table 9-1 Recommended Rust-preventive Oil and Corrosion Inhibitor

| JIS No. | Recommended product   | Usage   |
|---------|---|---|
| K2246   | NP-3<br>Nippon Oil Corporation<br>Anti Rust P-1600                          | Prevention of rust on exposed machined surfaces |
|         | NP-9<br>Nippon Oil Corporation<br>Anti Rust P-2400                          | Prevention of Rust in Fuel System               |
| Z1519   | -<br>Ryokou Chemical Co., Ltd.<br>VCI Diana ND volatile corrosion inhibitor | Prevention of rust in air intake system         |

### Maintenance During Storage

Charge the battery once a month. Check the battery electrolyte for proper level and then charge the battery.

## Using the Engine After Storage

1. Remove the cover from the engine.
2. Connect a fully charged battery.
3. Remove the cover from the starter and alternator.
4. Adjust the belt tension.

Note: Refer to "[Belt and Belt Tension - Inspect and Adjust](#)" (8-2) for belt tension adjustment.

5. Remove sealing tapes from the openings of the engine.
6. Connect pipes.
7. Fill the fuel tank with fuel, and bleed air from the fuel system.

Note: For bleeding fuel system, refer to "[Fuel System - Bleed Air](#)" (3-2).

8. Check the engine oil and coolant level.
9. Inspect the whole engine.
10. Remove the rocker covers, and lubricate the valve mechanisms.
11. While pulling the manual stop lever, crank the engine for approx 10 seconds using the starter. Stop the operation for approx 1 minute, then, repeat the operation two or three times.
12. After starting up the engine, make sure the engine oil pressure rises.
13. Conduct a warm-up operation for a sufficient duration to fit each part.

Note: For starting the engine, refer to "[Start](#)" (3-12).

14. Apply load and increase the engine speed to the rated speed.

## Storing the Engine in an Operable Condition for 3 Months or More

When the engine is not operated during storage of 3 months or more, internal engine parts can rust and lose oil film. As a result, the engine can seize when it is started after storage. To prevent such a risk, the engine must be operated periodically during storage.

### Operating the Engine for Maintenance

Operate the engine for maintenance at least once a month as described below.

1. While pulling the manual stop lever, crank the engine for approx 10 seconds using the starter. Stop the operation for approx 1 minute, then, repeat the operation two or three times.
2. After starting up the engine, make sure the engine oil pressure rises.
3. Operate the engine about 5 to 10 minutes under no load as the maintenance operation.

Note: For starting the engine, refer to "[Start](#)" (3-12).

## Lifting the Engine

**WARNING**

To lift the engine, use wire ropes, shackles and slings capable of supporting the weight of the engine.

Attach the wire rope to the hangers provided on the engine using a correct sling.

Keep the engine balanced during lifting by considering the engine's center of gravity.

The hangers equipped with the engine is designed for lifting the engine only. When mounting generator on the engine, use the special hanger of common bed.

Hangers of engine cannot be used.

When mounting marine gear on the engine, be sure not to apply the load on the hangers of engine only. Keep the angle formed by slings attached to hangers within 60°. If the angle exceeds this limit, excessive load could be imposed on the hangers and this could damage the hangers and result in a serious accident. Attach wire ropes to the hangers after removing the pipe cover and the insulator near the hangers. To prevent wire ropes from contacting the engine, use a cloth or other soft padding.

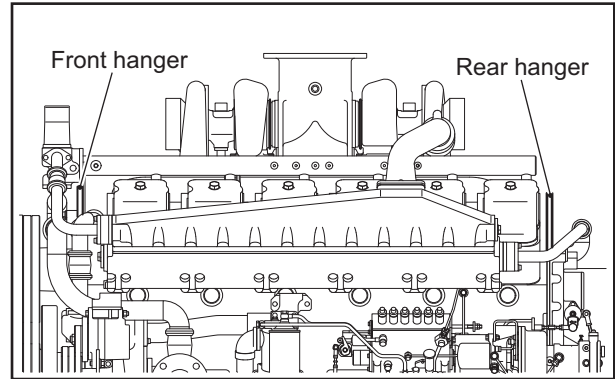


Fig. 10-1 Hanger

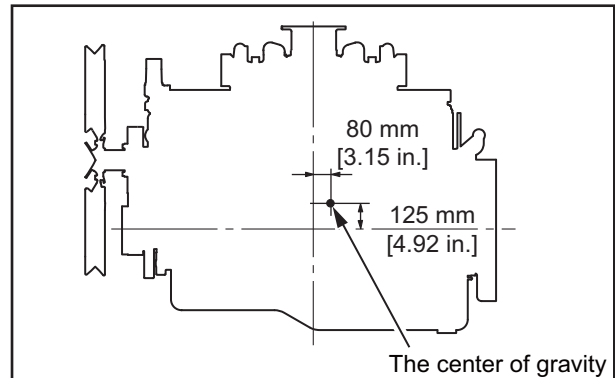


Fig. 10-2 Engine's center of gravity (standard specification)

## General Precautions

### Contact a Dealer of Mitsubishi Heavy Industries, Ltd. for Repair Service

Repairing a malfunctioning engine may require special equipments or involve potentially dangerous work, except for relatively simple procedures such as the change and addition of fuel, engine oil and coolant. When repairing malfunctioning engine, contact a dealer of Mitsubishi Heavy Industries, Ltd.

### Considerations Before Work

Before troubleshooting, consider possible causes of the problem and try to find out if the same problem have occurred in the past.

Check the parts that may be causing the problem in the most efficient order.

When disassembling a component, pay close attention to the disassembly sequence so that you can reassemble the component in reverse order of disassembly.

### Cautions Against Contamination

Dust and foreign materials are the most common cause of rapid wear of parts.

When disassembling a component, take measures to prevent dust and foreign materials from entering the component being disassembled.

### Cautions Regarding Parts Handling

Handle parts carefully.

When replacing parts, use only genuine parts by referring to the parts catalogue.

### Safety Work

Be sure to use wrenches of the correct size. Using a wrench of the wrong size can cause not only nut damage but also the personal injury.

Use correct tools and perform apposite work with the most careful attention.

Be sure to accurately estimate the weight of the part being dismantled. If the removed part is much heavier than you have estimated, it may fall down during lifting and can result in the damage to the parts or personal injury.

## Case of Problems, and Conceivable Causes and Remedies

### The Starter Does Not Crank or Cranks Slowly, Resulting in Start Failure

Table 11-1 The Starter Does Not Crank or Cranks Slowly, Resulting in Start Failure

| Cause              |  | Remedies  |
|--------------------|--|---|
| Electrical system  | Faulty wire connection                 | <ul style="list-style-type: none"> <li>♦Check the DC fuse.</li> <li>♦Check wiring connection between battery, starter and starter switch</li> </ul>                                   |
|                    | Insufficiently charged battery         | <ul style="list-style-type: none"> <li>♦Check alternator. (<a href="#">Refer to P8-25</a>)</li> <li>♦Check and adjust belt. (<a href="#">Refer to P8-2</a>)</li> </ul>                |
|                    | Faulty battery                         | <ul style="list-style-type: none"> <li>♦Check specific gravity of battery electrolyte. (<a href="#">Refer to P8-24</a>)</li> <li>♦Charge battery</li> <li>♦Change battery.</li> </ul> |
|                    | Faulty starter or starter relay        | <ul style="list-style-type: none"> <li>♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>  |
| Lubricating system | Oil viscosity too high                 | <ul style="list-style-type: none"> <li>♦Use appropriate engine oil. (<a href="#">Refer to P5-1</a>)</li> </ul>  |
|                    | Excessive oil                          | <ul style="list-style-type: none"> <li>♦Check amount of engine oil and lubrication system. (<a href="#">Refer to P3-9</a>)</li> </ul>   |
| Basic engine       | Rapid wear of sliding parts, or locked | <ul style="list-style-type: none"> <li>♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>  |

Note: The table above also include the parts Mitsubishi Heavy Industries, Ltd. does not supply. For the parts Mitsubishi Heavy Industries, Ltd. does not supply, inspect and maintain them following the manufacturer's operation manual.

## The Starter Cranks, but the Engine Does Not Start

Table 11-2 The Starter Cranks, but the Engine Does Not Start

| Cause             |   | Remedies   |
|-------------------|---|--|
| Fuel system       | Run out of fuel, blocked pipe                   | <ul style="list-style-type: none"> <li>•Inspect fuel tank, supply fuel, bleed air. (<a href="#">Refer to P8-6</a>)</li> <li>•Check fuel pipes, valves.</li> </ul>                                  |
|                   | Improper fuel property                          | <ul style="list-style-type: none"> <li>•Use appropriate fuel. (<a href="#">Refer to P4-1</a>)</li> <li>•Remove dust, water impurities. (<a href="#">Refer to P8-6</a>)</li> </ul>                  |
|                   | Fuel leakage in fuel pipes and injection pipes. | <ul style="list-style-type: none"> <li>•Check faults and retighten fuel pipes and injection pipes.</li> <li>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>                      |
|                   | Clogged fuel filter                             | <ul style="list-style-type: none"> <li>•Inspect and replace fuel filter. (<a href="#">Refer to P8-10</a>)</li> <li>•Clean gauze filter. (<a href="#">Refer to P8-8</a>)</li> </ul>                 |
|                   | Faulty fuel feed pump                           | <ul style="list-style-type: none"> <li>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>   |
|                   | Faulty fuel injection pump                      | <ul style="list-style-type: none"> <li>•Check fuel injection pump rack stroke.</li> <li>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>  |
|                   | Faulty fuel injection nozzle                    | <ul style="list-style-type: none"> <li>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>   |
| Air intake system | Insufficient amount of air                      | <ul style="list-style-type: none"> <li>•Check turbocharger. (<a href="#">Refer to P8-20</a>)</li> <li>•Clean, inspect and replace air cleaner element. (<a href="#">Refer to P8-22</a>)</li> </ul> |
| Control system    | Faulty governor                                 | <ul style="list-style-type: none"> <li>•Fuel control link - Check (<a href="#">Refer to P3-9</a>)</li> <li>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>                       |
| Basic engine      | Low compression pressure                        | <ul style="list-style-type: none"> <li>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>   |

Note: The table above also include the parts Mitsubishi Heavy Industries, Ltd. does not supply. For the parts Mitsubishi Heavy Industries, Ltd. does not supply, inspect and maintain them following the manufacturer's operation manual.



## Output Decrease

Table 11-3 Output decrease

| Cause                     |                                     | Remedies   |
|---------------------------|-------------------------------------|--|
| Fuel system               | Improper fuel property              | •Use appropriate fuel. (Refer to P4-1)   |
|                           | Clogged fuel filter                 | •Inspect and replace fuel filter. (Refer to P8-10)<br>•Clean gauze filter. (Refer to P8-8)   |
|                           | Faulty fuel injection timing        | •Check fuel injection pump couplings.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
|                           | Improper amount of injected fuel    | •Check fuel injection pump rack stroke.<br>•Check left and right bank.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
|                           | Faulty fuel feed pump               | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
| Cooling system            | Overheat, overcooled                | •Check fan and heat exchange equipment.<br>•Check control system.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
| Inlet and exhaust systems | Insufficient amount of air          | •Check turbocharger. (Refer to P8-20)<br>•Clean, inspect and replace air cleaner element. (Refer to P8-22)<br>•Check intake air pressure and leakage of intake air.<br>•Check intake air temperature and ventilation device.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd. |
|                           | Increase resistance of exhaust air. | •Check turbocharger. (Refer to P8-20)<br>•Check exhaust pipes and silencer.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
| Basic engine              | Low compression pressure            | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
|                           | Faulty valve timing                 | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
|                           | Wear of sliding parts               | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
| Control system            | Faulty governor control             | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |

Note: The table above also include the parts Mitsubishi Heavy Industries, Ltd. does not supply. For the parts Mitsubishi Heavy Industries, Ltd. does not supply, inspect and maintain them following the manufacturer's operation manual.

## Exhaust Smoke is White or Blue

Table 11-4 Exhaust Smoke is White or Blue

| Cause              |                              | Remedies  |
|--------------------|------------------------------|---|
| Fuel system        | Improper fuel property       | ♦Check cetane index, and use appropriate fuel. ( <a href="#">Refer to P4-1</a> )  |
|                    | Faulty fuel injection timing | ♦Check fuel injection pump couplings.<br>♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
|                    | Uneven fuel injection        | ♦Check ignition noise, exhaust smoke temperature, left and right bank balance.<br>♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.        |
|                    | Faulty fuel injection nozzle | ♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
| Lubricating system | Combustion of engine oil     | ♦Check amount of engine oil and lubrication system. ( <a href="#">Refer to P3-9</a> )<br>♦Consult a dealer of Mitsubishi Heavy Industries, Ltd. |
| Cooling system     | Overcooled                   | ♦Check heat exchanger.<br>♦Check control system.<br>♦Thermostat - Inspect<br>♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.             |
| Basic engine       | Faulty valve timing          | ♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
|                    | Low compression pressure     | ♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |

Note: The table above also include the parts Mitsubishi Heavy Industries, Ltd. does not supply. For the parts Mitsubishi Heavy Industries, Ltd. does not supply, inspect and maintain them following the manufacturer's operation manual.

## Exhaust Smoke is Black or Charcoal

Table 11-5 Exhaust Smoke is Black or Charcoal

| Cause                     |                                     | Remedies   |
|---------------------------|-------------------------------------|--|
| Fuel system               | Improper fuel property              | •Use appropriate fuel. (Refer to P4-1)   |
|                           | Faulty fuel feed pump               | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
|                           | Faulty fuel injection pump          | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
|                           | Faulty fuel injection nozzle        | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
|                           | Faulty fuel injection timing        | •Check fuel injection pump couplings.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
|                           | Uneven fuel injection               | •Check ignition noise, exhaust smoke temperature, left and right bank balance.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
| Inlet and exhaust systems | Insufficient amount of air          | •Check turbocharger. (Refer to P8-20)<br>•Clean, inspect and replace air cleaner element. (Refer to P8-22)<br>•Check intake air pressure and leakage of intake air.<br>•Check intake air temperature and ventilation device.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd. |
|                           | Increase resistance of exhaust air. | •Check turbocharger. (Refer to P8-20)<br>•Check exhaust pipes and silencer.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
| Basic engine              | Low compression pressure            | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
|                           | Faulty valve timing                 | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
|                           | Wear of sliding parts               | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
| Control system            | Increase in load                    | •Check control system and governor controller.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |

Note: The table above also include the parts Mitsubishi Heavy Industries, Ltd. does not supply. For the parts Mitsubishi Heavy Industries, Ltd. does not supply, inspect and maintain them following the manufacturer's operation manual.

## Fuel Consumption is High

Table 11-6 Fuel Consumption is High

| Cause                     |   | Remedies   |
|---------------------------|---|--|
| Fuel system               | Faulty fuel injection nozzle                    | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
|                           | Faulty fuel injection timing                    | •Check fuel injection pump couplings.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
|                           | Improper fuel property                          | •Use appropriate fuel. ( <a href="#">Refer to P4-1</a> )   |
|                           | Fuel leakage in fuel pipes and injection pipes. | •Check faults and retighten fuel pipes and injection pipes.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
| Cooling system            | Overcooled                                      | •Check fan and heat exchanger.<br>•Check control system.<br>•Thermostat - Inspect<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
| Inlet and exhaust systems | Insufficient amount of air                      | •Check turbocharger. ( <a href="#">Refer to P8-20</a> )<br>•Clean, inspect and replace air cleaner element. ( <a href="#">Refer to P8-22</a> )<br>•Check intake air pressure and leakage of intake air.<br>•Check intake air temperature and ventilation device.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd. |
|                           | Increase resistance of exhaust air.             | •Check turbocharger. ( <a href="#">Refer to P8-20</a> )<br>•Check exhaust pipes and silencer.<br>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
| Basic engine              | Low compression pressure                        | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
|                           | Faulty valve timing                             | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |
|                           | Rapid wear of sliding parts                     | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.   |

Note: The table above also include the parts Mitsubishi Heavy Industries, Ltd. does not supply. For the parts Mitsubishi Heavy Industries, Ltd. does not supply, inspect and maintain them following the manufacturer's operation manual.

## Engine Oil Consumption is High

Table 11-7 Engine oil Consumption is High

| Cause                     |  | Remedies  |
|---------------------------|--|---|
| Fuel system               | Faulty fuel injection timing           | <ul style="list-style-type: none"> <li>♦Check fuel injection pump couplings.</li> <li>♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>   |
| Lubricating system        | Oil leakage to the outside of engine   | <ul style="list-style-type: none"> <li>♦Check oil leakage.</li> <li>♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>   |
|                           | Faulty engine oil property (viscosity) | ♦Analyze oil property. Use appropriate engine oil. (Refer to P5-3)  |
|                           | Engine oil temperature is high.        | <ul style="list-style-type: none"> <li>♦Check amount of engine oil and lubrication system. (Refer to P3-9)</li> <li>♦Check oil cooler and oil thermostat</li> <li>♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul> |
| Cooling system            | Overheating                            | <ul style="list-style-type: none"> <li>♦Check heat exchanger.</li> <li>♦Check control system.</li> <li>♦Thermostat - Inspect</li> <li>♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>                             |
| Inlet and exhaust systems | Spread oil to intake part              | <ul style="list-style-type: none"> <li>♦Check oil leakage to the turbocharger.</li> <li>♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>   |
|                           | Wear of valve operating system         | ♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
| Control system            | Increase in load                       | <ul style="list-style-type: none"> <li>♦Check control system and governor controller.</li> <li>♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>  |
| Basic engine              | Wear of sliding parts                  | ♦Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |

Note: The table above also include the parts Mitsubishi Heavy Industries, Ltd. does not supply. For the parts Mitsubishi Heavy Industries, Ltd. does not supply, inspect and maintain them following the manufacturer's operation manual.

## Overheating

Table 11-8 Overheating

| Cause          |                                 | Remedies  |
|----------------|---------------------------------|---|
| Cooling system | Low coolant level               | <ul style="list-style-type: none"> <li>•Check coolant leakage</li> <li>•Check coolant level. (<a href="#">Refer to P3-10</a>)</li> </ul>  |
|                | Faulty water pump operation     | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
|                | Faulty thermostat operation     | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
|                | Faulty heat exchanger operation | •Check and clean heat exchanger.  |
| Control system | Increase in load                | <ul style="list-style-type: none"> <li>•Check fuel injection pump rack stroke.</li> <li>•Check control system and governor controller.</li> <li>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul> |
| Basic engine   | Wear of sliding parts           | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |

Note: The table above also include the parts Mitsubishi Heavy Industries, Ltd. does not supply. For the parts Mitsubishi Heavy Industries, Ltd. does not supply, inspect and maintain them following the manufacturer's operation manual.

## Low Engine Oil Pressure

Table 11-9 Low Engine Oil Pressure

| Cause              |  | Remedies  |
|--------------------|--|---|
| Lubricating system | Insufficient amount of engine oil      | •Check amount of engine oil and lubrication system. ( <a href="#">Refer to P3-9</a> )   |
|                    | Faulty engine oil property (viscosity) | •Analyze oil property. Use appropriate engine oil. ( <a href="#">Refer to P5-1</a> )  |
|                    | Engine oil temperature is high.        | <ul style="list-style-type: none"> <li>•Check coolant system.</li> <li>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>                  |
|                    | Oil filter clogged                     | •Inspect and replace oil filter and bypass oil filter. ( <a href="#">Refer to P8-15</a> )   |
|                    | Faulty oil pump operation              | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
|                    | Faulty relief valve operation          | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
| Control system     | Oil pressure gauge failure             | <ul style="list-style-type: none"> <li>•Check control system and wire.</li> <li>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul>         |
| Basic engine       | Increase in load                       | <ul style="list-style-type: none"> <li>•Check fuel injection pump rack stroke.</li> <li>•Consult a dealer of Mitsubishi Heavy Industries, Ltd.</li> </ul> |
|                    | Rapid wear of sliding parts            | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |
|                    | Increase clearance of sliding part.    | •Consult a dealer of Mitsubishi Heavy Industries, Ltd.  |

## When Fuel has Run Out

When fuel runs out while engine is running and the engine has stopped, restart the engine as described below.

1. Return the starter switch to the "OFF" position.
2. Add fuel to the fuel tank.  
For filling fuel tank, refer to ["Fuel Tank Oil Level - Check" \(3-9\)](#).
3. Bleed air from the fuel system.  
For bleeding fuel system, refer to ["Fuel System - Bleed Air" \(3-2\)](#).
4. Restart the engine.  
For starting the engine, refer to ["Start" \(3-12\)](#).

# Chapter 12 MAIN SPECIFICATIONS

## Main Specifications

Table 12-1 Main Specifications

| Item  | Specifications   |
|---|--|
| Engine model  | S12A2  |
| Type  | Water-cooled 4-stroke cycle, turbocharged with aircooler                                   |
| No. of cylinders - arrangement  | 12-V   |
| Cylinder bore x stroke  | ø150 x 160 mm [5.91 x 6.30 in.]  |
| Displacement  | 33.93 L [8.96 U.S. gal]  |
| Combustion type   | Direct injection system  |
| Compression ratio   | 13.9 : 1   |
| Firing order  | 1 - 12 - 5 - 8 - 3 - 10 - 6 - 7 - 2 - 11 - 4 - 9   |
| Direction of rotation   | Counterclockwise as viewed from flywheel side  |
| Dimensions (L x W x H)<br>The value in parentheses shows the size when the large type oil pan is installed. | Approx. 2060 x 1382 x 1542 (1613) mm<br>[81.10 x 54.41 x 60.71 (63.50) in.]                |
| Dry weight  | Approx. 3400 kg [7496 lb]  |
| Fuel  | Diesel fuel  |
| Fuel injection pump   | BOSCH S3S or S7S   |
| Governor  | Mechanical oil pressure or electrical type   |
| Fuel filter   | Paper-element type   |
| Fuel injection nozzle   | Hole type  |
| Fuel injection starting pressure  | 21.57 MPa {220 kgf/cm <sup>2</sup> } [3129 psi]  |
| Lubrication method  | Forced circulation (pressure feed by oil pump)   |
| Lubrication oil   | Class CF or CH-4 oil (API service classification)  |
| Engine oil capacity   | Oil pan: Approx. 100 L [26.42 U.S. gal.],<br>Whole engine: Approx. 120 L [31.70 U.S. gal.] |
| Oil filter  | Paper-element type   |
| Oil cooler  | Water cooled multi-plate   |
| Cooling method  | Forced water cooling   |
| Coolant capacity  | Approx. 100 L [26.42 U.S. gal.] (in engine only)   |
| Starting system   | Electrical or pneumatic type   |
| Starter   | 24V DC - 7.5 kW × 2  |
| Alternator  | DC 24 V - 30 A   |
| Turbocharger  | Mitsubishi TD10 or TD13  |
| Flywheel  | Equivalent of SAE. 18 in.  |
| Flywheel housing  | Equivalent of SAE. No.0  |

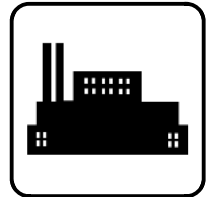
Note: (a) The specification above are subject to change without prior notice.

(b) The specification above are described for the standard model. The special model specifications may differ from those.



# Controller Setup and Application

## Industrial Generator Sets



Models:

**20–3250 kW**

Controllers:

Decision-Maker® 550

**KOHLER**<sup>®</sup>  
POWER SYSTEMS

**ISO 9001**  
**KOHLER**  
POWER SYSTEMS  
NATIONALLY REGISTERED

TP-6140 10/01d



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# Safety Precautions and Instructions

IMPORTANT SAFETY INSTRUCTIONS. Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. **SAVE THESE INSTRUCTIONS.**

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

## DANGER

Danger indicates the presence of a hazard that **will cause severe personal injury, death, or substantial property damage.**

## WARNING

Warning indicates the presence of a hazard that **can cause severe personal injury, death, or substantial property damage.**

## CAUTION

Caution indicates the presence of a hazard that **will or can cause minor personal injury or property damage.**

## NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

## Accidental Starting

### WARNING



**Accidental starting.  
Can cause severe injury or death.**

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

**Disabling the generator set. Accidental starting can cause severe injury or death.** Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

## Battery

### WARNING



**Sulfuric acid in batteries.  
Can cause severe injury or death.**

Wear protective goggles and clothing. Battery acid may cause blindness and burn skin.

### WARNING



**Explosion.  
Can cause severe injury or death.  
Relays in the battery charger  
cause arcs or sparks.**

Locate the battery in a well-ventilated area. Isolate the battery charger from explosive fumes.

**Battery electrolyte is a diluted sulfuric acid. Battery acid can cause severe injury or death.** Battery acid can cause blindness and burn skin. Always wear splashproof safety goggles, rubber gloves, and boots when servicing the battery. Do not open a sealed battery or mutilate the battery case. If battery acid splashes in the eyes or on the skin, immediately flush the affected area for 15 minutes with large quantities of clean water. Seek immediate medical aid in the case of eye contact. Never add acid to a battery after placing the battery in service, as this may result in hazardous spattering of battery acid.


**Battery acid cleanup. Battery acid can cause severe injury or death.** Battery acid is electrically conductive and corrosive. Add 500 g (1 lb.) of bicarbonate of soda (baking soda) to a container with 4 L (1 gal.) of water and mix the neutralizing solution. Pour the neutralizing solution on the spilled battery acid and continue to add the neutralizing solution to the spilled battery acid until all evidence of a chemical reaction (foaming) has ceased. Flush the resulting liquid with water and dry the area.

**Battery gases. Explosion can cause severe injury or death.** Battery gases can cause an explosion. Do not smoke or permit flames or sparks to occur near a battery at any time, particularly when it is charging. Do not dispose of a battery in a fire. To prevent burns and sparks that could cause an explosion, avoid touching the battery terminals with tools or other metal objects. Remove all jewelry before servicing the equipment. Discharge static electricity from your body before touching batteries by first touching a grounded

metal surface away from the battery. To avoid sparks, do not disturb the battery charger connections while the battery is charging. Always turn the battery charger off before disconnecting the battery connections. Ventilate the compartments containing batteries to prevent accumulation of explosive gases.

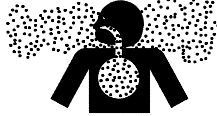
**Battery short circuits. Explosion can cause severe injury or death.** Short circuits can cause bodily injury and/or equipment damage. Disconnect the battery before generator set installation or maintenance. Remove all jewelry before servicing the equipment. Use tools with insulated handles. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery. Never connect the negative (-) battery cable to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together.

## Engine Backfire/Flash Fire

|  |
|--|
| <b>⚠ WARNING</b>   |
|   |
| <p><b>Fire.</b><br/><b>Can cause severe injury or death.</b></p> <p>Do not smoke or permit flames or sparks near fuels or the fuel system.</p> |

**Combustible materials. A fire can cause severe injury or death.** Generator set engine fuels and fuel vapors are flammable and explosive. Handle these materials carefully to minimize the risk of fire or explosion. Equip the compartment or nearby area with a fully charged fire extinguisher. Select a fire extinguisher rated ABC or BC for electrical fires or as recommended by the local fire code or an authorized agency. Train all personnel on fire extinguisher operation and fire prevention procedures.

## Exhaust System

|   |
|---|
| <b>⚠ WARNING</b>  |
|    |
| <p><b>Carbon monoxide.</b><br/><b>Can cause severe nausea, fainting, or death.</b></p> <p>The exhaust system must be leakproof and routinely inspected.</p> |

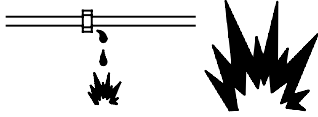
**Generator set operation. Carbon monoxide can cause severe nausea, fainting, or death.** Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Avoid breathing exhaust fumes when working on or near the generator set. Never operate the generator set inside a building unless the exhaust gas is piped safely outside. Never operate the generator set where exhaust gas could accumulate and seep back inside a potentially occupied building.

**Carbon monoxide symptoms. Carbon monoxide can cause severe nausea, fainting, or death.** Carbon monoxide is a poisonous gas present in exhaust gases. Carbon monoxide is an odorless, colorless, tasteless, nonirritating gas that can cause death if inhaled for even a short time. Carbon monoxide poisoning symptoms include but are not limited to the following:

- Light-headedness, dizziness
- Physical fatigue, weakness in joints and muscles
- Sleepiness, mental fatigue, inability to concentrate or speak clearly, blurred vision
- Stomachache, vomiting, nausea

If experiencing any of these symptoms and carbon monoxide poisoning is possible, seek fresh air immediately and remain active. Do not sit, lie down, or fall asleep. Alert others to the possibility of carbon monoxide poisoning. Seek medical attention if the condition of affected persons does not improve within minutes of breathing fresh air.

## Fuel System

|  |
|--|
| <b>⚠ WARNING</b>   |
|   |
| <p><b>Explosive fuel vapors.</b><br/><b>Can cause severe injury or death.</b></p> <p>Use extreme care when handling, storing, and using fuels.</p> |

**The fuel system. Explosive fuel vapors can cause severe injury or death.** Vaporized fuels are highly explosive. Use extreme care when handling and storing fuels. Store fuels in a well-ventilated area away from spark-producing equipment and out of the reach of children. Never add fuel to the tank while the engine is running because spilled fuel may ignite on contact with hot parts or from sparks. Do not smoke or permit flames or sparks to occur near sources of spilled fuel or fuel vapors. Keep the fuel lines and connections tight and in good condition. Do not replace flexible fuel lines with rigid lines. Use flexible sections to avoid fuel line breakage caused by vibration. Do not operate the generator set in the presence of fuel leaks, fuel accumulation, or sparks. Repair fuel systems before resuming generator set operation.

**Explosive fuel vapors can cause severe injury or death.** Take additional precautions when using the following fuels:

**Gasoline**—Store gasoline only in approved red containers clearly marked GASOLINE.

**Propane (LP)**—Adequate ventilation is mandatory. Because propane is heavier than air, install propane gas detectors low in a room. Inspect the detectors per the manufacturer's instructions.

**Natural Gas**—Adequate ventilation is mandatory. Because natural gas rises, install natural gas detectors high in a room. Inspect the detectors per the manufacturer's instructions.

## Hazardous Noise

### CAUTION



**Hazardous noise.**  
Can cause hearing loss.

Never operate the generator set without a muffler or with a faulty exhaust system.

**Engine noise. Hazardous noise can cause hearing loss.** Generator sets not equipped with sound enclosures can produce noise levels greater than 105 dBA. Prolonged exposure to noise levels greater than 85 dBA can cause permanent hearing loss. Wear hearing protection when near an operating generator set.

## Hazardous Voltage/Moving Parts

### DANGER



**Hazardous voltage.**  
Will cause severe injury or death.

Disconnect all power sources before opening the enclosure.

### WARNING



**Hazardous voltage. Moving parts.**  
Can cause severe injury or death.

Operate the generator set only when all guards and electrical enclosures are in place.

### WARNING



**Hazardous voltage.**  
**Backfeed to the utility system can cause property damage, severe injury, or death.**

If the generator set is used for standby power, install an automatic transfer switch to prevent inadvertent interconnection of standby and normal sources of supply.

**Grounding electrical equipment. Hazardous voltage can cause severe injury or death.** Electrocutation is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

**Connecting the battery and the battery charger. Hazardous voltage can cause severe injury or death.** Reconnect the battery correctly, positive to positive and negative to negative, to avoid electrical shock and damage to the battery charger and battery(ies). Have a qualified electrician install the battery(ies).

**Short circuits. Hazardous voltage/current can cause severe injury or death.** Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

**Testing live electrical circuits. Hazardous voltage or current can cause severe injury or death.** Have trained and qualified personnel take diagnostic measurements of live circuits. Use adequately rated test equipment with electrically insulated probes and follow the instructions of the test equipment manufacturer when performing voltage tests. Observe the following precautions when performing voltage tests: (1) Remove all jewelry. (2) Stand on a dry, approved electrically insulated mat. (3) Do not touch the enclosure or components inside the enclosure. (4) Be prepared for the system to operate automatically. (600 volts and under)

### WARNING



**Airborne particles.**  
Can cause severe injury or blindness.

Wear protective goggles and clothing when using power tools, hand tools, or compressed air.

**Servicing the generator set when it is operating. Exposed moving parts can cause severe injury or death.** Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.


## Hot Parts

### WARNING



**Hot coolant and steam.**  
Can cause severe injury or death.

Before removing the pressure cap, stop the generator set and allow it to cool. Then loosen the pressure cap to relieve pressure.

|   |
|---|
| <b>⚠ WARNING</b>  |
|  |
| <b>Hot engine and exhaust system.<br/>Can cause severe injury or death.</b>       |
| Do not work on the generator set until it cools.                                  |

**Servicing the alternator. Hot parts can cause severe injury or death.**

Avoid touching the alternator field or exciter armature. When shorted, the alternator field and exciter armature become hot enough to cause severe burns.

**Servicing the exhaust system. Hot parts can cause severe injury or death.**

Do not touch hot engine parts. The engine and exhaust system components become extremely hot during operation.

## Notice

|  |
|--|
| <b>NOTICE</b>  |
| This generator set has been rewired from its nameplate voltage to                        |
| <div style="border: 1px solid black; width: 150px; height: 40px; margin: 0 auto;"></div> |
| <small>246242</small>  |

### NOTICE

**Voltage reconnection.** Affix a notice to the generator set after reconnecting the set to a voltage different from the voltage on the nameplate. Order voltage reconnection decal 246242 from an authorized service distributor/dealer.



This manual provides setup and application information for 20–3250 kW generator sets equipped with the following controller:

- Decision-Maker® 550

In addition, some diagnostic information is shown for selected components.

This manual may be used for models not listed on the front cover.

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury. Read and follow the Safety Precautions and Instructions section at the beginning of this manual. Keep this manual with the equipment for future reference.

Generator set controller setup and diagnostic work must be performed by appropriately skilled and suitably trained personnel familiar with generator set operation and service.

The disk supplied with this generator set is a backup copy of the generator set personality program containing data specific to the engine and alternator. The engine and alternator data was preprogrammed in the controller at the factory and no further use of the disk should be necessary. Typically, your authorized distributor stores this disk for possible future use such as controller replacement or other circumstances requiring a backup.

## List of Related Materials

Separate literature contains communication and software information not provided in this manual. The following table lists the available literature part numbers.

| <b>550 Controller Literature Description</b>      | <b>Literature Part Number</b>                               |
|---|---|
| 550 Controller Spec Sheet                         | G6-46   |
| 550 Controller Generator Set Operation Manual     | TP-6083 or TP-6200  |
| Generator Set/Controller Wiring Diagram Manual    | Multiple Part Numbers<br>Contact your<br>Distributor/Dealer |
| 550 Communications Spec Sheet                     | G6-50   |
| KBUS Communications Spec Sheet                    | G6-38   |
| Monitor II Software Operation/Installation Manual | TP-5972   |
| Modbus Communication Operation Manual             | TP-6113   |
| Program Loader Software Installation              | TT-1285   |
| Communication Kits Installation                   | TT-847  |

# Service Assistance

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For professional advice on generator set power requirements and conscientious service, please contact your nearest Kohler distributor or dealer.

- Consult the Yellow Pages under the heading Generators—Electric.
- Visit the Kohler Power Systems website at KohlerPower.com.
- Look at the labels and stickers on your Kohler product or review the appropriate literature or documents included with the product.
- Call toll free in the US and Canada 1-800-544-2444.
- Outside the US and Canada, call the nearest regional office.

## **Headquarters Europe, Middle East, Africa (EMEA)**

Kohler Power Systems  
3 rue de Brennus  
93200 Saint Denis  
France  
Phone: (33) 1 49 178300  
Fax: (33) 1 49 178301

## **Asia Pacific**

Power Systems Asia Pacific Regional Office  
Singapore, Republic of Singapore  
Phone: (65) 6264-6422  
Fax: (65) 6264-6455

## **China**

North China Regional Office, Beijing  
Phone: (86) 10 6518 7950  
(86) 10 6518 7951  
(86) 10 6518 7952  
Fax: (86) 10 6518 7955

East China Regional Office, Shanghai  
Phone: (86) 21 6288 0500  
Fax: (86) 21 6288 0550

## **India, Bangladesh, Sri Lanka**

India Regional Office  
Bangalore, India  
Phone: (91) 80 3366208  
(91) 80 3366231  
Fax: (91) 80 3315972

## **Japan, Korea**

North Asia Regional Office  
Tokyo, Japan  
Phone: (813) 3440-4515  
Fax: (813) 3440-2727

## **Latin America**

Latin America Regional Office  
Lakeland, Florida, USA  
Phone: (863) 619-7568  
Fax: (863) 701-7131

# Section 1 Features and Operation Overview

The 550 controller, available on 20–3250 kW generator sets, meets the requirements of NFPA 99 and NFPA 110. The controller contains microprocessor-based logic and communicates with a personal computer (PC) individually or on a network when equipped with optional communication software products. The controller provides complete compatibility with select engine electronic control module (ECM) and non-ECM equipped generator set engines. Refer to Section 2.2, ECM Engines and Controller Displays, for identification of compatible ECM engines. All other engines, even if ECM equipped, are not compatible and considered non-ECM engines. The controller is compatible with 12- or 24-volt engine battery systems. See Figure 1-1.

The controller displays both engine and generator conditions as well as numerous system functions. The controller monitors engine and generator parameters

and displays and stores 100 system events. Optional menu-driven, Windows®-based PC software monitors engine and alternator parameters and also provides control capability. The controller supports the Modbus® remote terminal unit (RTU), an industry standard open communication protocol.

The 550 controller standard features include:

- Built-in digital voltage regulator.
- Inherent alternator protection including overload and short circuit matched to each alternator.
- User-programmable load shed function.
- Smart-starting idle mode for noncritical operation.
- Digital inputs, analog inputs, and digital outputs for system control.

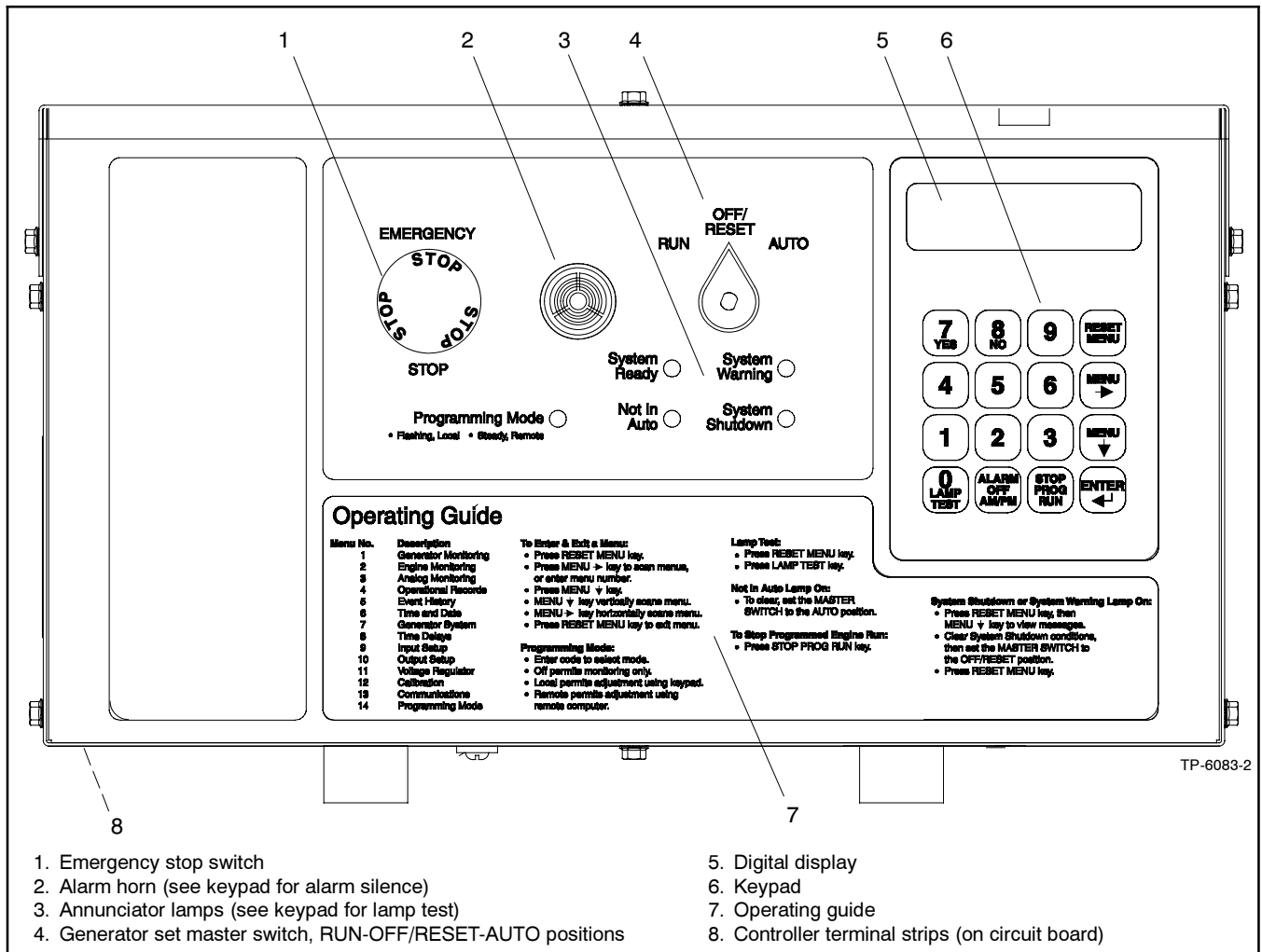


Figure 1-1 Controller Front View

## 1.1 Controller Overview

The 550 controller features a built-in voltage regulator to better match engine and generator performance. The 550 controller regulates voltage internally without using an external voltage regulator board.

Each controller/generator set is loaded with a unique, factory-loaded personality parameter file. The controller personality file is specific to the generator set application. The personality parameter file can be reinstalled at the installation site when required.

The controller circuit has a speed sensor and uses the voltage input as a secondary means of crank disconnect and overspeed. ECM equipped engines use the ECM speed signal as a basis for engine crank termination and overspeed shutdown. If the ECM signal circuit is interrupted, the engine shuts down.

No safeguard breaker option is required. The controller has overload and short circuit protection with the data built into the personality parameter file.

Communication is possible using the controller KBUS and Modbus® RS-232 and RS-485 connections.

The 550 controller engine harness is unique and not compatible with Decision-Maker 3+ or Decision-Maker 340 controller applications.

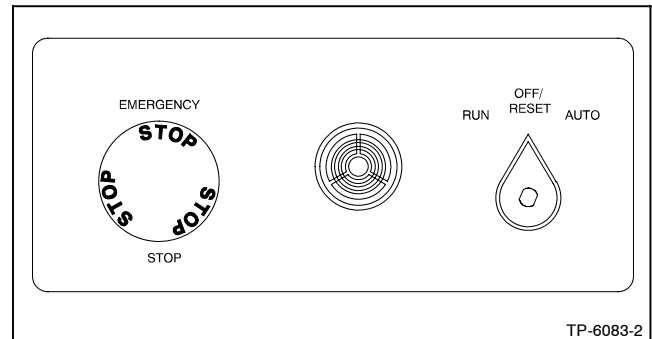
Engine sensors for oil and coolant are 3-wire types on non-ECM engines providing system integrity monitoring. ECM engines utilize ECM communications to provide engine faults and warnings. ECM engines utilize SAE J1939 serial communication to the 550 controller and allow information captured by the ECM to be used for controller system functions, eliminating redundant sensors on the engine. The engine monitoring menu or the monitoring software displays additional status information.

The 550 controller requires a customer connection kit when relay driver outputs are used for remote annunciation. Customer-specified analog inputs are provided with 0–5 VDC signals and/or digital inputs are available where the signal goes to chassis ground.

## 1.2 Controller Operation

The generator set master RUN-OFF/RESET-AUTO switch is a 3-position, rotary, selector switch. See Figure 1-2. The RUN position starts the generator set locally. The AUTO position starts and stops the generator set remotely. OFF stops the generator set without any time delay when operating locally in the RUN position. When the generator set shuts down due

to a fault, reset the control system by moving the selector to the center OFF/RESET position prior to a restart. Controllers are available with a key-operated switch.



**Figure 1-2** Switches and Alarm Horn

Pressing the emergency stop switch bypasses any time delays and provides an immediate engine shutdown when operating. The switch latches in the open position; pull the switch knob outward to reset it.

The alarm horn sounds whenever the selector switch is not in the AUTO position or a fault shutdown occurs. The alarm also sounds along with various warning indications. To silence the horn, place the generator set master switch in the AUTO position and depress the keypad alarm off button.

### 1.2.1 Cooldown Mode

The cooldown period is based on coolant temperature. The engine shuts down early if it reaches the engine cooldown temperature (which is part of the personality profile) before the engine cooldown time delay period times out. If the engine does not reach the defined engine warmed-up temperature before being put into the cooldown mode, it will shut down immediately.

### 1.2.2 Idle (Speed) Mode (ECM equipped engines only)

The idle (speed) mode function provides the ability to start and run the engine at idle (reduced) speed for a selectable time period (0–10 minutes) during warm up. The controller overrides the idle speed mode if the engine reaches the preprogrammed engine warmed-up temperature before the idle mode times out.

During the idle (speed) mode, the controller continues to monitor critical engine parameters such as oil pressure, coolant temperature, and engine speed. The voltage regulator, thermal protection feature, and AC metering are disabled in the idle speed mode.

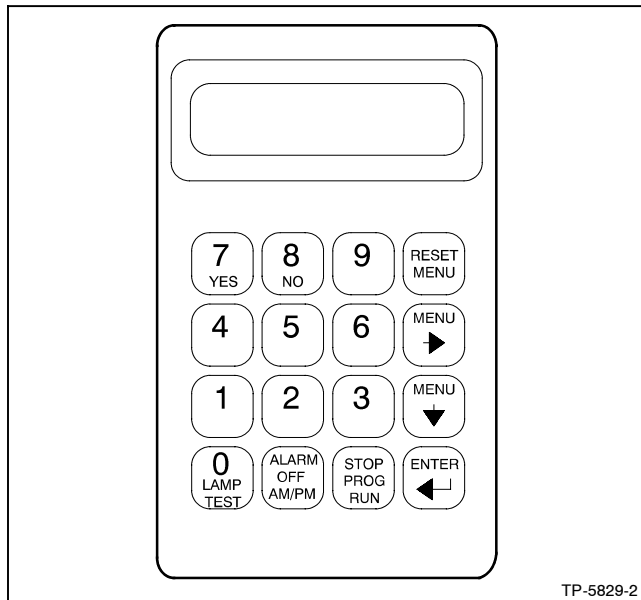
Modbus® is a registered trademark of Schneider Electric

The controller overrides the idle speed function when the generator set is signaled to start while in the AUTO position. This override provides immediate emergency generator set power in the event of a utility power failure. When the utility power returns and the generator set is signaled to stop, the generator set will continue to run until the idle mode switch circuit is opened. If idle mode is not active, the generator set will enter a cooldown period as discussed earlier.

Use menu 9 to activate the idle speed function as a user-defined digital input. The idle speed feature requires an ECM-equipped engine with the idle speed function.

### 1.3 Keypad

Use the keypad to interact locally with the controller by accessing generator set data and preset settings. Program crank cycles and time delays under password control with the keypad. Pressing any key activates the controller panel display. The 2-line vacuum fluorescent display provides generator set and engine condition information. See Figure 1-3.



**Figure 1-3** Digital Display and Keypad

The 14 available menus are listed in Figure 1-4. Additionally, menu 20 allows factory setup.

To enter a menu:

1. Clear the display by pressing RESET MENU.
2. Enter menu number 1-14.
3. Press ENTER.
4. Once in the menu, use the arrow keys to navigate.

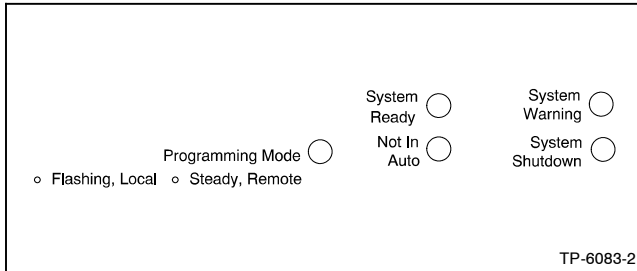
| Menu | Title                | Function   |
|------|----------------------|--|
| 1    | Generator Monitoring | Provides generator set output data including line-to-line and line-to-neutral voltages, current, frequency, power factor (PF), kW, kVA, and kVAR.  |
| 2    | Engine Monitoring    | Provides engine operating data including oil pressure, coolant temperature, engine RPM, and battery voltage. Additional monitoring is available on ECM-equipped engines depending on the engine family selected.               |
| 3    | Analog Monitoring    | Provides battery voltage status and up to 7 user-defined analog monitoring inputs. On non-ECM engines, inputs 03-07 are available where analog inputs 01 and 02 are reserved for engine oil pressure and coolant temperature.  |
| 4    | Operational Records  | Provides generator set operational records including operating start date, last logged maintenance, total run time loaded and unloaded, run time since last maintenance, number of starts, and number of running days.         |
| 5    | Event History        | Provides up to 100 stored warning and shutdown events that are day and time dated.   |
| 6    | Time and Date        | Sets time, date, and internal calendar. Necessary for exercise run time and event records. The starting battery must remain connected for time and date to stay valid.   |
| 7    | Generator System     | Contains factory-preset generator set voltage and frequency data. Data may be changed if the unit is reconnected. Overvoltage, undervoltage, overfrequency, underfrequency, and overspeed settings are also located in menu 7. |
| 8    | Time Delays          | Displays and sets up cycle cranking, start and shutdown functions, and auxiliary shutdown and inhibit time delays.   |
| 9    | Input Setup          | Provides setup of user-defined digital and analog warning and shutdown inputs. These inputs are dictated by the generator set application and are field-installed. There is a default for factory setup.                       |
| 10   | Output Setup         | Provides setup of user-defined outputs.  |
| 11   | Voltage Regulation   | Provides voltage regulator function setup including line-to-line voltages, underfrequency unloading, reactive droop, PF, and kVAR adjustments.   |
| 12   | Calibration          | Provides voltage sensing logic calibration. Calibration is set at the factory. Recalibration is necessary only when the generator set is reconnected for an optional voltage or the controller is replaced.                    |
| 13   | Communications       | Provides local or remote access to the control logic and displays by a PC or other system.   |
| 14   | Programming Mode     | Provides local or remote access to the programming function. The user enters a password to access the programming mode. Default password is 0. Monitoring is always allowed.   |

**Figure 1-4** Menu Summary

## 1.4 Controller Lights

Five annunciator panel lamps, as shown in Figure 1-5 and described in Figure 1-6, provide an immediate visual indication of generator set status. Conditions causing a system warning are listed in Figure 1-7. Conditions causing a system shutdown are listed in Figure 1-8.

**Note:** Lists are dependent on engine alternator combination.



**Figure 1-5** Annunciator Lamps

| Lamp             | Description  |
|------------------|--|
| System Ready     | Green lamp illuminates when the generator set master switch is in the AUTO position and the system senses no faults.   |
| Not In Auto      | Yellow lamp illuminates when the generator set master switch is not in the AUTO position.  |
| Programming Mode | Yellow lamp in flashing mode indicates local programming selection, steady on mode for remote programming mode. No light indicates controller is in the off programming mode.                        |
| System Warning   | Yellow lamp identifies an existing fault condition but does not shut down the generator set. A continuing system warning fault condition may cause a system shutdown if the source is not corrected. |
| System Shutdown  | The red lamp identifies generator set shutdown because of a fault condition. A system shutdown may follow a system warning condition.  |

**Figure 1-6** Annunciator Panel Lamps

| Engine Functions   | General Functions  | Generator Functions  |
|--|--|--|
| <ul style="list-style-type: none"> <li>• Coolant temperature signal loss</li> <li>• High battery voltage</li> <li>• High coolant temperature</li> <li>• Low battery voltage</li> <li>• Low coolant temperature</li> <li>• Low fuel (level or pressure)*</li> <li>• Low oil pressure</li> <li>• Oil pressure signal loss</li> <li>• Speed sensor fault</li> <li>• Starting aid fault</li> <li>• Weak battery</li> </ul> | <ul style="list-style-type: none"> <li>• Auxiliary-analog inputs (up to 7 programmable shutdowns or warnings)</li> <li>• Auxiliary-digital inputs (up to 21 programmable shutdowns or warnings)</li> <li>• Battery charger fault*</li> <li>• Emergency power system (EPS) supplying load</li> <li>• Engine cooldown delay</li> <li>• Engine start delay</li> <li>• Load shed kW overload</li> <li>• Load shed underfrequency</li> <li>• Master switch not in AUTO</li> <li>• Master switch open</li> <li>• NFPA 110 fault</li> </ul> | <ul style="list-style-type: none"> <li>• AC sensing loss</li> <li>• Generator running</li> <li>• Ground fault*</li> <li>• Overcurrent</li> </ul> |
| *Requires optional input sensors   |  |  |

**Figure 1-7** System Warning

| Engine Functions  | General Functions   | Generator Functions   |
|---|---|---|
| <ul style="list-style-type: none"> <li>• Air damper control fault, if equipped</li> <li>• Air damper indicator fault, if equipped</li> <li>• High coolant temperature</li> <li>• High oil temperature</li> <li>• Low coolant level</li> <li>• Low oil pressure</li> <li>• Overcrank</li> <li>• Overspeed</li> </ul> | <ul style="list-style-type: none"> <li>• Auxiliary-analog inputs (up to 7 programmable shutdowns or warnings)</li> <li>• Auxiliary-digital inputs (up to 21 programmable shutdowns or warnings)</li> <li>• ECM communications loss</li> <li>• Emergency stop</li> <li>• Internal fault</li> <li>• Master switch in off/reset position</li> <li>• Master switch error</li> <li>• Master switch open</li> <li>• NFPA 110 fault</li> </ul> | <ul style="list-style-type: none"> <li>• Locked rotor (failed to crank)</li> <li>• AC output overvoltage</li> <li>• AC output undervoltage</li> <li>• Field overvoltage</li> <li>• Alternator protection, overloads, short circuits</li> <li>• Overfrequency</li> <li>• Underfrequency</li> </ul> |

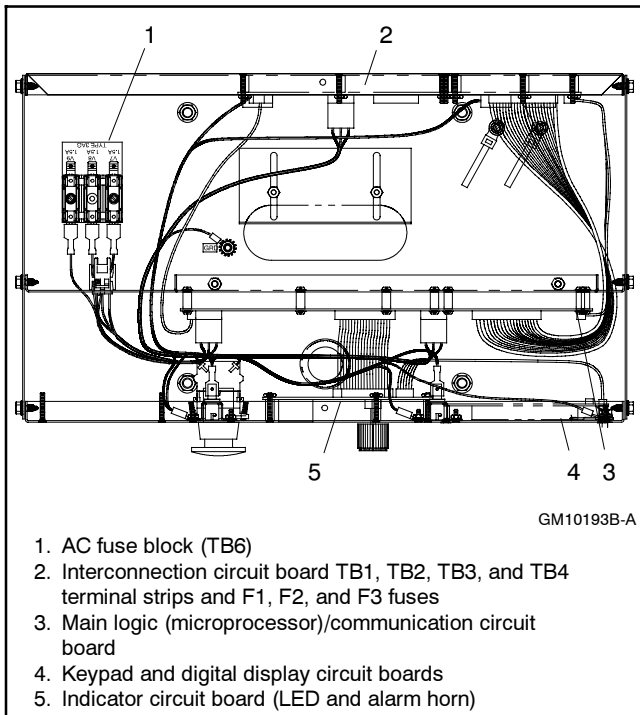
**Figure 1-8** System Shutdown

## 1.5 Controller Circuit Boards

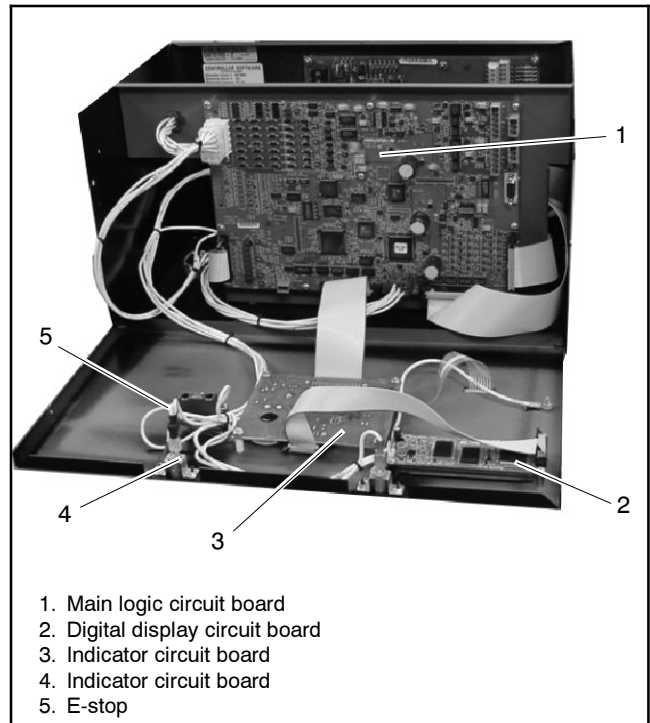
The controller has five circuit boards as listed in Figure 1-9. See Figure 1-10, Figure 1-11, and Figure 1-12 for circuit board locations. See Figure 1-13 for controller connections.

| Circuit Board                             | Description and Function   |
|---|--|
| Indicator                                 | Includes the LED status lamps and alarm horn.  |
| Interconnection                           | Provides the terminal strips to connect the customer connection and/or dry contact kits and three fuses (F1, F2, and F3).                      |
| Keypad                                    | Provides the keypad to navigate the generator set displays and enter data.   |
| Digital Display                           | Provides the digital display for monitoring the generator set functions and output values.   |
| Main Logic (Microprocessor)/Communication | Provides the controller operation logic and provides communication locally (direct) or remotely (via modem) using RS-232 or RS-485 connectors. |

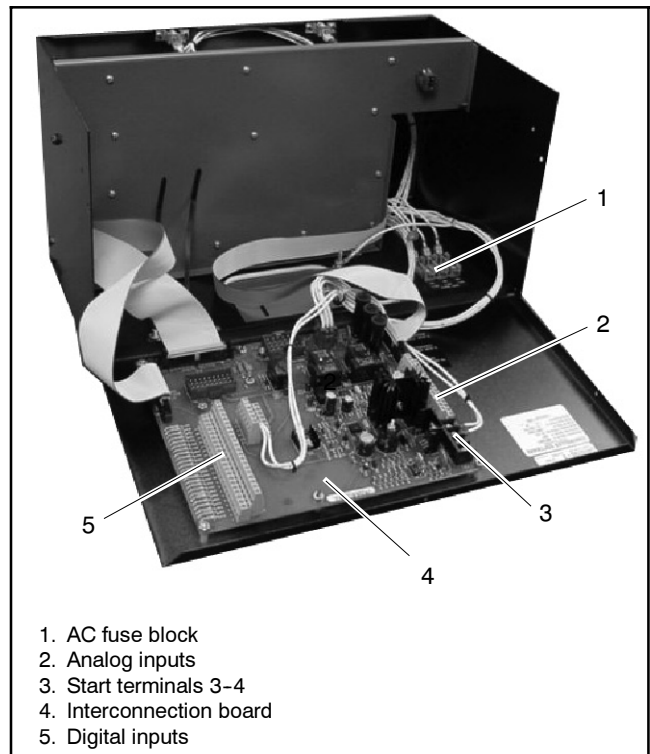
**Figure 1-9** Controller Circuit Boards



**Figure 1-10** Controller Circuit Boards and Fuses (Controller Top View)



**Figure 1-11** Front Panel Controller Layout



**Figure 1-12** Back Panel Controller Layout

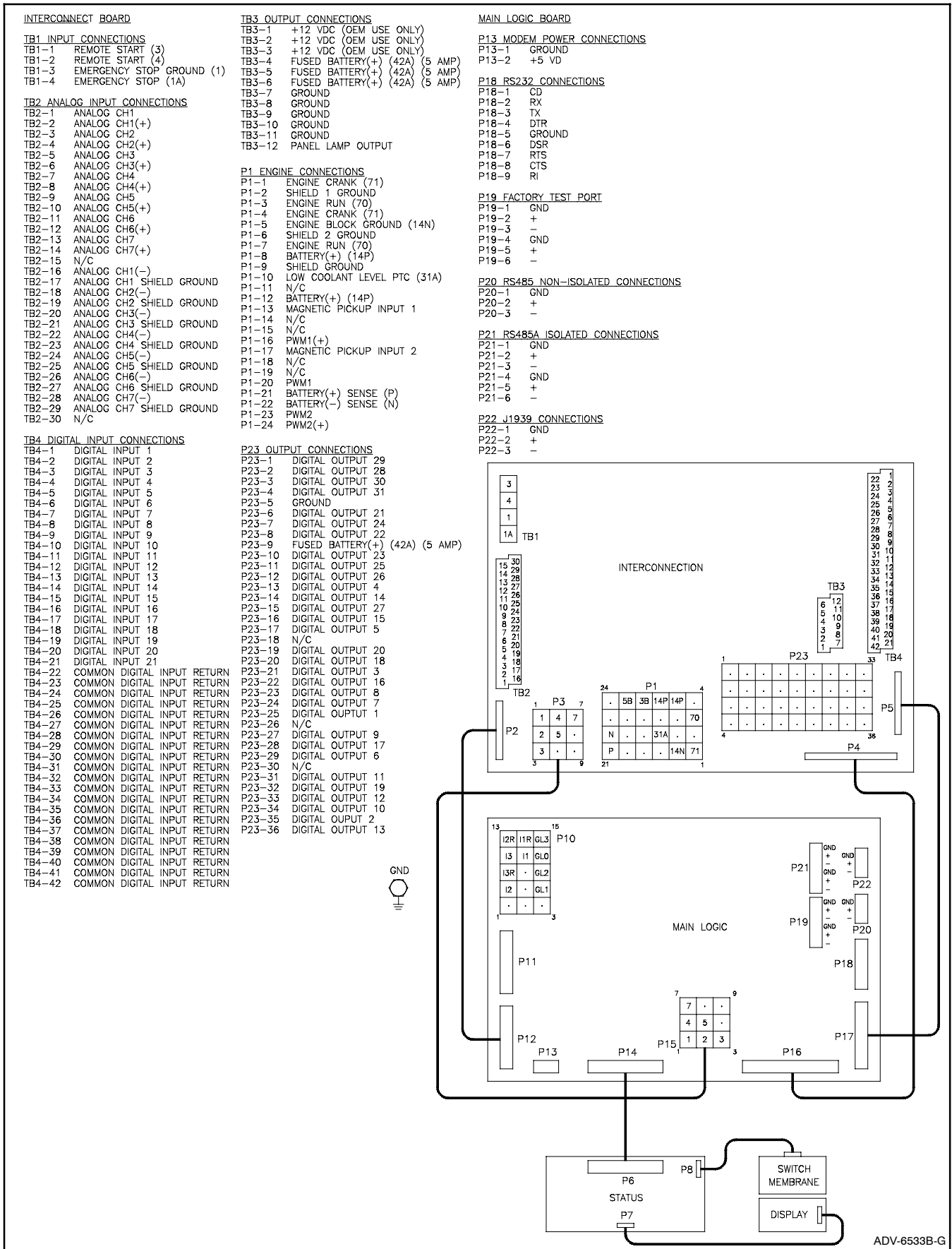
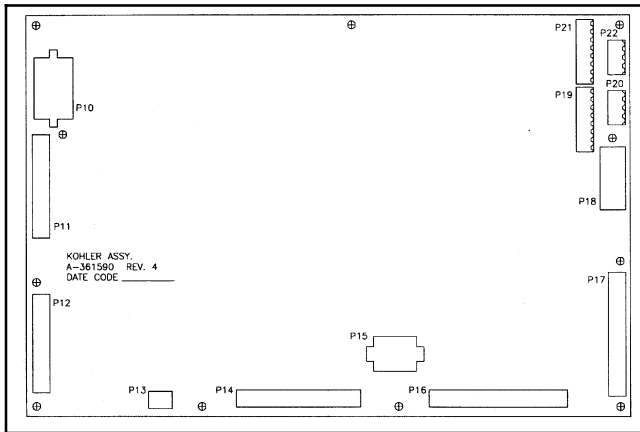


Figure 1-13 Controller Connections



## 1.5.1 Main Logic Circuit Board

The main logic circuit board is responsible for all microprocessor logic functions, remote communications, and display and keypad functions. See Figure 1-14.



**Figure 1-14** Main Logic Circuit Board

**P10** Harness plug connection for the voltage and current inputs. The voltage inputs are from V7, V8, V9, and V0. The current inputs are from the CT burden resistor board.

**P12** Ribbon cable connection from the interconnection board. This connection links the analog input terminal strip to the logic board.

**P13** Modem power connection (future connection).

**P14** Ribbon cable connection to the status board. This is the communications link for annunciation of alarms, digital display, and keypad.

**P15** Harness connection from the interconnection board and power input to the main logic board.

**P16** Ribbon cable connection for digital outputs from the main logic board.

**P17** Ribbon cable connection for digital inputs. This connection links the interconnection board's digital input terminal strip to the main logic board.

**P18** RS-232 communication connection for communication to a PC at a distance of 15 m (50 ft.) or less.

**P20** RS-485 communication connection for Modbus® communications.

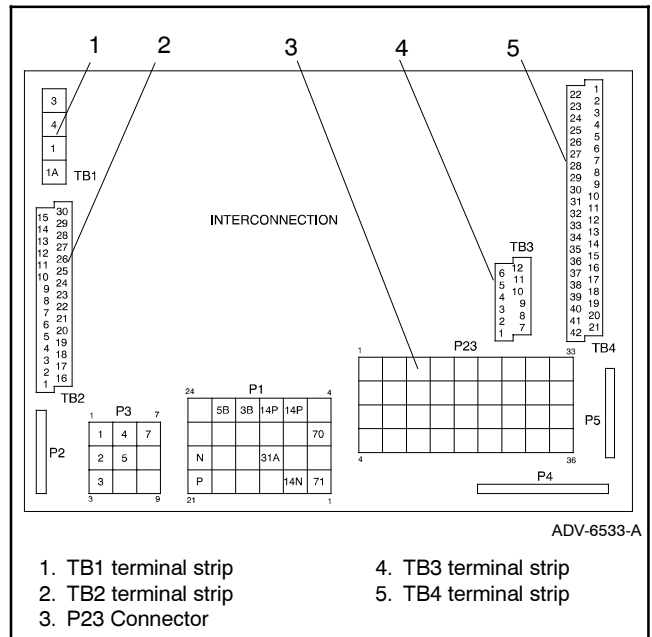
**P21** RS-485 communication connection for communication to a PC for distances of 15–1220 m (50–4000 ft.). This connection is used for KBUS communications.

**P19** RS-485 communication connection is a spare connection for factory use.

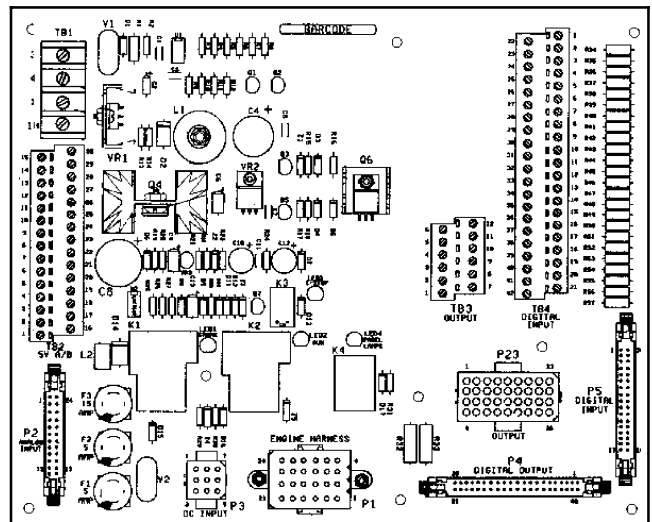
**P22** SAE J1939 connector for communications with an ECM, when equipped.

## 1.5.2 Interconnection Circuit Board

The interconnection circuit provides the terminal strips to connect the customer connection and/or dry contact kits and three fuses (F1, F2, and F3). See Figure 1-15 and Figure 1-16.



**Figure 1-15** Interconnection Circuit Board Terminal Strips and Connectors



**Figure 1-16** Interconnection Circuit Board

**P1** Main engine harness connection.

**P2** Ribbon cable connection used to link the analog inputs to the main logic board.

**P3** Harness connection for the DC power input to the main logic board.

**P4** Ribbon cable connection to the main logic board (used to link digital outputs from the main logic board).

**P5** Ribbon cable connector that transfers the digital inputs to the main logic board.

**P23** Output plug that transfers the digital output logic to the customer connection board.

**TB1** Customer connection point for remote start (3-4) and emergency stop input (1-1A).

**TB2** Customer connection point for the analog inputs.

**TB3** Customer connection point for the DC control power.

**TB4** Customer connection point for the digital inputs.

2.1 ECM Communications

The J1939 serial communication link accesses information from certain Detroit Diesel engines with DDEC ECMs. See Figure 2-1. The communication link provides access to DDEC data and is displayed in menu 2 of the 550 controller. The J1939 link also provides engine sensor data access eliminating redundant senders on the engine. If the J1939 communication link from the ECM to the 550 controller is lost, the generator set shuts down on a loss of ECM communication fault. See Figure 2-2.

Menu 2, Engine Monitoring, provides information about the various engine parameters while the generator set is either operational or shut down. Menu 2 is only an informational menu, and the user cannot set or change engine parameters.

Some available engine data is dependent on the engine family. As a result, some monitoring displays may not be available with a given engine.

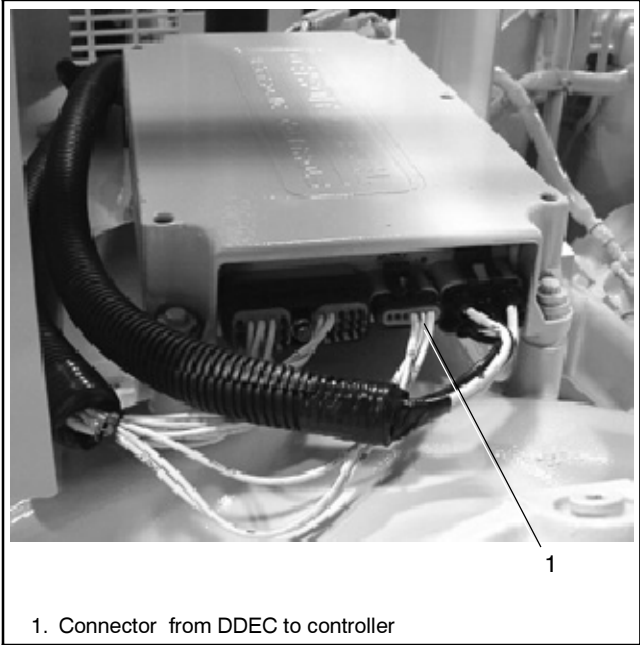


Figure 2-1 Detroit Diesel Engine DDEC Engine Control Module (ECM)

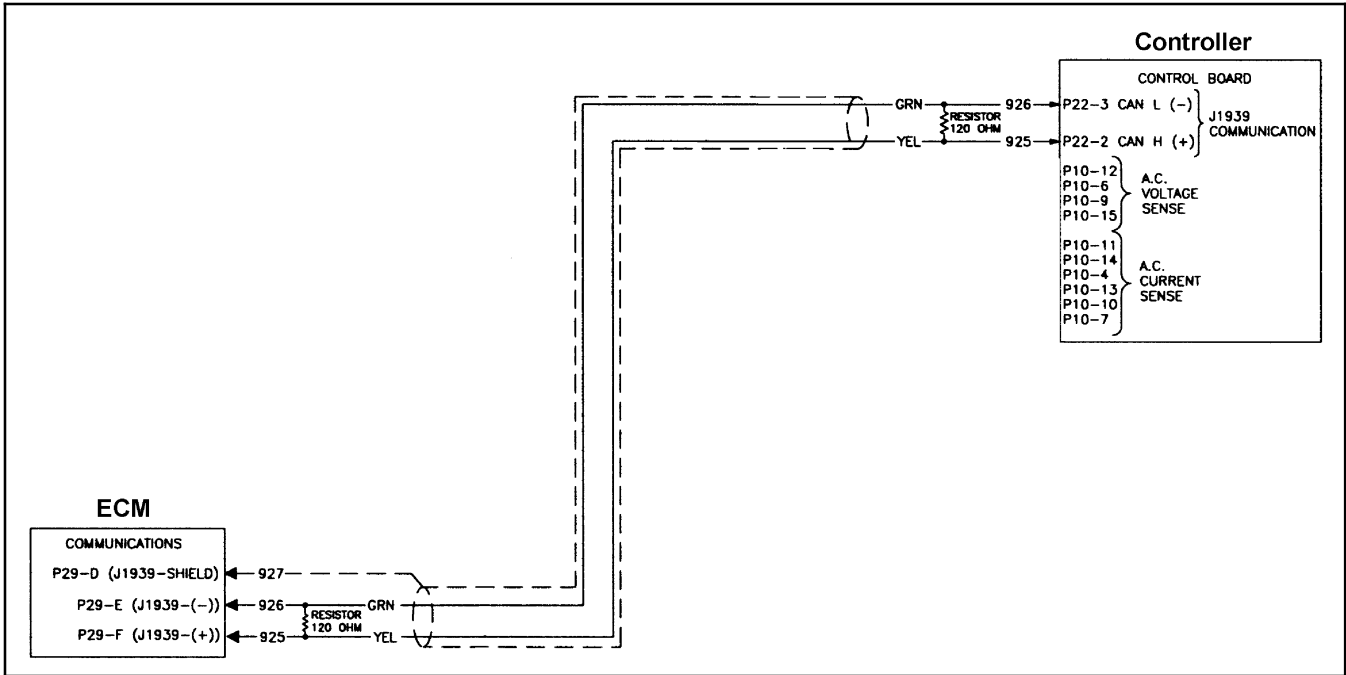


Figure 2-2 J1939 Communication Link Between Engine ECM and 550 Controller

## 2.2 ECM Engines and Controller Displays

Detroit Diesel series 60, 2000, and 4000 engines are ECM-equipped. The controller displays provided by each engine are listed in Figure 2-3. Figure 2-4 lists references to typical wiring schematics on the following pages.

| Display               | Generator Set Models                      |                                       |  |
|-----------------------|---|---------------------------------------|--|
|                       | 230-400 kW<br>DDC Series 60 Diesel Engine | 450-1000 kW<br>DDC Series 2000 Engine | 1250-2000 kW<br>DDC Series 4000 Engine |
| Engine speed          | X   | X                                     | X                                      |
| Fuel pressure         | #   | X                                     | X                                      |
| Fuel temperature      | X   | X                                     | X                                      |
| Fuel consumption rate | X   | X                                     | X                                      |
| Fuel used last run*   | X   | X                                     | X                                      |
| Coolant pressure      | #   | #                                     | X                                      |
| Coolant temperature   | X   | X                                     | X                                      |
| Oil pressure          | X   | X                                     | X                                      |
| Oil temperature       | X   | X                                     | X                                      |
| Crankcase pressure    | #   | #                                     | X                                      |
| Ambient temperature   | X   | X                                     | X                                      |
| ECM battery voltage   | X   | X                                     | X                                      |
| Engine model number   | X   | X                                     | X                                      |
| Engine serial number  | X   | X                                     | X                                      |
| Unit number           | X   | X                                     | X                                      |
| ECM serial number     | X   | X                                     | X                                      |
| Coolant level switch  | #   | #                                     | #                                      |
| Oil level switch      | #   | #                                     | #                                      |

X Available display feature  
 \* Value must be reset using the DDEC reader  
 # Not available at this time

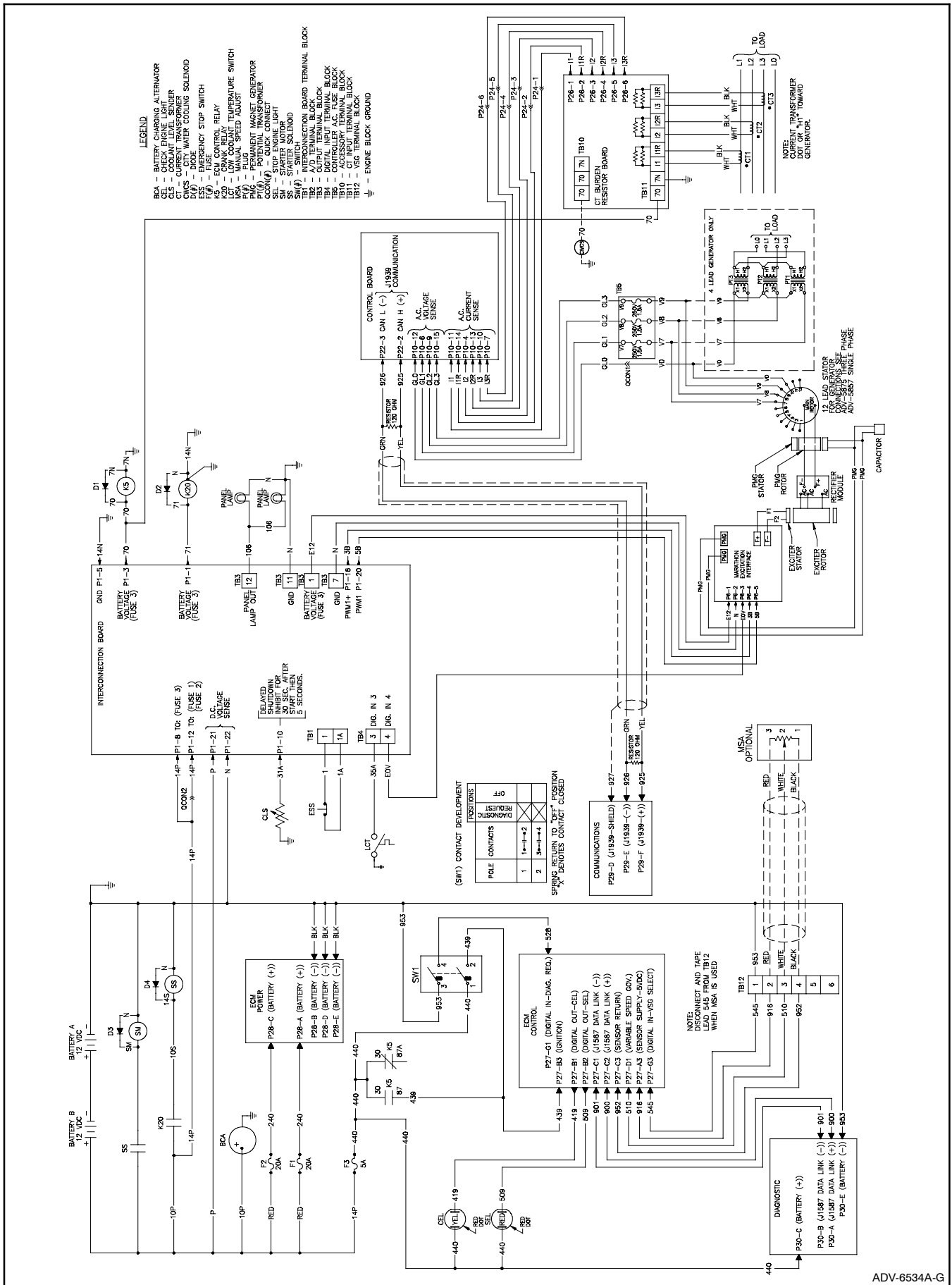
**Figure 2-3** Controller Displays for ECM-Equipped Engines

| Wiring Schematic                                   | Figure Number |
|--|---------------|
| ECM Equipped Engine and 200 kW Alternator          | Figure 2-5    |
| ECM Equipped Engine and 230-300 kW Alternator      | Figure 2-6    |
| ECM Equipped Engine and 350/400 kW Alternator      | Figure 2-7    |
| ECM Equipped Engine and 450-2000 kW Alternator     | Figure 2-8    |
| Non-ECM Equipped Engine and 20-300 kW Alternator   | Figure 2-9    |
| Non-ECM Equipped Engine and 350-2000 kW Alternator | Figure 2-10   |

**Figure 2-4** Typical Wiring Schematics







ADV-6534A-G

Figure 2-7 ECM Equipped Engine and 350/400 kW Alternator

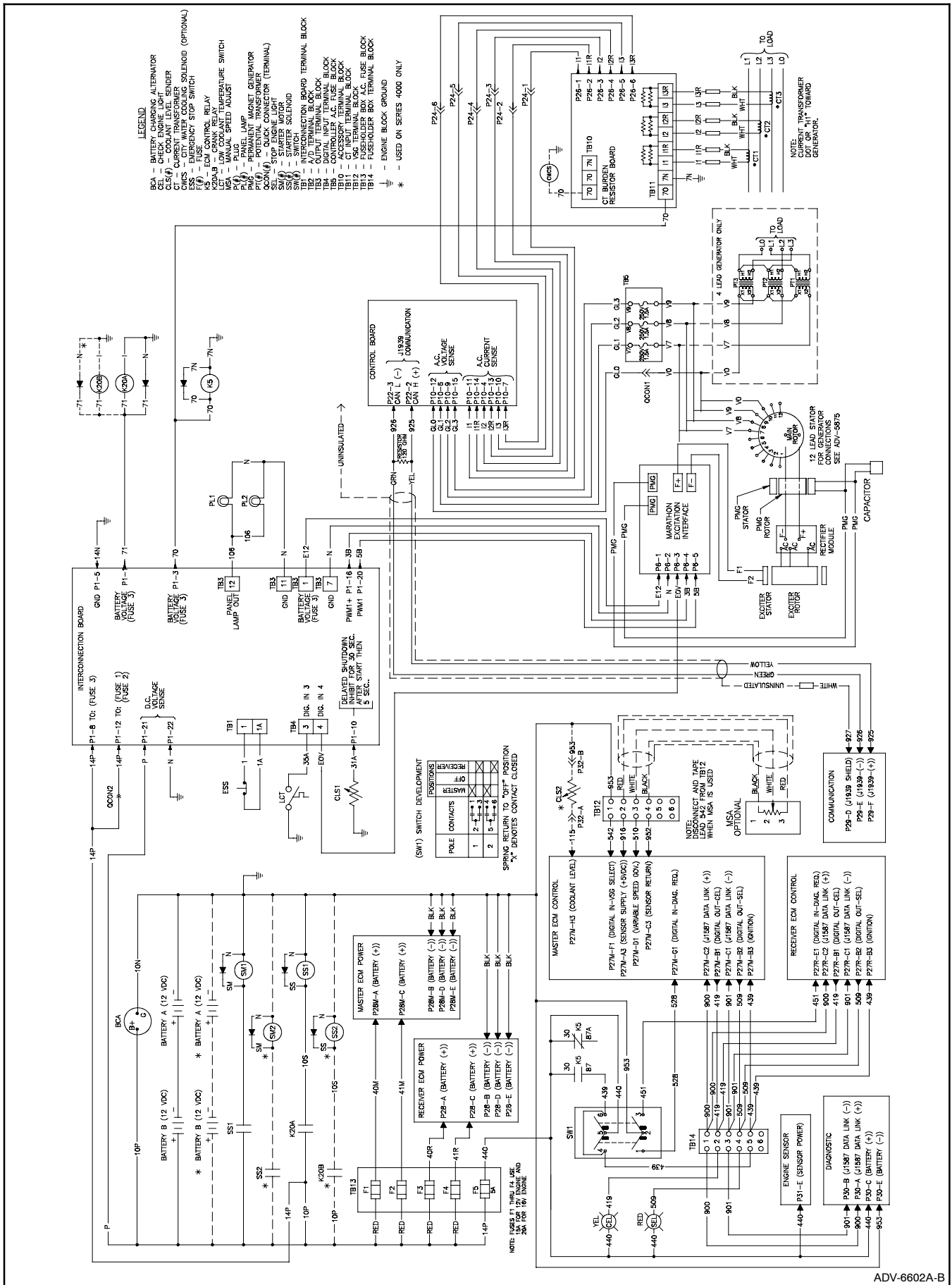


Figure 2-8 ECM Equipped Engine and 450-2000 kW Alternator





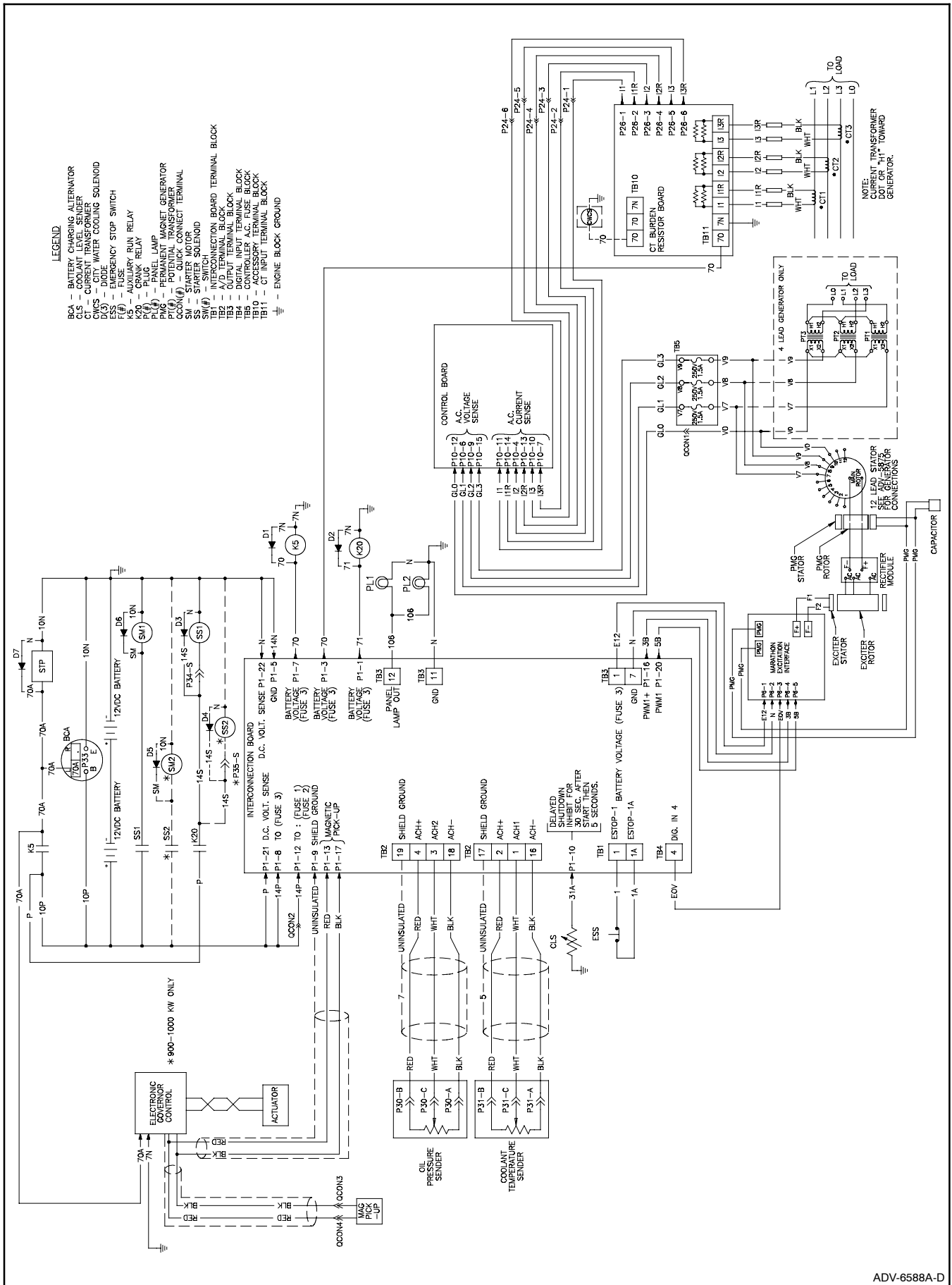


Figure 2-10 Non-ECM Engine and 350-2000 kW Alternator

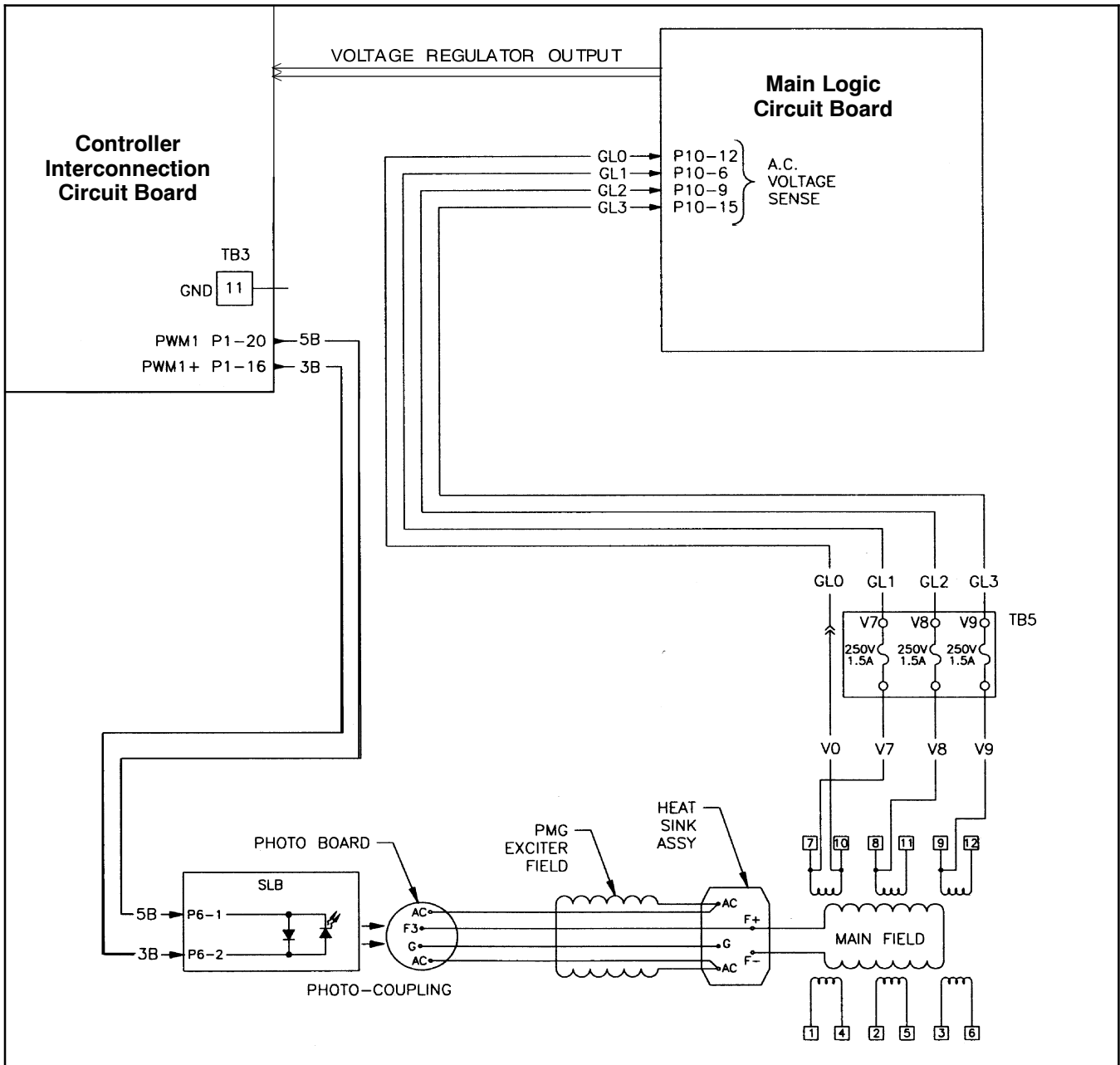
## 2.3 20-300 kW Voltage Regulator (Brushless Alternator with Brushless Exciter)

The 550 controller voltage regulator provides  $\pm 0.25\%$  regulation for single- or three-phase loading. See Figure 2-11. The three-phase voltage-sensing regulator is part of the main logic board software and is serviced as part of the complete controller.

Voltage regulation and stability controls are based on programmed parameters that are part of the 550 controller personality profile specific to the generator set application.

The regulator output is a pulse width modulation (PWM) signal. The PWM signal controls the current flow through the main rotor field, which in turn controls voltage supply at the alternator stator lead output. For any given load and alternator speed, the alternator output voltage is proportional to the regulator PWM signal level.

Menu 11 displays voltage regulator setup functions including line-to-line voltages, voltage adjustment, underfrequency unloading (volts per Hz), reactive droop, power factor (PF), and kVAR adjustments. Reactive droop, PF, and kVAR adjustments are required only when the generator set is used in paralleling applications.



**Figure 2-11** Main Logic Circuit Board and Controller Interconnection Circuit Board

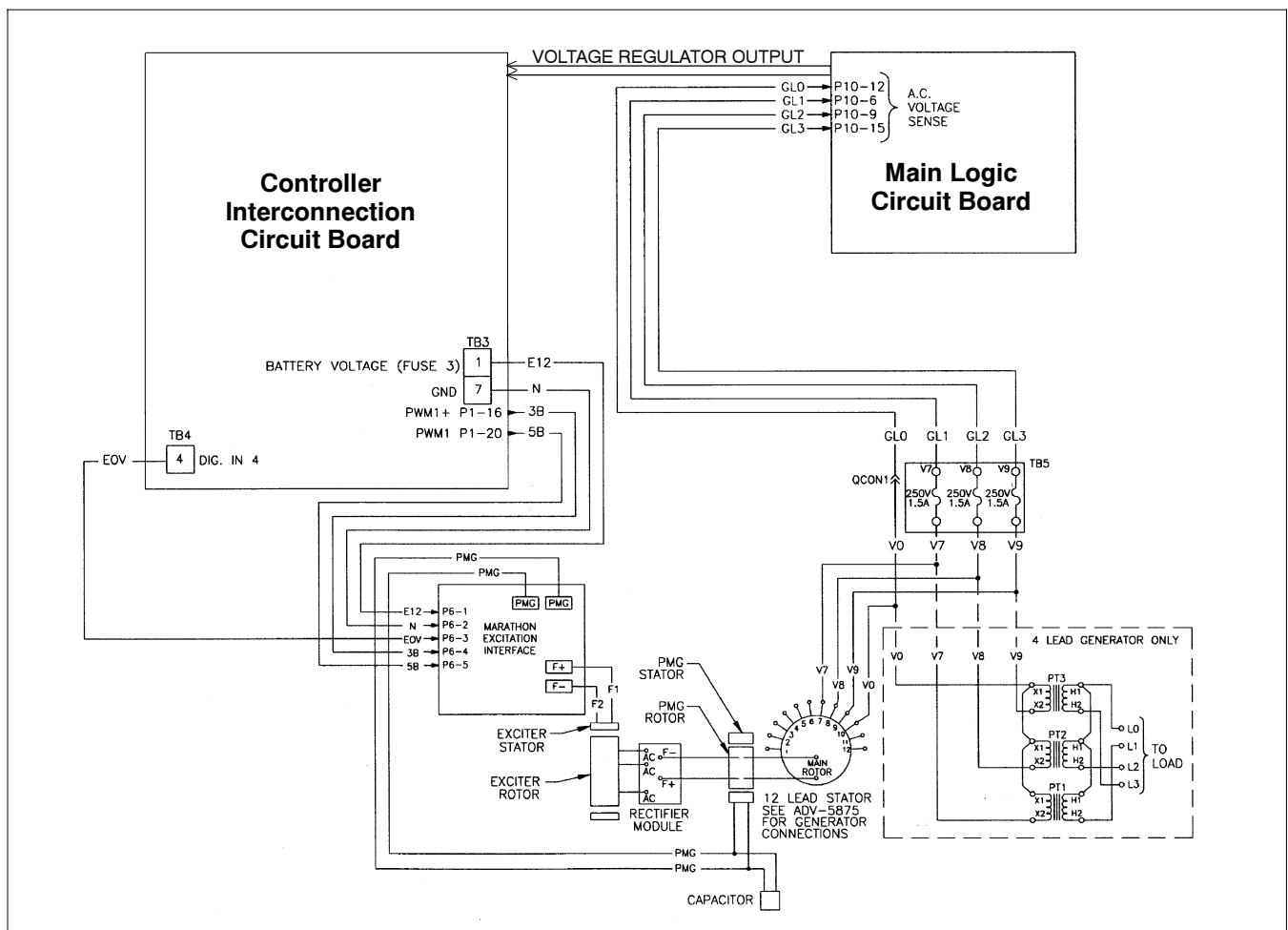
## 2.4 350-3250 kW Voltage Regulator (Brushless Alternator with Brushless Pilot Exciter)

The three-phase voltage-sensing regulator is built into the main controller logic board. Additionally, an interface board excites the 350-3250 kW alternator. See Figure 2-12. Voltage and stability control is based on programmed parameters that are part of the 550 controller personality profile for the specific generator set application. These programmed parameters are not field-adjustable. The voltage regulator output (3B-5B) is a pulse width modulation (PWM) signal. This PWM signal triggers the interface board excitation circuit allowing for DC main rotor field excitation.

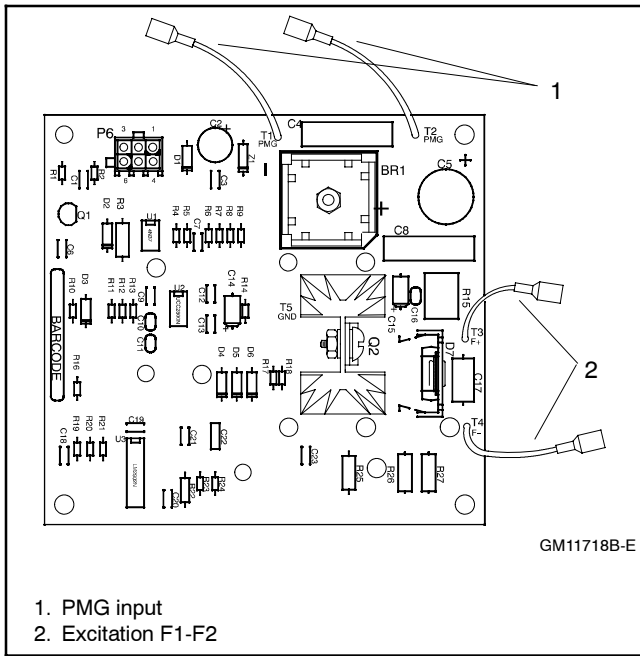
## 2.5 Interface Board

The interface board is required as part of the voltage regulation for 350-3250 kW alternators. The permanent magnet generator (PMG) input signal is rectified on the interface board. This rectified voltage provides the output stator excitation power.

The interface board requires battery voltage (12 or 24 volts) for control power. This power is fused with F3 located on the controller interconnect board. The overvoltage adjustment potentiometer controls the shutdown point for field overvoltage (EOV). The EOV output signal from the interface board is wired to interconnect board digital input 4. This input is defaulted for 350-3250 kW alternators to activate the field overvoltage shutdown (Marathon Over V). See Figure 2-13.



**Figure 2-12** Main Logic Circuit Board and Controller Interconnection Circuit Board with 350-3250 kW Excitation Interface Circuit Board



**Figure 2-13** Interface Board

## 2.6 Voltage Regulator Adjustment

### 2.6.1 Voltage Adjust

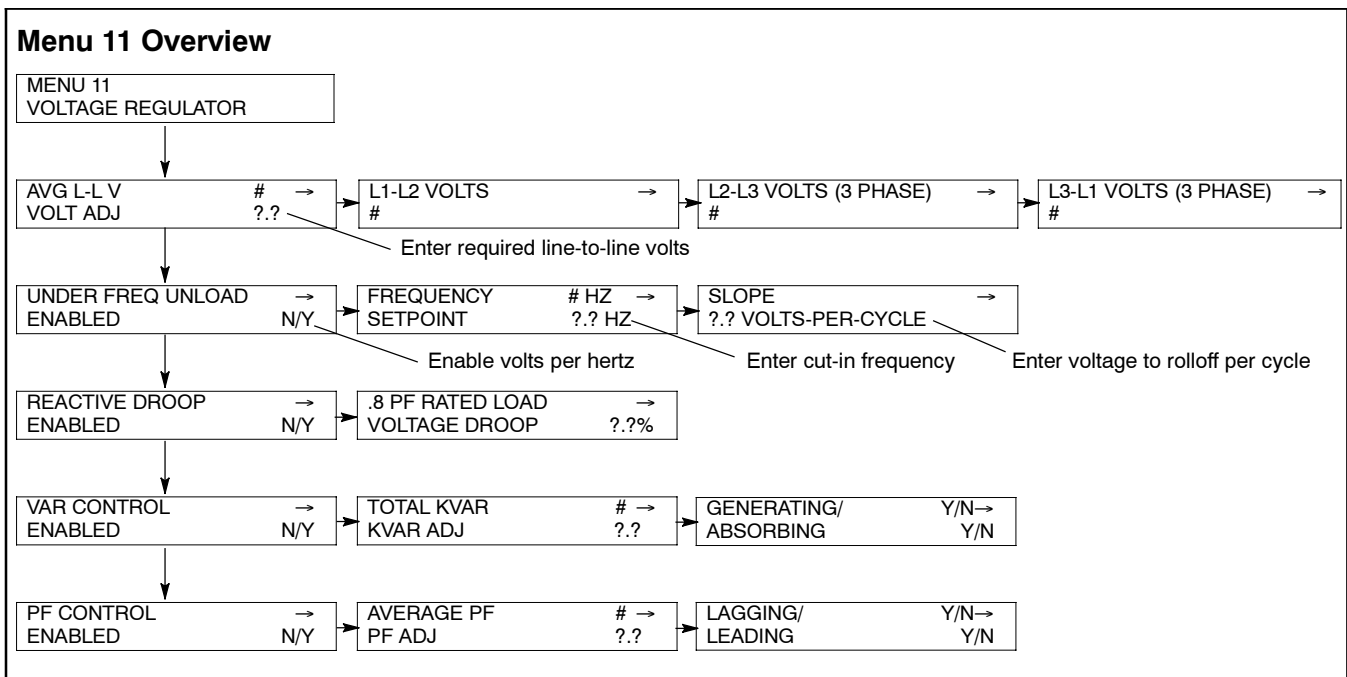
The voltage adjust is entered as the rated or otherwise desired line-to-line voltage. See Figure 2-14. The average of the line-to-neutral voltages is then regulated to the corresponding value. The setting may be as precise as one tenth of a volt. The voltage adjustment

defaults to the rated system voltage. The voltage adjust may be set to any value within 20% of the system voltage. The upper limit is 20% above the system voltage, and the lower limit is 20% below the system voltage. If a value beyond these limits is entered, a RANGE ERROR message appears.

As a reference, the present voltage adjust setting is displayed as well as the average value of the line-to-line voltages. The individual line-to-line voltages are also displayed on the subsequent menu screens, allowing the user to monitor any one phase if desired. The voltage adjust setting may be changed by means other than the menu; i.e., digital input or communications. If this occurs, the new value displays accordingly in the voltage adjust menu.

### 2.6.2 Underfrequency Unload Enable

This menu turns the underfrequency unload on or off. A yes entry turns the feature on and the display shows ENABLED YES. A no entry turns the feature off and the display shows ENABLED NO. The underfrequency unload defaults to an enabled (ON) condition. Underfrequency unload lowers the output voltage when the frequency dips due to large loads.



**Figure 2-14** Menu 11, Voltage Regulator

### 2.6.3 Frequency Setpoint

Frequency setpoint is the cut-in point for the underfrequency unloading. At any operating frequency below this value, the output voltage is reduced. The frequency may be entered with resolution to tenths of a hertz. The range of acceptable entries is 40 to 70 Hz. Any entry beyond these limits will cause a RANGE ERROR display, and the setting will not change. The default value is 1 cycle per second (or 2 for non-ECM engines) below the system frequency normal. The frequency setpoint changes to the default value if the system frequency changes. A setting of 40 Hz will essentially disable the underfrequency unload feature because most engines will not normally drop to this low speed even during load applications.

### 2.6.4 Underfrequency Unload Slope

The slope determines how much the voltage is reduced during an unloading condition. The line-to-line voltage is regulated to a value less than the voltage adjust setting by this amount for every cycle below the frequency setpoint. The voltage may be entered with resolution as fine as one tenth of one volt. The default value is 2.0 volts/Hz. A zero entry for the slope will in effect turn the underfrequency unload feature OFF.

## 2.7 Paralleling Applications (Reactive Droop)

### 2.7.1 Reactive Droop Enable

This menu allows the user to ENABLE the reactive droop feature. A yes entry turns the feature on and the display shows ENABLED YES. A no entry turns the feature off and the display shows ENABLED NO. Use reactive droop in a generator set to generator set paralleling application.

### 2.7.2 Voltage Droop

The amount of reactive droop is entered as a percentage of system voltage when applying full rated load, at 0.8 PF. The entry is made as precise as one tenth of a volt. This entry determines how much the voltage droops when the alternator provides reactive current. The actual amount the voltage changes is equal to the voltage droop setting times the VAR load as a fraction of the rated VARs at 0.8 PF.

If the generator set provides full rated load at 0.8 PF, the expected voltage change equals the voltage droop setting as a percentage of system voltage. A voltage droop setting of zero will in effect disable the reactive droop feature. The default value is 4% droop at full rated load at 0.8 PF. The voltage droop setting is displayed for reference. As this value changes via the remote communications, the display setting changes.

## 2.8 Paralleling Applications with Utility

### 2.8.1 VAR Control Enable

In order for the VAR control function to operate, it must be enabled. Entering yes at this menu turns the feature on. Because the function is designed to operate while in parallel with the utility, it also requires the proper indication that all tying circuit breakers are closed. This is done through the user programmable digital inputs. Because VAR control cannot be enabled at the same time that PF control is enabled, the action of turning VAR Control on (ENABLED) turns the PF control off (DISABLED) if it was previously ENABLED.

To activate the VAR or PF modes, a digital input to TB-4 is required. This input should indicate the generator set is paralleled to the utility. After the digital input is grounded, the VAR or PF adjustment initiates.

**Note:** When the VAR control is enabled, the unit will not shut down when TB-4-17 is grounded.

### 2.8.2 KVAR Adjust

The KVAR adjustment is used to set the desired operating value for the generator set reactive load when in a utility paralleling application. Enter the desired generator set load directly as kVARs. The value entered may be as low as zero or as high as the rated value (rated kW x 0.75). Any entry beyond this will not be accepted and a RANGE ERROR message is displayed. The default value for KVAR adjust is zero. Any time the system rated kW is changed, the KVAR adjust will revert to this default value. Because the KVAR adjust may be changed via other inputs, the display setting changes.

### 2.8.3 Generating/Absorbing

While operating in the VAR control mode, the generator load may be specified to be out of (generating) or into (absorbing) the generator. Set through the generating/absorbing menu. Because the normal flow of reactive current is out of the generator, the default value for this setting is generating. If absorbing is desired, a NO entry at this menu will change the control mode to absorbing. When absorbing is selected, another NO entry will revert back to generating. It is assumed that this mode will not be changed when the generator set is running. Therefore, an attempt to change the mode while running will return a RANGE ERROR message. Shut down the generator set to change this setting.

### 2.8.4 Power Factor Adjust

Use the PF adjust to set the desired operating relationship for the generator set output and current when connected in parallel with the utility. The regulated excitation maintains a PF that is equal to the entered value. The value entered may be 0.7 for leading PFs to 0.6 for lagging PFs. Any entries outside these limits cause a RANGE ERROR message display. The default value for PF adjust is 0.8 lagging. Whenever the system rated kW changes, the PF adjustment reverts to the default value. If the PF adjustment is changed via other inputs, the display setting changes.

### 2.8.5 Lagging/Leading

It is possible to select either a leading or lagging PF for utility parallel applications. The controller displays the selected mode. A NO entry switches the controller to use the opposite relationship for regulation purposes. This may only be changed while the generator set is not running. Lagging is the default value because the most common mode of operation has a lagging PF.

## 2.9 Alternator Protection

Inherent alternator protection is part of the personality parameters program installed in the controller. The parameters program is specific to the alternator listed in menu 20 of the controller. The alternator part number is listed on the controller software label located inside the 550 controller. The programmed protection limits for the controller/alternator cannot be adjusted. When the alternator current output exceeds the programmed overload and short circuit limits, the generator set shuts down. The local display will read *altrntr protect sdwn* (alternator protection shutdown).

## 2.10 Load Shed

The load shed feature is based on either kW overload or underfrequency. See Figure 2-15.

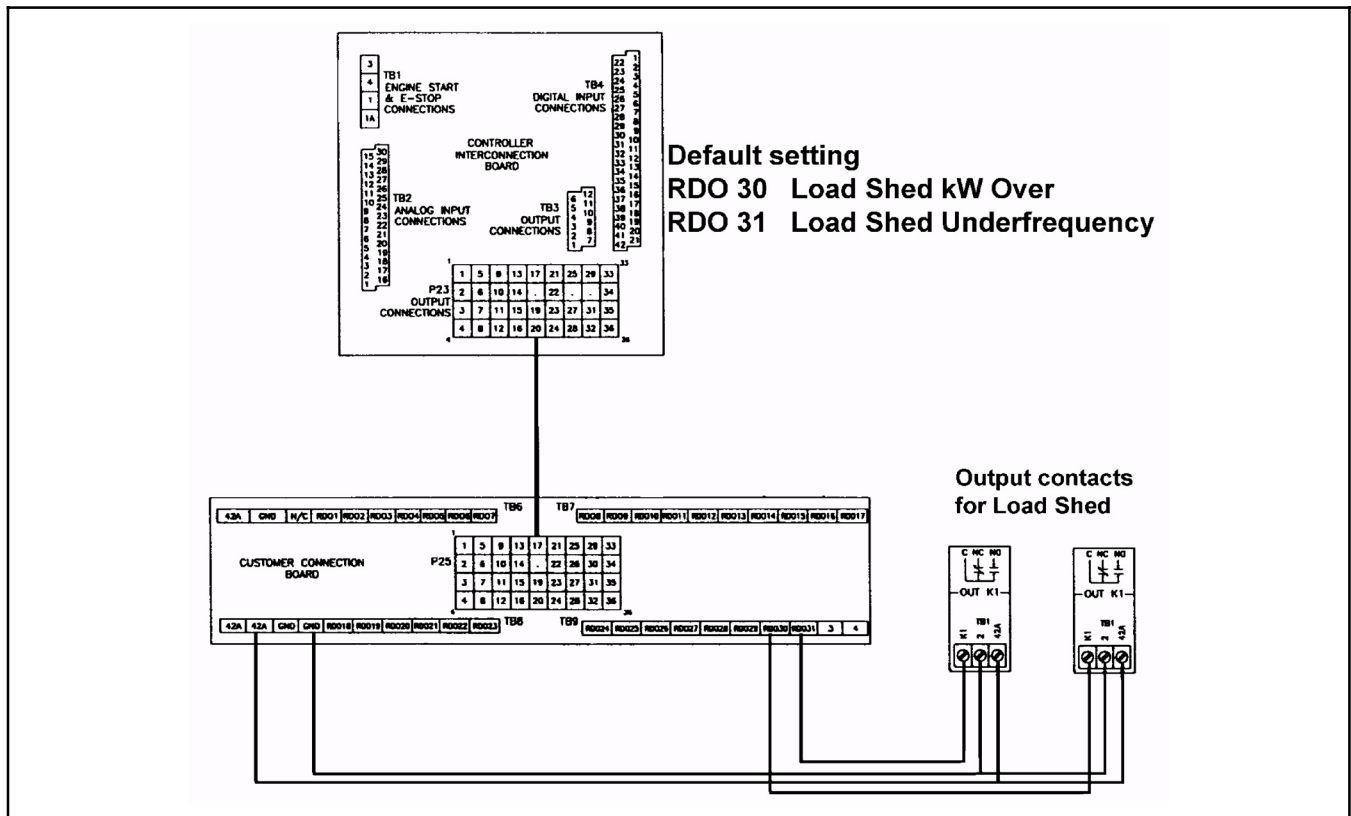


Figure 2-15 Load Shed Feature

If the generator set output exceeds the kW load shed limits defined in menu 7, a local warning for load shed kW over is displayed. This warning, defined as a relay driver output (RDO), trips a downstream circuit breaker allowing the excess load to be shed when the generator set is online. If the generator set output frequency drops to 59 Hz for 60 Hz operation or 49 Hz for 50 Hz operation, the controller displays a load shed underfrequency local warning. This warning can be programmed as an RDO to trip a circuit breaker allowing load shedding. The underfrequency setpoint is a fixed nonadjustable setting and is programmed with a 5-second time delay.

## 2.11 Controller with Marathon DVR 2000 Voltage Regulator Substitution

Certain early shipments of the 550 controller were equipped with the Marathon DVR2000 voltage regulator. Figure 2-16 shows the location of the DVR 2000 voltage regulator inside the junction box.

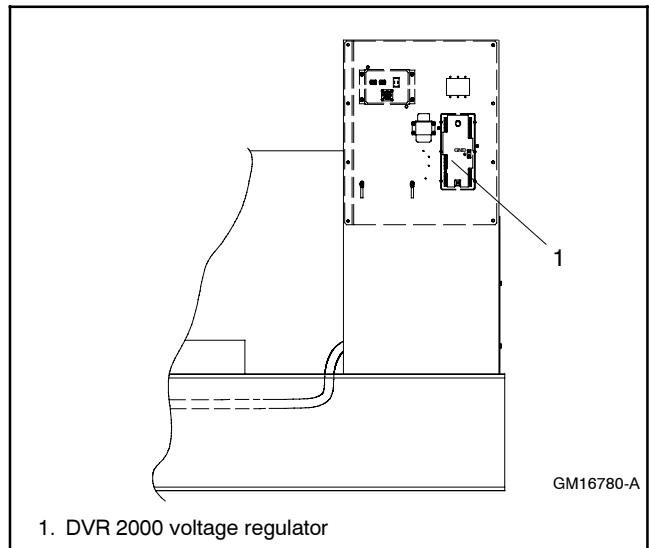
The internal 550 controller voltage regulator and the DVR2000 voltage regulator share most features. The following features, however, are not available with the DVR 2000 voltage regulator:

- Voltage regulator programming using the controller keypad. Make adjustments to the DVR 2000 voltage regulator at the voltage regulator. Remove the junction box cover to adjust the DVR 2000 voltage regulator.
- Voltage setting using the controller keypad.
- Volts/Hz display.

- VAR/power factor controller, display, and adjustment. This feature is available as an accessory; order part number PA-347165 or PA-347165-SD.
- Reactive droop controller, display, and adjustment.
- Engine idle mode capability using the controller (voltage regulator is deenergized).

The 550 controller spec sheet and operation manual provide only information regarding the controller voltage regulator. For information regarding the DVR 2000 voltage regulator, obtain TP-5579, Operation Manual, DVR 2000 Voltage Regulator.

Use Figure 2-17 for installation and troubleshooting of the electrical wiring system.



**Figure 2-16** DVR 2000 Voltage Regulator Mounting Location



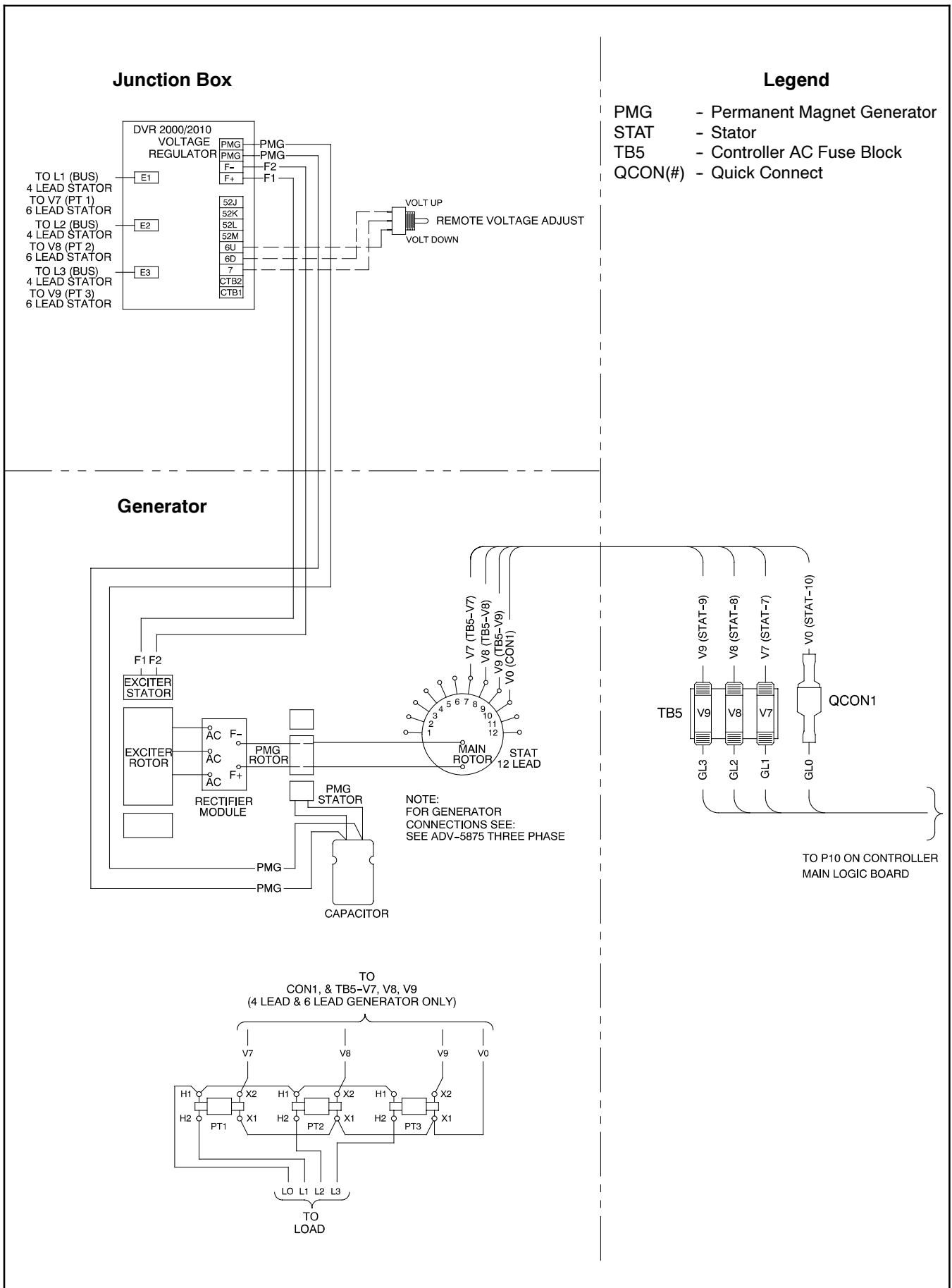


Figure 2-17 DVR 2000 Voltage Regulator/Alternator Interconnection Wiring Diagram, GM20500

# Notes

## 3.1 Voltage and Current Inputs

Voltage and current inputs enter the controller at P10 of the main logic board. The inputs are required for metering calculations, voltage regulation, voltage and current protection, and secondary crank termination (non-ECM engines). See Figure 3-1.

## 3.2 Voltage Measurement

The voltage inputs are V7, V8, V9, and V0 and terminate at generator windings 7,8,9, and neutral for 10- and 12-lead alternators. For a 4-lead alternator, a transformer assembly is required to step down the voltage to input levels acceptable for the controller (240 volts and below). TB5 is a fuse block for voltage input protection. The fuse rating is 1.5 amps at 250 volts.

## 3.3 Current Measurement

For generator sets above 200 kW, a CT burden resistor board is included with the 550 controller application. The board is located in the junction box with wiring between the 550 controller and the CT burden resistor board. CTs with 0.5 amps secondary current are mounted in the junction box and wired to TB11. The CT burden resistor board converts the CT current input to a voltage output (P26) for the 550 controller main logic board. The current input and voltage output are proportional; i.e., the greater the current sensed, the higher the voltage output. Generator sets 20-200 kW utilize a CT with the resistor installed as part of the CT, so no burden resistor board is required.

**Note:** The CTs with 0.5 amp secondary outputs are unique to the 550 controllers.

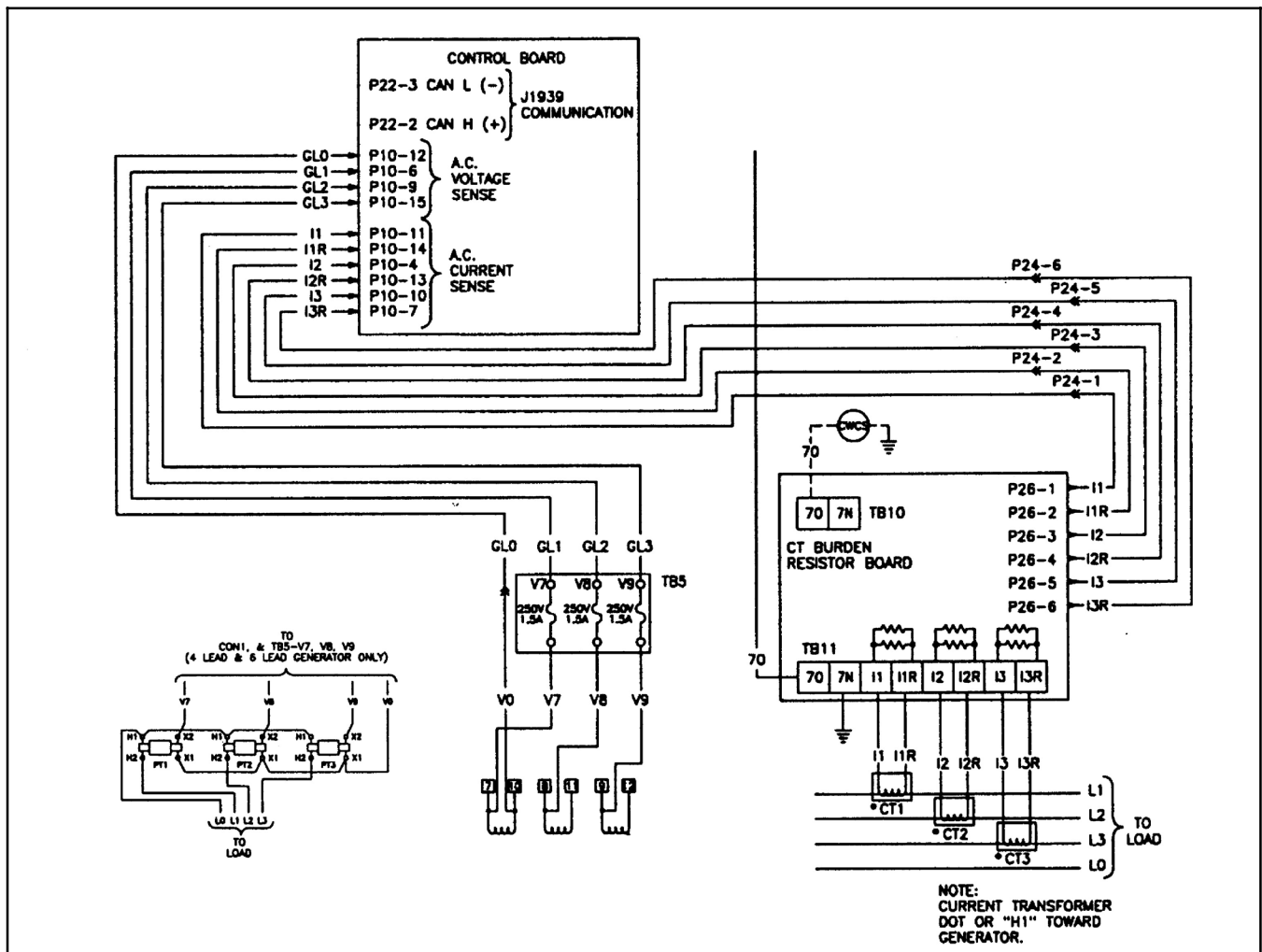


Figure 3-1 Voltage and Current Inputs

### 3.4 Calibration: Voltage and Amperage (Menu 12)

The 550 controller requires voltage and current sensing input calibration. See Figure 3-2. Calibration is initially done at the factory and typically requires no adjustment in the field. If, however, the system voltage is reprogrammed or the controller is replaced, calibration

is necessary. Controller calibration is based on readings taken from the generator output windings using a multimeter with a minimum accuracy of +/-1%. Voltage readings are taken from line-to-neutral and must be done for L1, L2, and L3, if required. Current measurement is based on readings taken with a handheld AC ammeter for L1, L2, and L3.

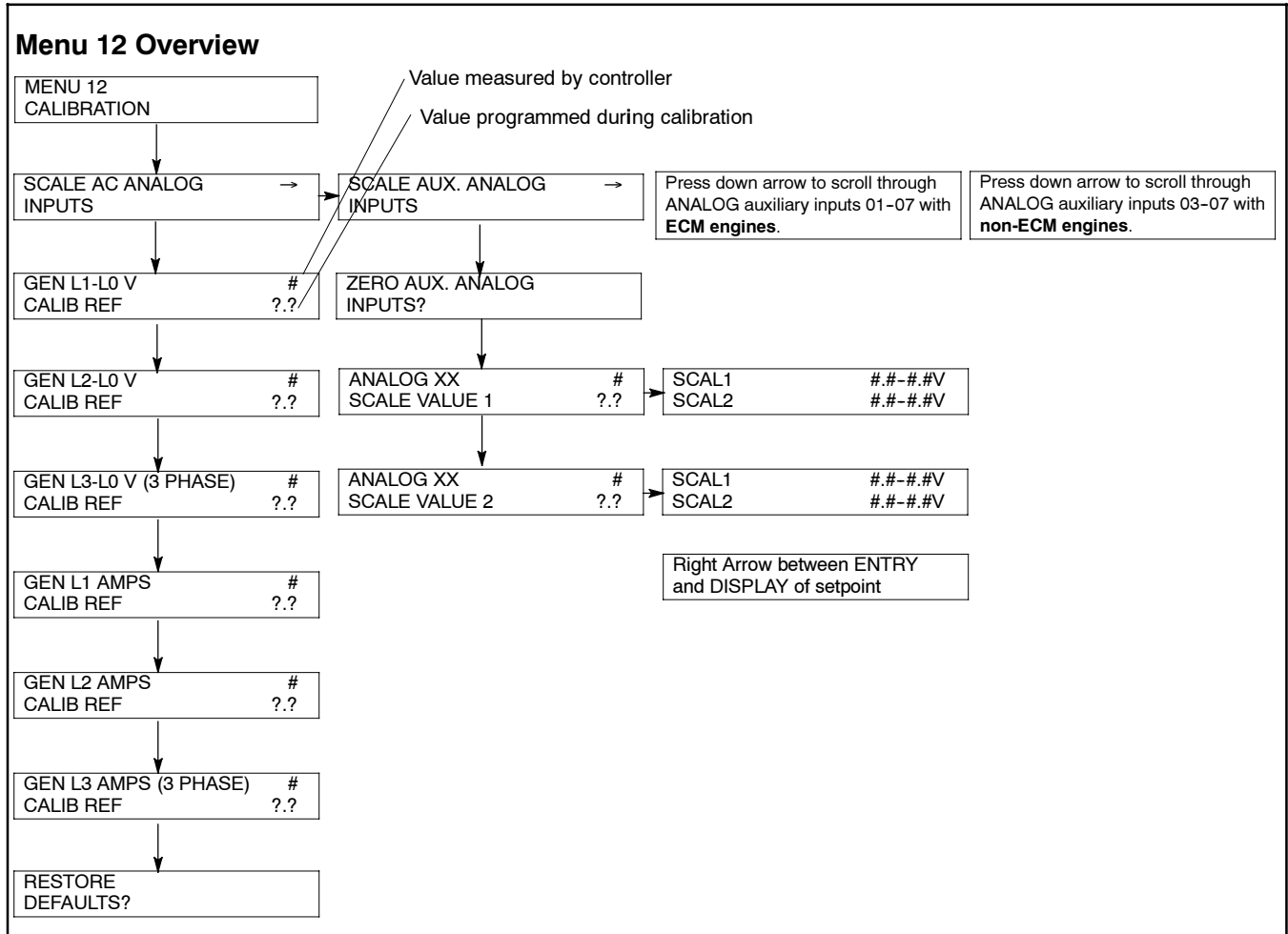


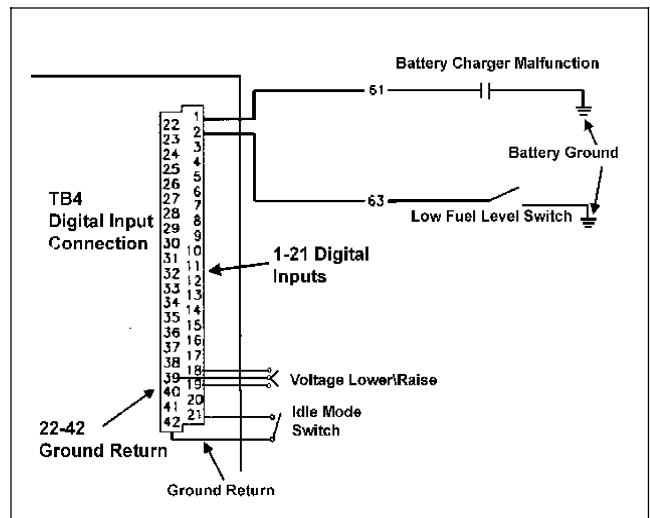
Figure 3-2 Menu 12, Calibration

## 3.5 Digital Inputs

Digital inputs are specific on-off inputs that monitor the external parameters. These inputs may come from a battery charger, switchgear, fuel tank, or other external devices. Inputs may be wired as a single-wire connection with the return wire going to battery ground (example: battery charger connection). Inputs can also be wired as a two-wire connection with the return ground going to TB4, 22-42 (example: idle mode switch). Inputs are based on the digital signal switching to battery ground or ground return of TB4 to initiate a controller action. Typically, the digital input signal switching is done with a relay dry contact and not with a powered contact. See Figure 3-3.

Factory programmed defaults for TB4 inputs 1 through 21 are as follows:

1. Battery Charger Fault
2. Low Fuel
3. Low Coolant Temperature
4. Excitation Overvoltage (Marathon alternator only)
5. Warning
6. Warning
7. Warning
8. Warning
9. Warning
10. Warning
11. Warning
12. Warning
13. Warning
14. Warning (all models except 50-100ROZK)  
Low Coolant Level (50-100ROZK)  
**Note:** All models, except 50-100ROZK use P1-10 as the low coolant level.
15. Remote Shutdown
16. Remote Reset
17. VAR PF Model
18. Voltage Lower
19. Voltage Raise
20. Air Damper
21. Idle Mode



**Figure 3-3** Digital Inputs

Each input (other than those predestined) can be programmed as a warning or a shutdown and also can have an inhibit and a delay time.

If the controller is programmed to meet NFPA 110 requirements (the NFPA 110 setting is found in menu 7), inputs 1, 2, and 20 are factory-defined and the user cannot change the preset function. If the controller is used with an ECM-equipped engine, digital input 3 (low coolant temperature) is predefined. If the controller is used in conjunction with the Marathon alternator, digital input 4 (MARATHON OVER V) is predefined. Both digital and analog input descriptions can be defined remotely with alphanumeric characters on the controller display. Define inputs as needed by using the communication software and programming inputs as desired.

### 3.5.1 Idle Mode Switch

The idle mode input function is only active on ECM-equipped engines. The idle speed function starts and runs the engine at idle during nonemergency operation. Closing the switch starts the generator set in idle mode, and the engine remains running at idle until the generator set reaches a predefined temperature or the idle timer is complete. When warmed-up temperature is reached, the engine is ramped to rated speed and remains running until the switch is opened. The alternator output is disabled during idle operation.

### 3.5.2 Define Digital Inputs

Menu 9 identifies the user-defined wired inputs to the TB4 terminal strip. See Figure 3-4. Menu 9 allows the user to customize the digital inputs for the application required. Program menu 9 at the controller keypad or from a PC using the Monitor II software. If programming with the controller keypad, select the digital input descriptions in menu 9. See Figure 3-5.

When an input is activated, the controller displays the active input D1–D21 (after the inhibit time and delay time have timed out). The user can also program a relay driver output (RDO) in menu 10 that corresponds to the digital input.

| Input                | Description  |
|----------------------|--|
| Warning              | Horn sounds and customer auxiliary lamp lights                                   |
| Shutdown Type A      | Initiates shutdown removing power to ignition and crank                          |
| Shutdown Type B      | Initiates shutdown similar to type A and activates the air damper RDO            |
| Voltage Raise/Lower  | Remote input to adjust voltage   |
| VAR/PF Mode          | Initiates VAR or power factor mode of voltage regulator (parallel with utility)  |
| Remote Shutdown      | Used for remote shutdown from switchgear   |
| Remote Reset         | Used to reset controller faults from remote location                             |
| Air Damper           | Initiates air damper shutdown  |
| Low Fuel             | Warning for low fuel level or pressure   |
| Marathon Over V      | Field overvoltage shutdown (Marathon alternator)                                 |
| Battle Switch        | Overrides all warnings and shutdowns except overspeed and air damper             |
| Idle Mode            | ECM engines only; allows engine idle on startup and shutdown for programmed time |
| Ground Fault         | Indicates ground fault (ground fault sensor required)                            |
| Bat Chgr Fault       | Warns of battery charger malfunction   |
| High Oil Temperature | Initiates high oil temperature shutdown  |
| Low Coolant Level    | Initiates low coolant level shutdown   |
| Low Coolant Temp     | Activates digital input 3 (only available when used with ECM engines)            |

Figure 3-4 Selection Group Digital Inputs

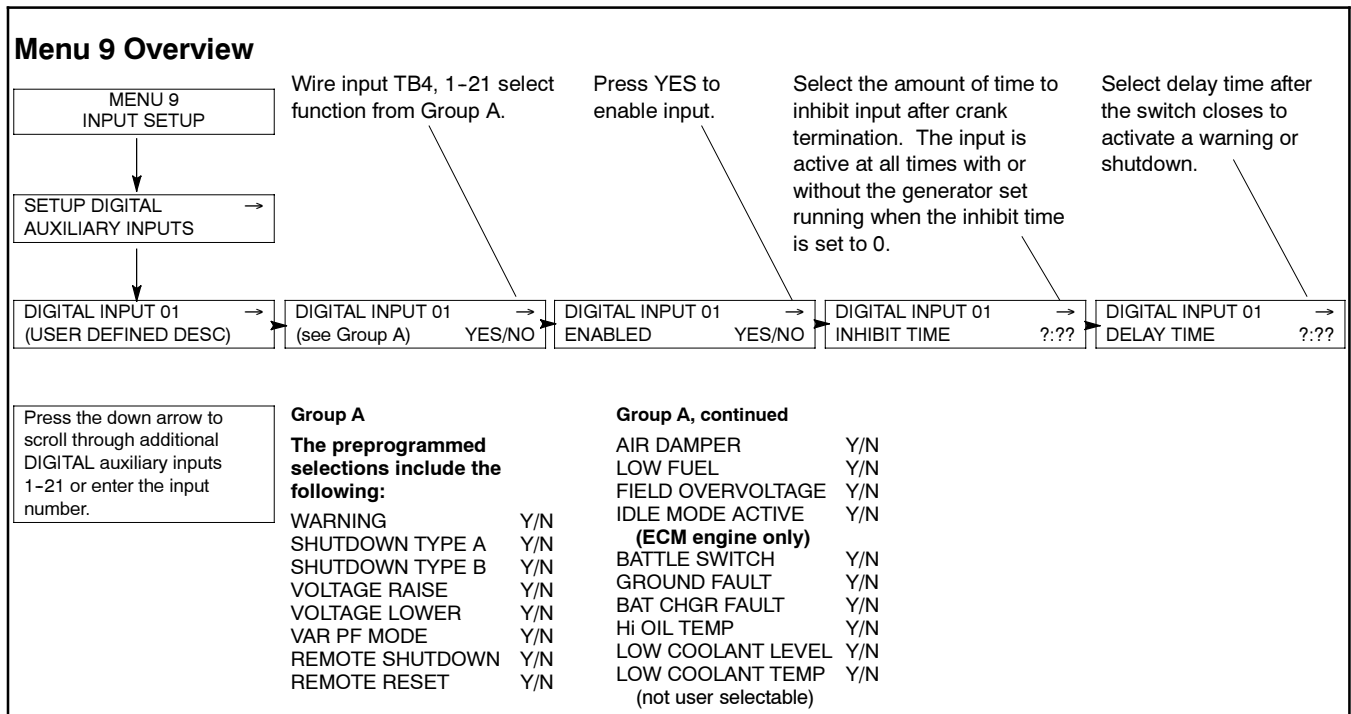


Figure 3-5 Menu 9, Input Setup (Programming of Digital Input 01 Shown, Repeat for Inputs 02-21 as needed)

### 3.5.3 TB1 Customer Connection

TB1 provides access to remote start inputs 3-4. See Figure 3-6. Contact closure on terminals 3-4 initiates an engine start sequence, provided the master control switch is in the auto position. Typical installation has the remote start wired to the automatic transfer switch.

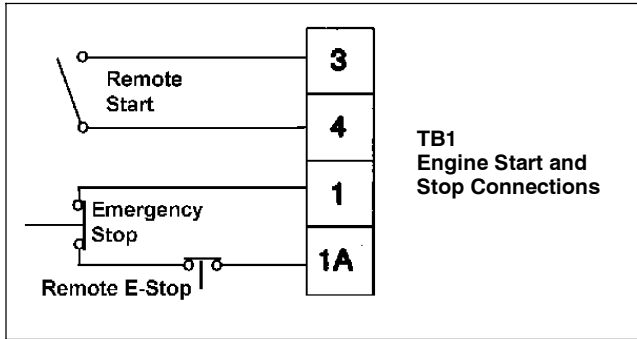


Figure 3-6 TB1 Engine Start/Stop Connections

Terminals 1-1A are used for the emergency stop switch. The switch is normally closed and opening causes an immediate engine shutdown. If adding remote E-stop switches, always use a series connection between switches.

### 3.5.4 TB3 Accessory Output

The TB3 output accessory terminal block provides connections for 12 VDC options that require a fused 5-amp power source. TB3 allows connection to 42A and battery ground. Terminal 42A is a fused 5-amp battery supply (fuse F1). See Figure 3-7.

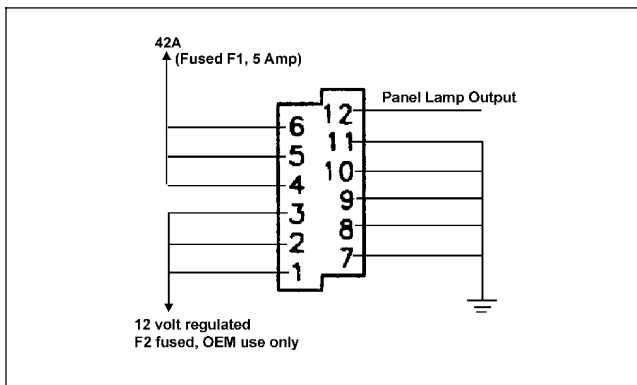


Figure 3-7 TB3 Fused 5-Amp Power Source

### 3.5.5 TB2 Analog Inputs

TB2 provides 0-5 VDC analog signal inputs for customer connections. The installer must scale and calibrate each analog input before the input value becomes a warning or shutdown trip point value. See Figure 3-8. Analog inputs 1-7 are available for user-defined applications on ECM-engine models. Non-ECM engines have analog inputs 3-7 available for optional applications, while inputs 1-2 are reserved for oil pressure and coolant temperature. On ECM engines, oil pressure and coolant temperature come from the ECM. Refer to Section 2.2, ECM Engines and Controller Displays, for identification of ECM engines.

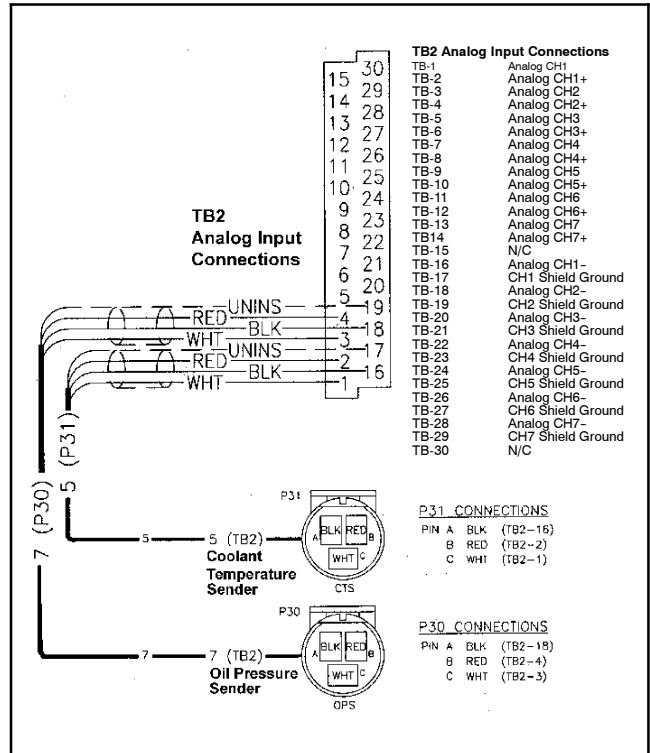


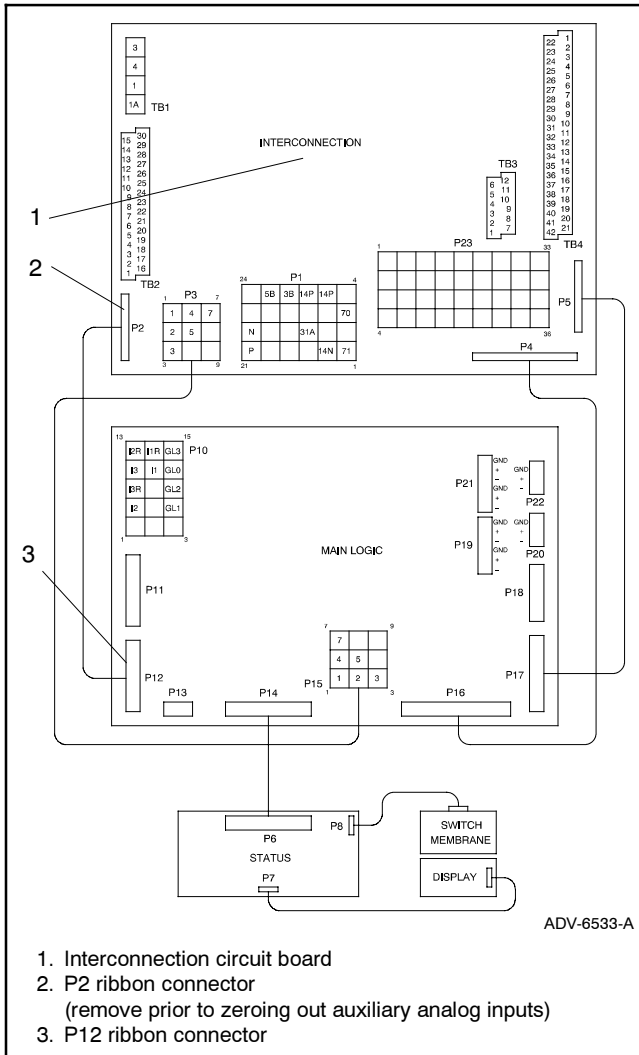
Figure 3-8 TB2 Analog Inputs

The oil pressure input is responsible for low oil pressure warning and shutdown functions and for the oil pressure value (menu 2). The coolant temperature sender is responsible for high coolant temperature warning and shutdown functions, low coolant temperature warning, and coolant temperature value (menu 2).

Analog inputs 1-2 for non-ECM units do not have access for adjustment or calibration. The oil pressure and coolant temperature parameters and calibration are part of the factory-installed personality blk program for the controller, and no further adjustment is necessary.

### 3.6 Zeroing Auxiliary Analog Inputs

In the calibration process for analog inputs (menu 12), the sender needs to be zeroed out. To accomplish this, disconnect the P2 ribbon cable prior to the zeroing out procedure. See Figure 3-9. After P2 has been disconnected, answer *yes* to the question ZERO AUX. ANALOG INPUTS? Then reconnect P2 connector to complete the sender calibration.



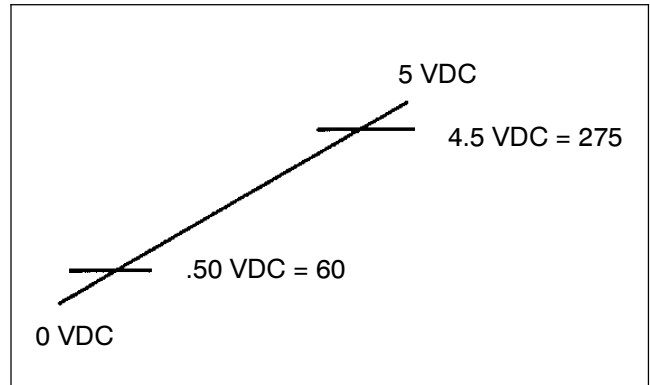
**Figure 3-9** Interconnection Circuit Board Ribbon Connector P2 (Top View of Circuit Board)

### 3.7 Analog Inputs (Calibration)

Using the analog input requires a sender or device that is scaled based on a 0-5 VDC signal with a calibrated output. See Figure 3-10.

Example: Temperature Sender

.50 VDC @ 60°F  
4.50 VDC @ 275°F



**Figure 3-10** Analog Input Scale Values (sample)

Analog calibration is required; see menu 12. See Figure 3-11. To calibrate analog inputs, program two scale values to allow the controller to create a linear scale between the two values that represents the selected device.

To set scale value 1, program a scale value based on the sender output voltage. For example, if the sender device output is 0.50 VDC, the value represents 60°F (based on calibration data of temperature sender). To set scale value 2, increase the device output to 4.5 VDC and enter a value of 275 (representing 275°F). This completes the linear scale setup.

The acceptable scale range is 0 to 9999, giving a resolution of one part in 10,000.



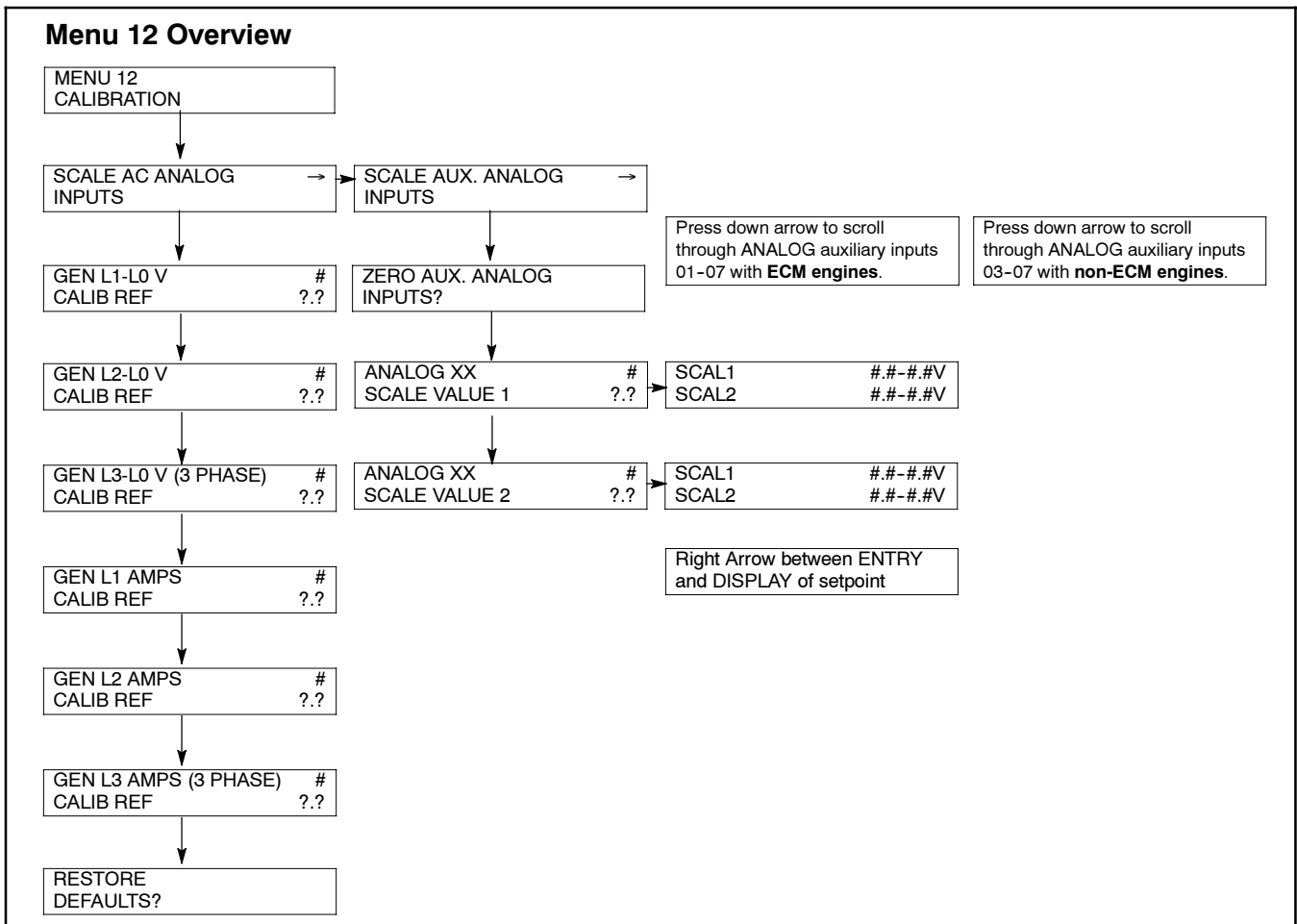


Figure 3-11 Menu 12, Calibration

### 3.8 Alternative Calibration Method

Substitute a potentiometer for the sender or device to calibrate the input values if it is difficult to adjust the sender output. Install a potentiometer in place of the three-wire sender to adjust the voltage between 0-5 VDC, and enter the calibrated values when the input value matches the known calibrated value. See Figure 3-12.

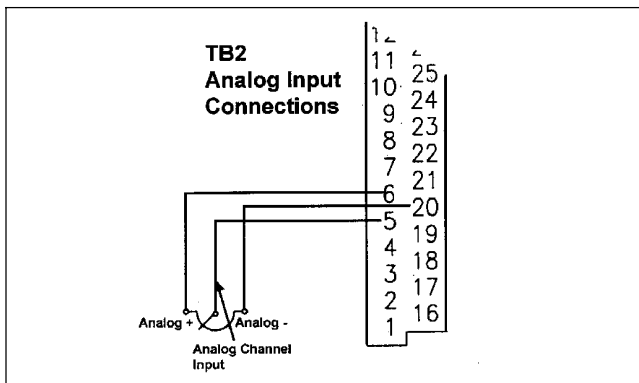


Figure 3-12 Potentiometer Connections on TB2

A 10-turn, 10 kOhm potentiometer is recommended for fine adjustment in calibration.

**Note:** Remember to zero auxiliary analog inputs before entering calibrated values.

Example: Temperature Sender

.50 VDC @ 60°F  
4.50 VDC @ 275°F

1. Wire the potentiometer according to Figure 3-13.
2. Adjust the potentiometer for value 1 to read 0.5 volts and enter 60 for the known calibrated value.
3. Adjust the potentiometer for value 2 to read 4.5 volts and enter 275 for the known calibrated value.

### 3.9 Analog Input (Warning/Shutdown)

Define the analog input as a warning and/or shutdown device or the analog input can be used for data information purposes only. To program the desired function, the user defines variables in menu 9. This menu allows the user to define the analog input for the desired application.

Procedure to define an analog input as a warning and/or shutdown:

1. After entering the analog input in menu 9, enable or activate the input as a warning and/or shutdown. If neither is selected, the input displays data but no action is associated with the input. See Figure 3-13.

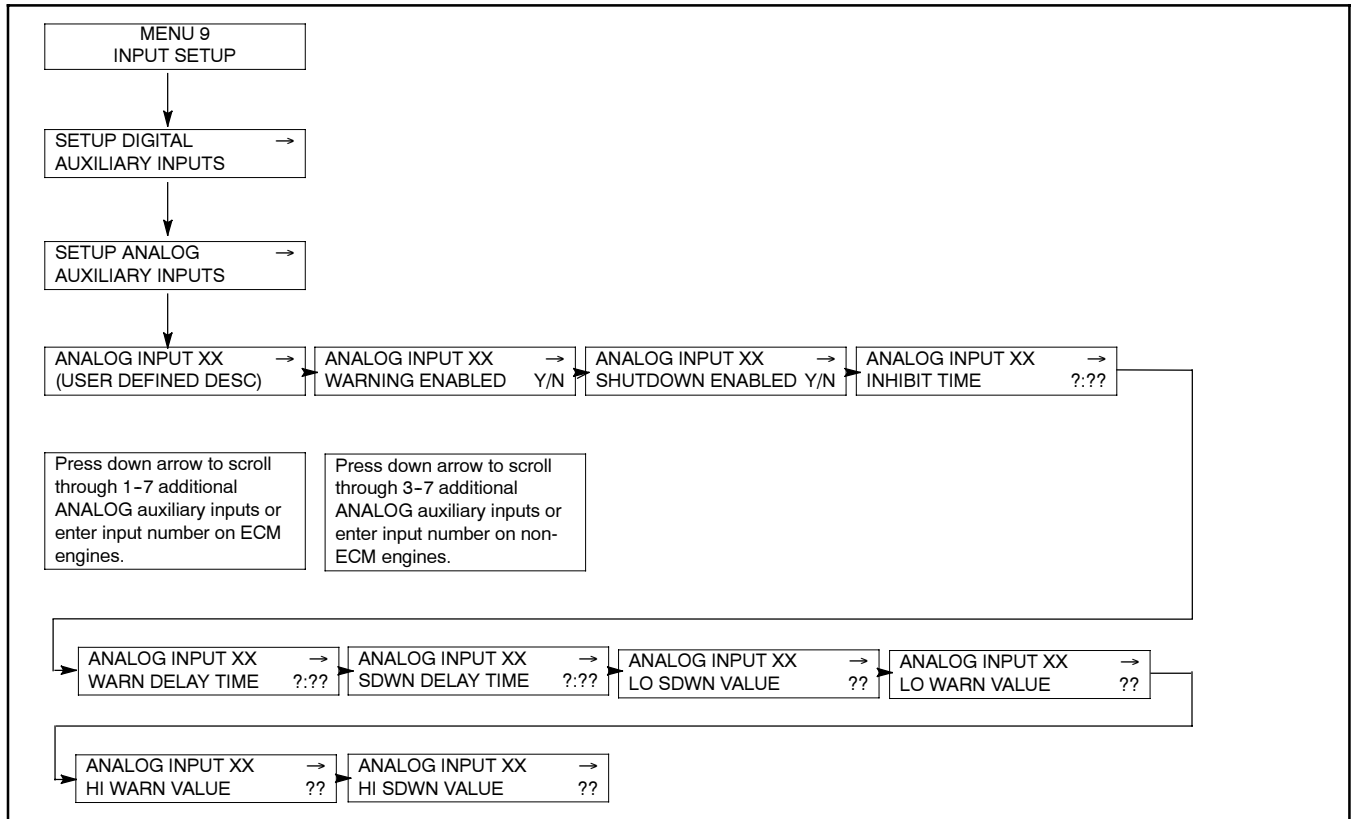


Figure 3-13 Menu 9, Input Setup

2. After the input is activated, program an inhibit time. This is a time delay preventing an action for a time (inhibit) after a crank disconnect. Typically this time is set at 30 seconds.

**Note:** To have the input *active* at all times, set the inhibit time to 0.

3. Program the delay time to function after the inhibit time delay has timed out. This time delay is the time period between when the controller first detects the fault and when the controller indicates a warning or shutdown. The fault must be present for the total delay time.
4. Enter values to initiate the controller action as a warning or shutdown. The operator determines the application values and enters the values based on the calibrated scale in menu 12. See Figure 3-14 for an example of warning and shutdown values.

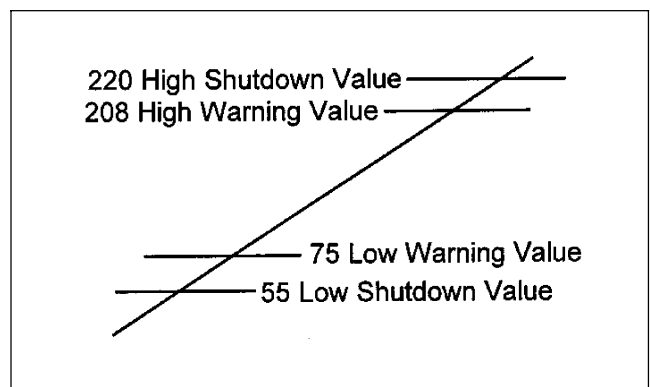


Figure 3-14 Setting Warning and Shutdown Values

## 3.10 Relay Driver Outputs (Menu 10)

Up to 31 RDOs are available to define using the system events, digital inputs, and analog inputs giving the user flexibility for control or remote annunciation. RDOs provide only the relay driver, not the relay. RDOs are used in conjunction with the customer connection kit and, typically, will drive all relay kits. Refer to Appendix D for RDO factory designations and user-defined designations.

### 3.10.1 NFPA Defaults

If the controller is programmed with NFPA enabled (menu 7), the controller will automatically define a number of RDOs as defaults, and the user cannot reset these defaults. If the user attempts to reassign the default, a message displays *Cannot Change NFPA is Enabled*.

### 3.10.2 Common Fault

The user can program the common faults (menu 10) from the list of system events, digital inputs, and analog inputs. To define a common fault, go through the submenus and enter yes to any items wanted as part of a common fault. Then designate an RDO (1-31) to drive the common fault relay output. See Figure 3-15.

A common fault acts as an *or* function. The output occurs when any one of the items occur, such as A or B or C, etc.

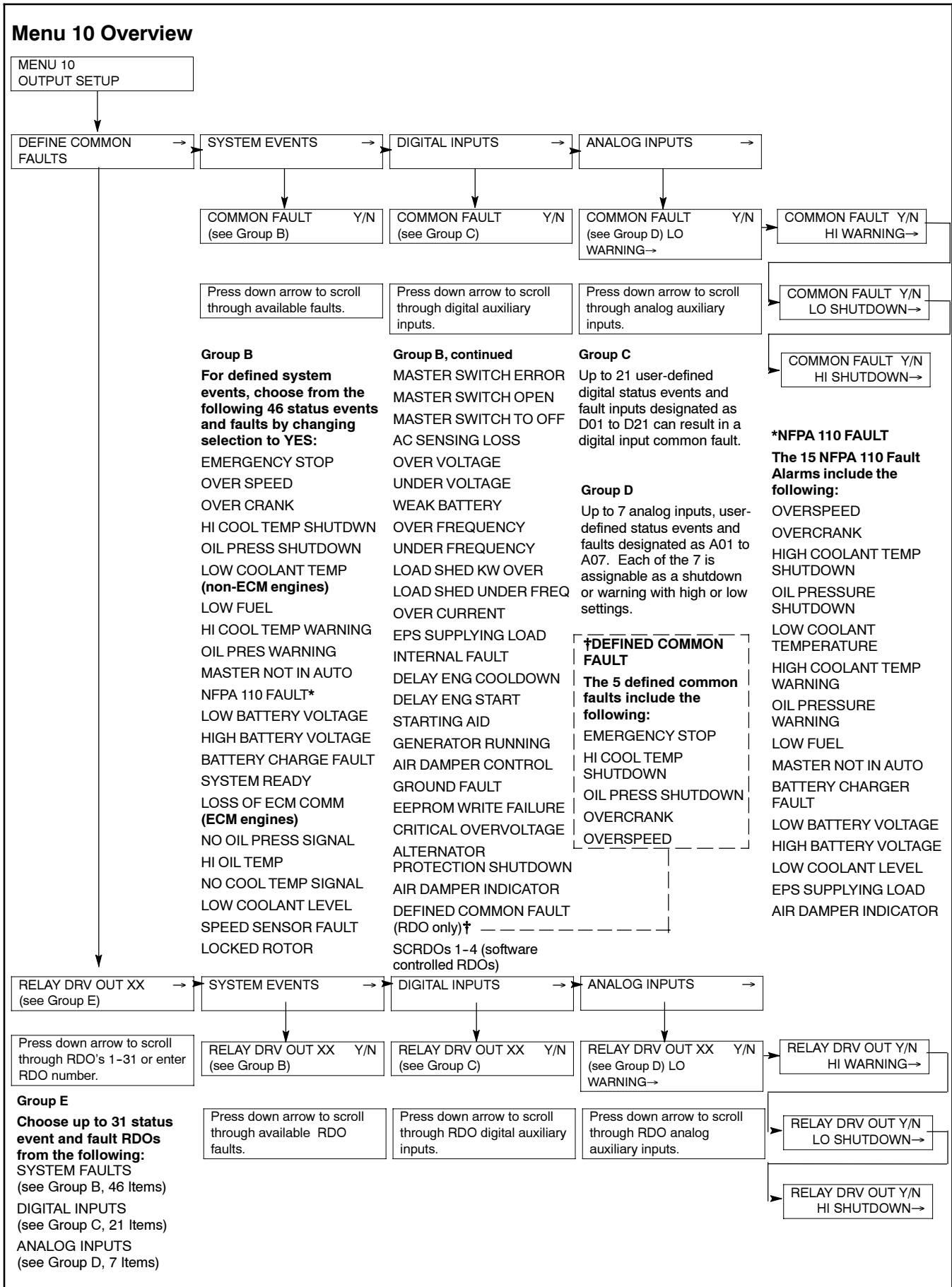


Figure 3-15 Menu 10, Output Setup

## Section 4 Accessory Installations

### 4.1 Accessories and Connections

Several accessories help finalize installation, add convenience to operation and service, and establish state and local code compliance.

Accessories vary with each generator set model and controller. Select factory-installed and/or shipped-loose accessories. See Figure 4-1 for a list of available kits. Kit and installation instruction part numbers change. Obtain the most current accessory information from your local authorized service distributor/dealer.

This section describes several accessories available at the time of print of this publication. Accessory kits generally include installation instructions. See the wiring diagram manual for electrical connections not shown in this section. See the installation instructions and drawings supplied with the kit for information on the kit mounting location. See Figure 4-2 and Figure 4-3.

The instructions provided with the accessory kit supersede these instructions where there are differences. Always run AC and DC wiring in separate conduit. Use shielded cable for all analog inputs. Observe all applicable national and local electrical codes during accessory installation.

| Kit Description  | Kit Part Numbers  | Installation Instructions                        |
|--|---|--|
| Audiovisual Alarm  | GM17070-KP1, GM17070-KP2, GM17070-KP3   | TT-1300  |
| Battle Switch  | New   | New  |
| Common Failure Relay (terminal 32A)  | GM17028-KP2, GM17032-KP2, 365569-KP14   | TT-1301  |
| Controller (customer) Connection   | GM17028-KP1, GM17032-KP1  | TT-1302  |
| Float/Equalize Battery Charger (with alarms)   | PAD-292863 (12 volt), PAD-292865 (24 volt)  | TT-680   |
| Idle (speed) Mode Feature  | No kit required. Use customer-supplied switch and leads.  | See operation manual (idle mode feature)         |
| Key Switch   | New   | New  |
| Low Fuel (level) Switch  | Multiple kits based on generator set subbase fuel tank or day tank selection.<br><b>Note:</b> The main fuel tank may include this switch as provided by the fuel tank supplier. | Multiple TTs or contact main fuel tank supplier. |
| Low Fuel (pressure) Switch   | Multiple kits based on generator set model number.  | Multiple TTs                                     |
| Prime Power Switch   | GM20652-KP1   | New  |
| Remote Annunciator (16-light panel)  | GM17071-KP1, GM17071-KP2, GM17071-KP3   | TT-1303  |
| Remote Emergency Stop  | PA-293906   | New  |
| Remote Reset Feature   | No kit required. Use customer-supplied switch and leads.  | See operation manual (remote reset feature)      |
| Remote Speed Adjustment Potentiometer (requires electronic governor)( non-ECM models only) | PA-273768   | TT-774   |
| Run Relay  | PA-273743 (12 volt), PA-273744 (24 volt), 365569-KA8 (24 volt)  | New  |
| Single-Relay Dry Contact   | GM17068-KP1, GM17068-KP2, 365569-KP9  | TT-1304  |
| Ten-Relay Dry Contact  | GM17069-KP1, GM17069-KP2, 365569-KP10   | TT-1305  |
| Twenty-Relay Dry Contact   | 365569-KA13   | New  |

**Figure 4-1** Optional Accessories

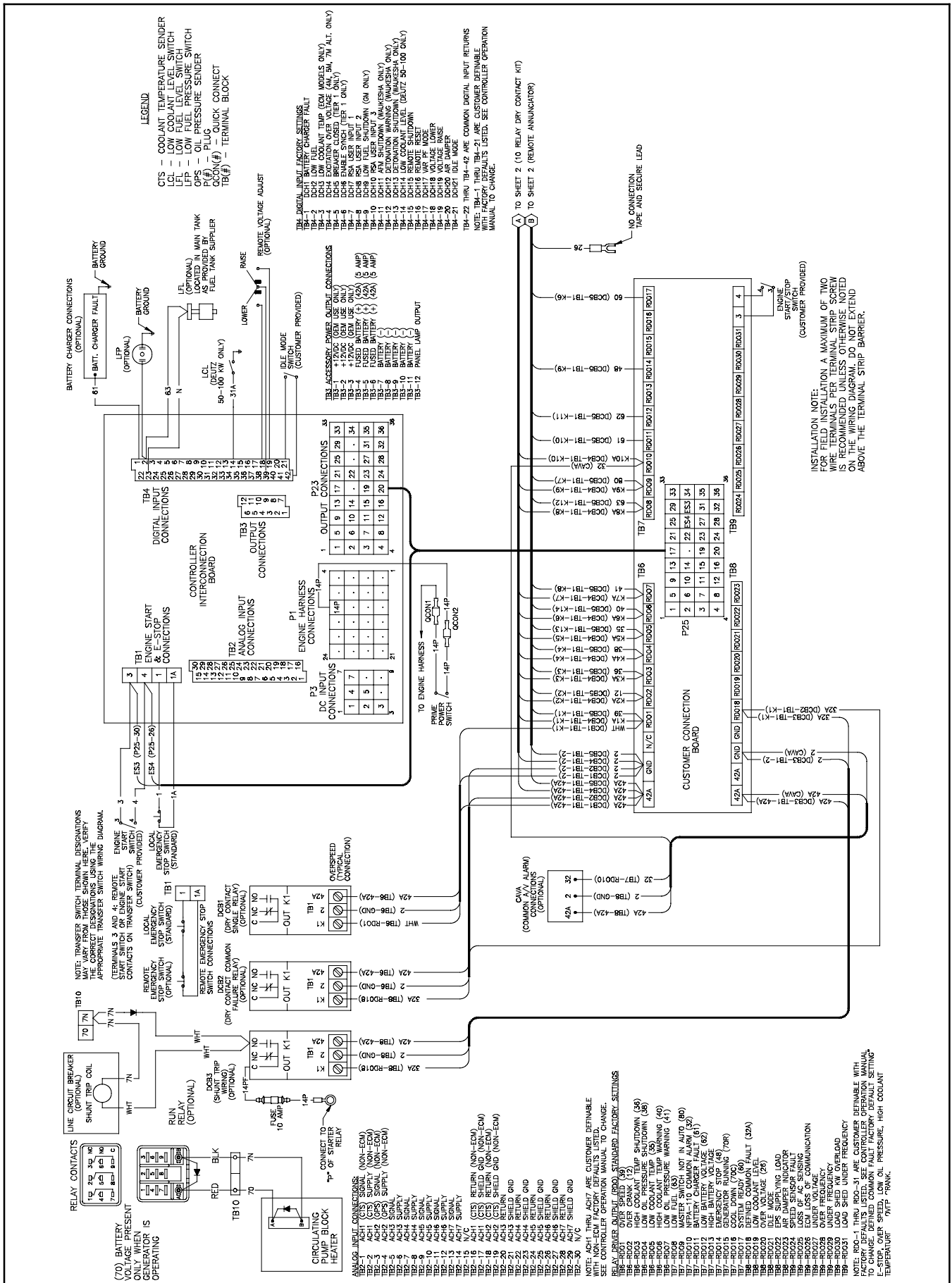


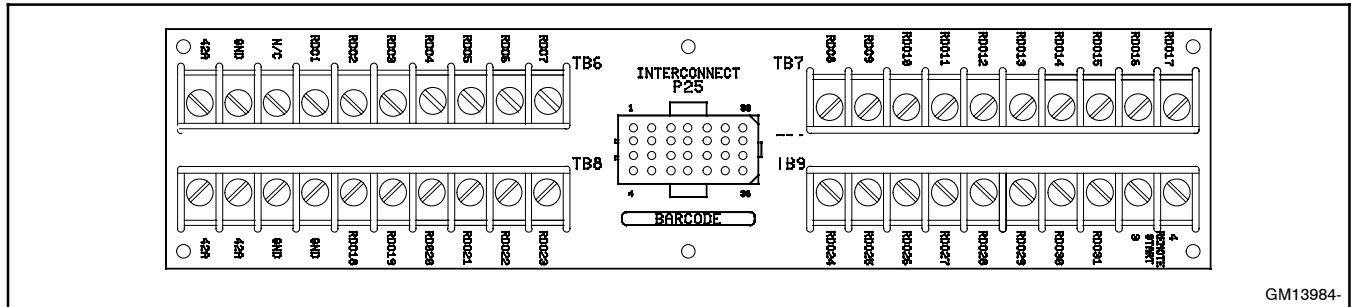
Figure 4-2 Accessory Connections, GM16088A-F



## 4.2 Controller (Customer) Connection Kit

A controller connection kit is required when a contact kit and/or the remote annunciator (NFPA remote audiovisual alarms) are specified.

The connection kit allows connection of accessories without opening the controller to make multiple terminal connections. The kit uses a wiring harness with plug connectors to link the controller's RDOs and power connections to a customer connection board for easy connection and identification of outputs. Remote start terminals are also accessible from the customer connection board. See Figure 4-4 and Figure 4-5.



GM13984-

**Figure 4-4** Terminal Strips TB6, TB7, TB8, and TB9 on the Controller Connection Kit in the Junction Box

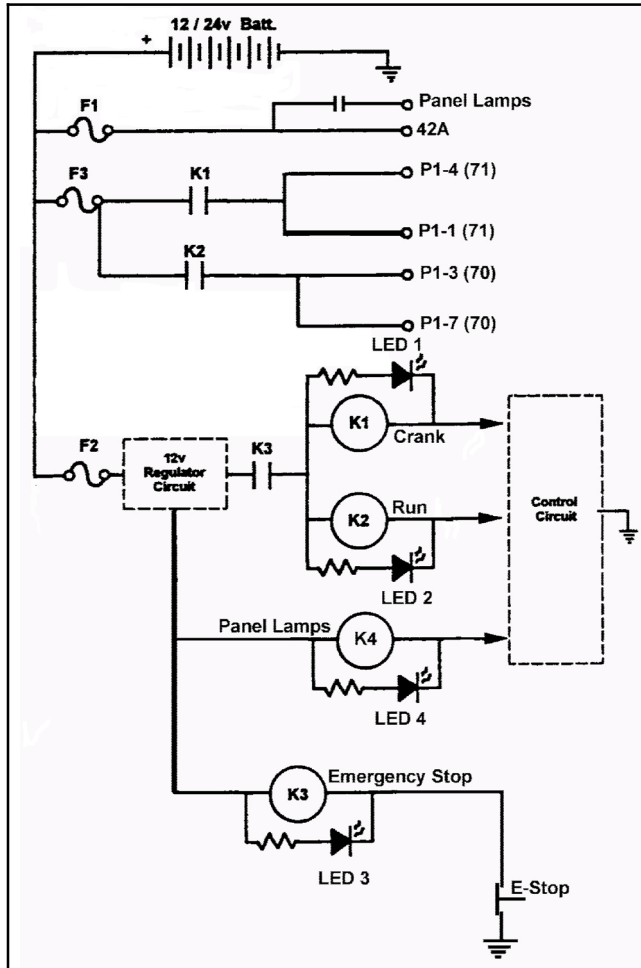
| TB6 Terminal Strip—RDOs 1-7   |   | TB9 Terminal Strip—RDOs 24-31  |                           |
|-------------------------------|---|--|---------------------------|
| Term.                         | Description                             | Term.  | Description               |
| 42A                           | Battery (+)                             | RDO24  | Speed sensor fault        |
| GND                           | Battery (-)                             | RDO25  | Loss of AC sensing        |
| N/C                           |   | RDO26  | ECM loss of communication |
| RDO1                          | Overspeed (39)                          | RDO27  | Undervoltage              |
| RDO2                          | Overcrank (12)                          | RDO28  | Overfrequency             |
| RDO3                          | High coolant temperature shutdown (36)  | RDO29  | Underfrequency            |
| RDO4                          | Low oil pressure shutdown (38)          | RDO30  | Load shed kW overload     |
| RDO5                          | Low coolant temperature (35)            | RDO31  | Load shed underfrequency  |
| RDO6                          | High coolant temperature warning (40)   | 3  | Remote start              |
| RDO7                          | Low oil pressure warning (41)           | 4  | Remote start              |
| TB7 Terminal Strip—RDOs 8-17  |   | <b>Note:</b> RDO-1 though RDO-31 are customer definable with the following factory defaults: emergency stop, high coolant temperature, low oil pressure, overcrank, and overspeed. Numbers in parentheses are the factory wire designations. |                           |
| Term.                         | Description                             | <b>*NFPA 110 common alarm faults include:</b>  |                           |
| RDO8                          | Low fuel (63)                           | Air damper indicator   |                           |
| RDO9                          | Master switch not in auto (80)          | Battery charger fault  |                           |
| RDO10                         | NFPA 110 common alarm (32)*             | EPS supplying load   |                           |
| RDO11                         | Battery charger fault (61)              | High battery voltage   |                           |
| RDO12                         | Low battery voltage (62)                | High coolant temperature warning   |                           |
| RDO13                         | High battery voltage                    | High coolant temperature shutdown  |                           |
| RDO14                         | Emergency stop (48)                     | Low battery voltage  |                           |
| RDO15                         | Generator running (70R)                 | Low coolant level  |                           |
| RDO16                         | Time delay engine cooldown (TDEC) (70C) | Low coolant temperature warning  |                           |
| RDO17                         | System ready (60)                       | Low fuel (level or pressure)   |                           |
| TB8 Terminal Strip—RDOs 18-23 |   | Low oil pressure warning   |                           |
| Term.                         | Description                             | Low oil pressure shutdown  |                           |
| 42A                           | Battery (+)                             | Master switch not in auto  |                           |
| 42A                           | Battery (+)                             | Overcrank  |                           |
| 2                             | Battery (-)                             | Overspeed  |                           |
| 2                             | Battery (-)                             |  |                           |
| RDO18                         | Defined common fault (32A)              |  |                           |
| RDO19                         | Low coolant level                       |  |                           |
| RDO20                         | Overvoltage (26)                        |  |                           |
| RDO21                         | Idle mode                               |  |                           |
| RDO22                         | EPS supplying load                      |  |                           |
| RDO23                         | Air damper indicator (56)               |  |                           |

**Figure 4-5** Controller (Customer) Connection Kit Terminal Strip Identification with Factory-Assigned Relay Driver Outputs (RDOs)

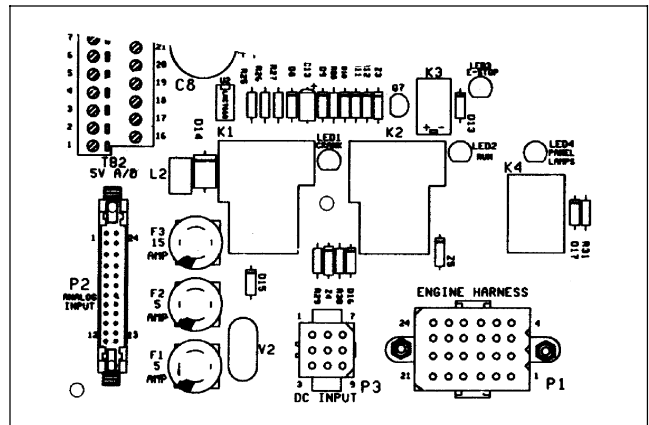


### 4.3 Interconnect Circuit Board

The interconnect circuit board contains four control relays: K1 (crank), K2 (run), K3 (emergency stop), and K4 (panel lamps). Main circuit board logic controls the K1, K2, and K4 relays. The manual E-Stop switch located on the control panel controls the K3 relay. See Figure 4-6 and Figure 4-7.



**Figure 4-6** Interconnect Circuit Board Schematic



**Figure 4-7** Interconnect Circuit Board Layout

**K1 Relay.** Energized only during the engine crank cycle. Wire 71 energizes when the K1 contact closes. LED 1 lights when power is supplied to the K1 relay coil.

**K2 Relay.** Energized during engine cranking cycle and normal engine running. The relay energizes when the control logic issues a start command. Wire 70 energizes when the K2 contacts close. LED 2 lights when power is supplied to the K2 relay coil.

**K3 Relay.** Energized at all times unless the emergency stop switch activates. When activated, the K3 contact opens, disabling power to the K1 and K2 relay coils.

**K4 Relay.** Energized when the main logic board turns on the panel lamps. Touch the keypad to turn on the light. The light turns off five minutes after the last keypad entry.

Three fuses mounted to the board protect the controller, customer accessories, and engine wiring.

**F1 Fuse.** Provides 5-amp circuit protection to 42A, which powers the customer-connected options and the panel lamps.

**F2 Fuse.** Provides 5-amp circuit protection for the controller's 12-volt regulator circuit, including K1, K2, K3, K4, and relay coils.

**F3 Fuse.** Provides 15-amp protection for the engine control circuit and other devices powered by wire 70 or wire 71.

# Notes

### 5.1 Factory Setup

The controller is functional after the factory setup is complete. Both an application program and personality parameters are factory-entered into the 550 controller. The application program controls the controller operating functions.

The personality parameter files specify the controller characteristics to match the alternator and engine requirements for generator set operation. Parameters include alternator characteristics for current and voltage protection, voltage regulation, calibration for oil pressure and water temperature if required, specification number, and serial number. A backup disk containing the personality parameters file and application file is created at the factory. The literature package shipped with the generator set includes the backup disk.

### 5.2 Program Loader

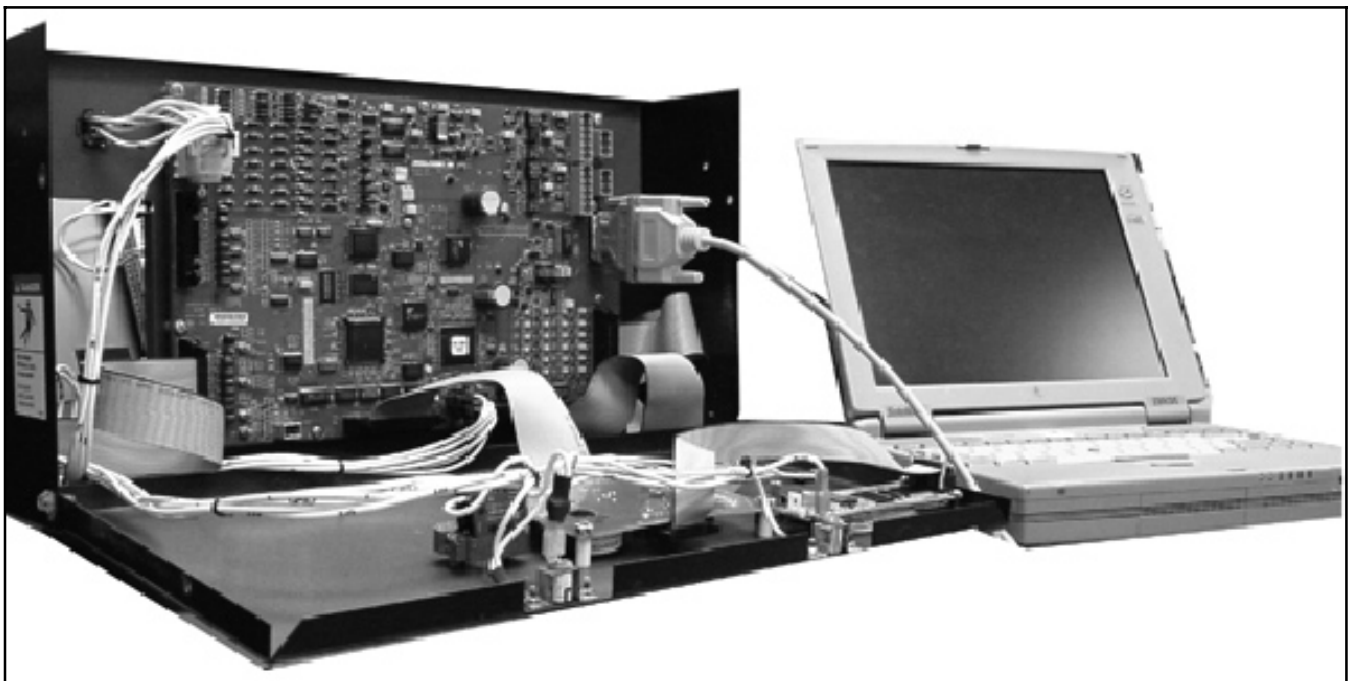
Use the Program Loader to load the files from a PC to the controller when replacing the 550 controller or upgrading the application program or personality files. See Figure 5-1. This program allows the technician to access the files stored on the backup disk and download the files to non-volatile memory, overwriting the

controller's original program. Refer to TT-1285, the program loader software instructions, for installation and operation. If the disk is damaged or misplaced, a copy can be created by the manufacturer using the generator set serial number as reference.

### 5.3 Communications

The 550 controller's remote monitoring or programming is accomplished using the Monitor II communication software. The software is installed on a host PC, and a communication link (RS-232/RS485) is installed between the digital controller and the PC. The PC can then access data from the generator set controller. The software, under password control, also allows the operator to program the generator set remotely. Connect the host PC to the controller using the RS-232 for a single controller or RS-485 for multiple controllers. Access can also be made over phone lines with the addition of a modem.

The software package is a Windows®-based graphical user interface allowing the operator to build data windows specifically for their application. The software package also allows for multiple and simultaneous device displays when using a local area network. Refer to the software operation and installation manual when using the Monitor II software.



**Figure 5-1** Program Loader Connections to the 550 Controller

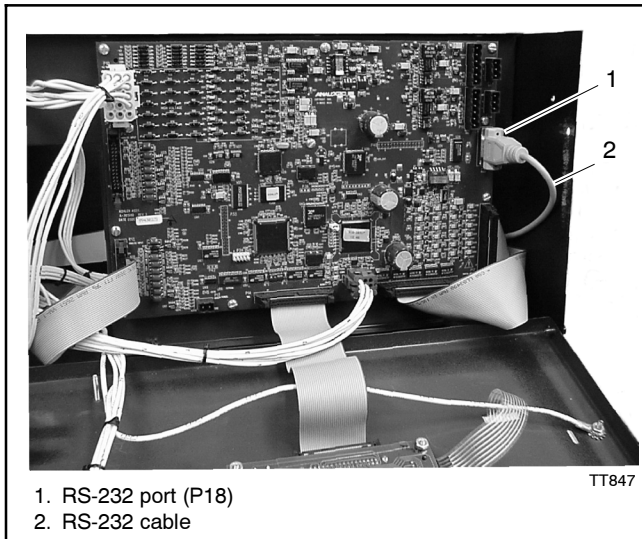
Windows® is a registered trademark of Microsoft Corporation

## 5.4 Personal Computer Communications

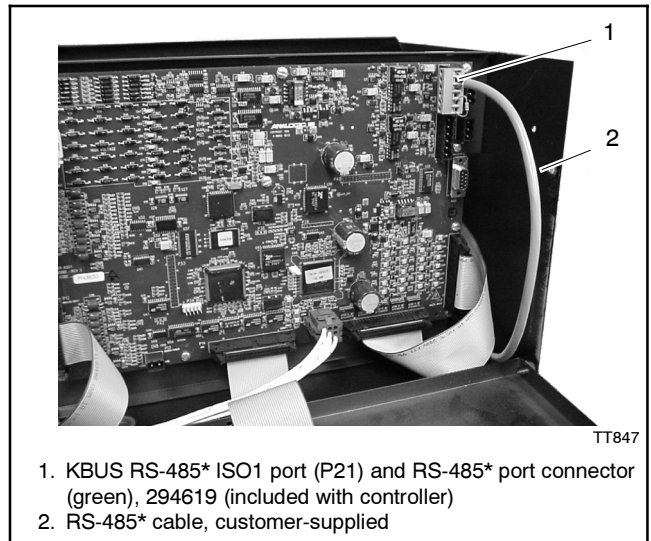
Figure 5-2 identifies the four ways to communicate with a personal computer (PC) and the generator set using KBUS protocol, the generator set manufacturer's communication protocol. See Figure 5-3 and Figure 5-4.

| Protocol                 | Description  |
|--------------------------|--|
| Local Single Connection  | A PC connects directly to the communication port with an RS-232 cable when the PC is within 15 m (50 ft.) of the device or RS-485* cable where the PC is up to 1220 m (4000 ft.) from the device. See Figure 5-5.  |
| Local Area Network (LAN) | A PC connects directly to the device's local area network through an address (1-128). A LAN is a system that connects more than one device to a single PC. See Figure 5-6.   |
| Remote Single Connection | A PC connects to a modem and a single device connects to a modem. The PC communicates to the device via a telephone network. Locate the PC anywhere a telephone line is available. See Figure 5-7.   |
| Remote Area Network      | A PC connects to a modem. The devices connect to a LAN network through a system ID and an address (1-128). The PC communicates to the devices via a telephone network that is interfaced to the LAN network. Locate the PC anywhere a telephone line is available. See Figure 5-8. |

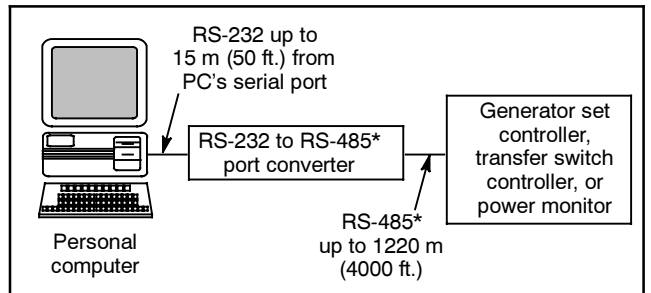
**Figure 5-2** KBUS Communication Protocol



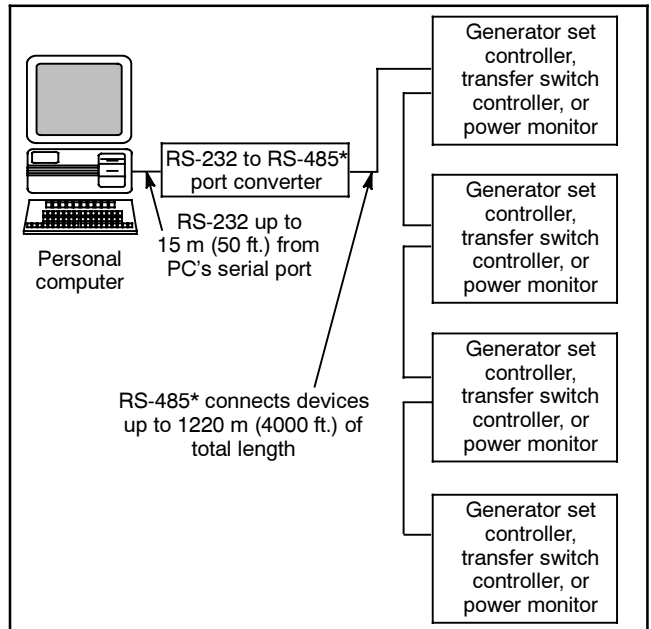
**Figure 5-3** RS-232 Port Location and Connection for the 550 Generator Set Controller



**Figure 5-4** RS-485\* KBUS Port Location and Connection for the 550 Generator Set Controller

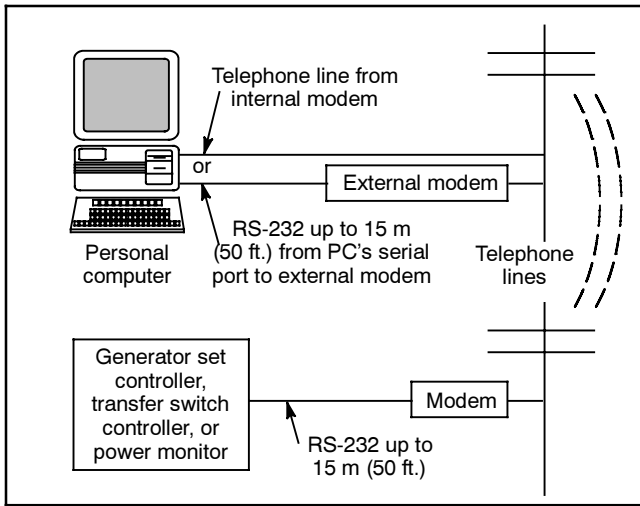


**Figure 5-5** Local Single Connection, up to 1220 m (4000 ft.)

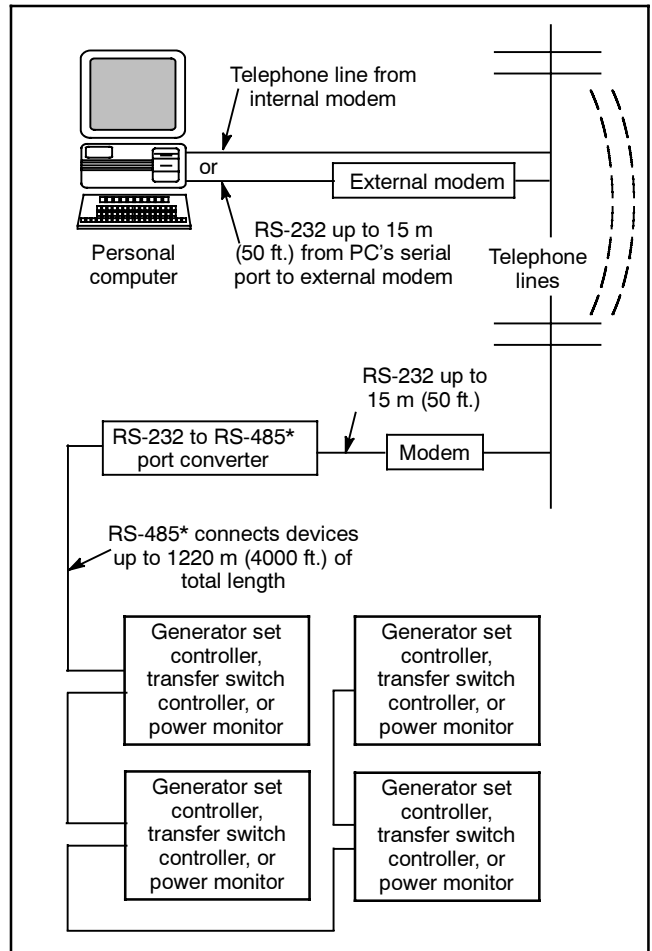


**Figure 5-6** Local Area Network Connection, up to 128 Devices

\* Belden #9841 or equivalent



**Figure 5-7** Remote Single Connection

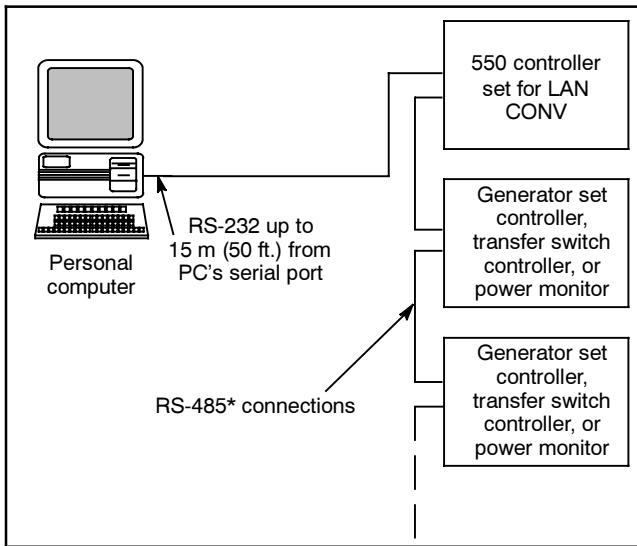


**Figure 5-8** Remote Area Network Connection

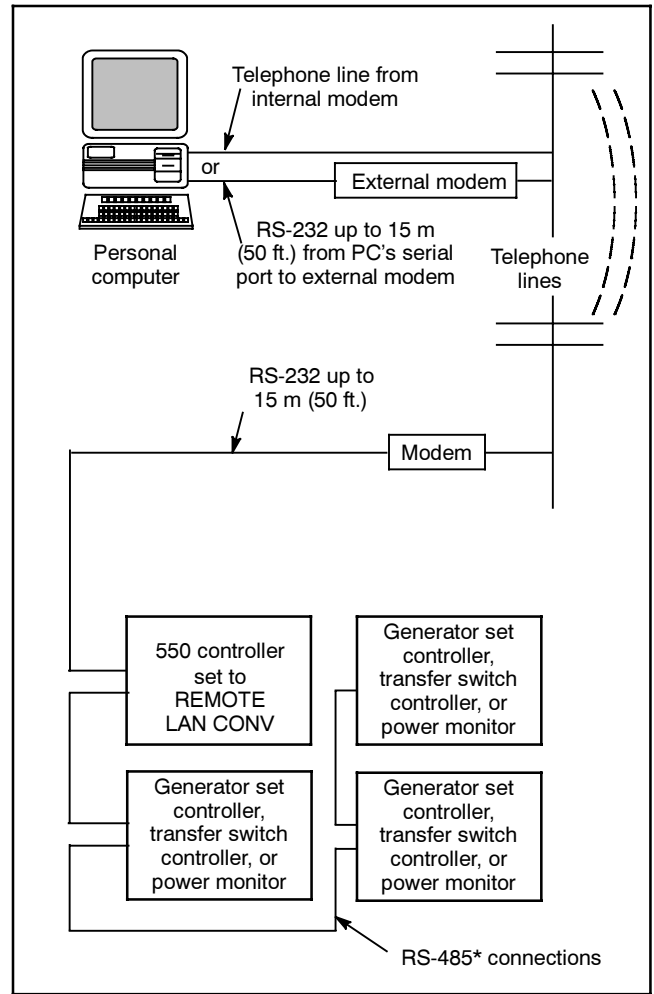
\* Belden #9841 or equivalent

## 5.5 Remote LAN Conversion

Use the 550 controller to convert RS-232 input signals from the PC to an RS-485\* output for other network devices. This built-in converter eliminates the need for an external RS-232 to RS-485\* converter. Use the 550 controller as a converter; connect the controller as the first device after the PC. Program (menu 13) them as either LOCAL LAN CONV or REMOTE LAN CONV depending on the application. See Figure 5-9 or Figure 5-10. To use the controller's built-in converter, the PC or modem connection must be within 15 m (50 ft.) of the 550 controller. If this distance is not possible, use the external RS-232 to RS-485\* converter. LAN CONV sets the controller to convert the RS-232 signal to RS-485\* output to other devices.



**Figure 5-9** 550 Controller LAN CONV Setting Converts a RS-232 PC Signal to a RS-485\* Output to other Devices

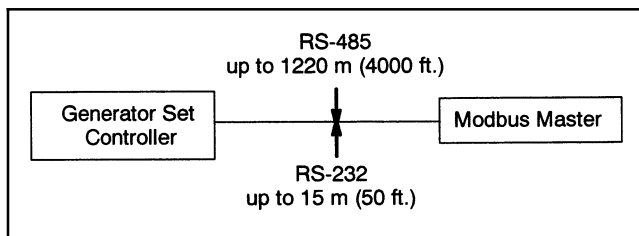


**Figure 5-10** Remote Area Network Connection with a 550 Controller REMOTE LAN CONV Setting

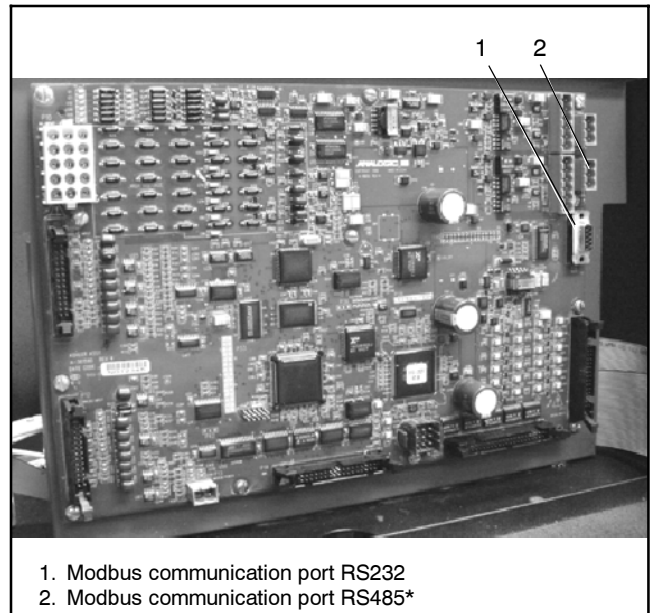
\* Belden #9841 or equivalent

## 5.6 Modbus Communications

Modbus® communications allow a host PC or Modbus master to obtain information from the generator set's 550 controller using Modbus communication protocol. See Figure 5-11. The Modbus protocol is viewed as an industry standard and was developed by the Modicon Corporation. The controller communicates using Modbus as a slave connection with the Modbus master initiating the communications. See See Figure 5-12. Modbus communications were developed so software applications other than Monitor II software can be used to gain access to 550 controller information. The Modbus master interrogates the controller system for alternator and engine parameters and also for diagnostic information. The controller also accepts data to alter controller parameters, including generator set start and stop functions.



**Figure 5-11** Generator Set Controller to Modbus Master Connections using RS-232 or RS-485\*



**Figure 5-12** Main Logic Board

Modbus® is a registered trademark of Schneider Electric  
\* Belden #9841 or equivalent

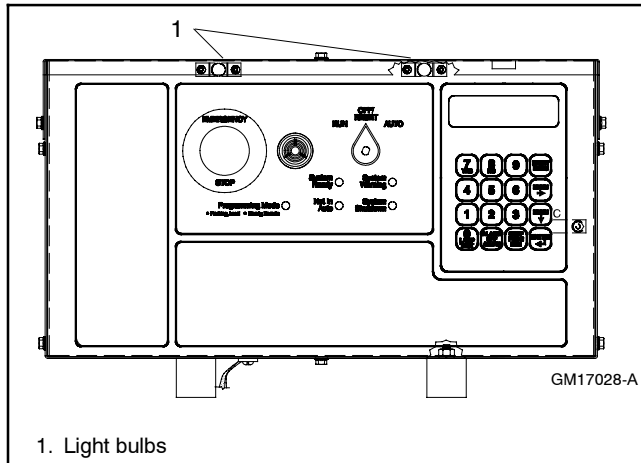
# Notes



## Section 6 Controller Replacement

### 6.1 Introduction

The 550 controller service replacement kit is available to replace a non-functional 550 controller. Use the following procedure to install the replacement controller. See Figure 6-1 for typical controller identification.



**Figure 6-1** 550 Controller Front Panel

When replacing the 550 controller, three files must be resident for the 550 controller to function.

- **Application program** contains the software that controls system operation. The application file is preprogrammed in the 550 controller at the factory.
- **Personality profile** is specific to the engine and alternator and is preprogrammed in the 550 controller at the factory. A backup disk of the personality profile is supplied with the literature packet. Typically, the distributor stores this disk for possible future use such as controller replacement or other circumstances requiring a backup.  
  
**Note:** If the personality disk is *not* available, request a replacement from the manufacturer using the generator set serial number or order number.
- **User parameters** unique to an installation include timer values, setpoints, generator set data such as kW and voltage, and input/output selections. These parameters are typically set up for or by the installer at the time of installation. Created user parameters are typically documented and stored on the personality profile disk, a separate backup disk, or written in Appendix C in the 550 controller operation manual. See Appendix C of this manual for a copy of the Controller User-Defined Settings form.

**Note:** If the user parameters are included on the personality disk, the disk label should indicate Site Program—Yes.

Read the entire installation procedure and compare the kit parts with the parts list in this publication before beginning installation. Perform the steps in the order shown.

Always observe applicable local and national electrical codes.

**Note:** The following service kit procedure changes only the controller. If the generator set requires voltage reconnection and/or frequency adjustment, see the 550 controller operation manual TP-6083 for Software (Code) Version Prior to 2.10 and TP-6200 for Software (Code) Version 2.0 or higher.

### 6.2 Installation

#### 6.2.1 Requirements

The following items are necessary PC requirements for installing the controller service replacement kits.


- Program loader kit GM17732 or GM17733. See the program loader kit instructions for additional items needed to complete the installation. The program loader kit includes the Monitor II software, version 2.2.5 or later.  
  
Use the Monitor II software, version 2.2.5 or greater, to enter the user parameters from a backup disk and/or enter alphanumeric data. See the Monitor II software instructions for additional items.
- Null modem RS-232 cable with a 9-pin male plug on the controller end, part no. GM16657 or kits PA-294992 or PA-294992-SD.

## 6.2.2 Procedure

Observe the following safety precautions while installing the kit.

---

**⚠ WARNING**




**Accidental starting.**  
**Can cause severe injury or death.**

Disconnect the battery cables before working on the generator set. Remove the negative (-) lead first when disconnecting the battery. Reconnect the negative (-) lead last when reconnecting the battery.

---

**Disabling the generator set. Accidental starting can cause severe injury or death.** Before working on the generator set or connected equipment, disable the generator set as follows: (1) Move the generator set master switch to the OFF position. (2) Disconnect the power to the battery charger. (3) Remove the battery cables, negative (-) lead first. Reconnect the negative (-) lead last when reconnecting the battery. Follow these precautions to prevent starting of the generator set by an automatic transfer switch, remote start/stop switch, or engine start command from a remote computer.

**⚠ WARNING**



**Hazardous voltage. Moving parts.**  
**Can cause severe injury or death.**

Operate the generator set only when all guards and electrical enclosures are in place.

**Grounding electrical equipment. Hazardous voltage can cause severe injury or death.** Electrocutation is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the generator set, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

**Connecting the battery and the battery charger. Hazardous voltage can cause severe injury or death.** Reconnect the battery correctly, positive to positive and negative to negative, to avoid electrical shock and damage to the battery charger and battery(ies). Have a qualified electrician install the battery(ies).

**Short circuits. Hazardous voltage/current can cause severe injury or death.** Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewelry while making adjustments or repairs. Remove all jewelry before servicing the equipment.

1. Acquire the user parameters.
  - a. Choose one of the following methods to retrieve the user parameters:
    - Backup disk. If a backup disk was previously made, obtain the parameters from this disk. If a disk was not previously made, create a backup if possible using the Monitor II software, version 2.2.5 or greater. The existing controller must function in order to create the file.
    - Paper form. Parameters should have been recorded on the User-Defined Settings form located in the 550 controller operation manual, Appendix C, or other similar form.
    - Controller menu. Manually review the controller menu displays if possible and enter the parameter information in the 550 controller operation manual, Appendix C, User-Defined Settings, form.
  - b. Save the user parameter data.
2. Acquire display data from the old controller for entry in the new controller.

Certain data cannot be stored on electronic media for archival purposes and must be entered using a PC or the controller keypad.

When possible, make note of the following data from the old controller for entry in the new controller. If the old controller is not functional, the installer *must* determine and document this information for entry later in this procedure. See Appendix C for the Controller User-Defined Settings form.

- a. From menu 7, Generator System
  - Metric Units, yes or no
- b. From menu 12, Calibration
  - Scale Aux. Analog Inputs. Repeat for each input 01-07
    - Analog 01, scale value 1
    - Analog 01, scale value 2

c. From menu 13, Communication

(1) Protocol KBUS

- KBUS online, yes or no
- Connection type
  - Local single, yes or no
  - Local LAN, yes or no
  - Local LAN conv, yes or no
  - Remote single, yes or no
  - Remote LAN, yes or no
  - Remote LAN conv, yes or no
- Primary port
  - RS-232, yes or no
  - RS-485 ISO1, yes or no
- Address (LAN connections)
- System ID (remote connections)
- BAUD rate
  - 1200
  - 2400
  - 9600

(2) Protocol Modbus

- Modbus online, yes or no
- Connection type
  - Single, yes or no
  - Convertor, yes or no
- Primary port
  - RS-485
  - RS-232
- Address
- BAUD rate
  - 9600
  - 19200

d. From menu 20, Factory Setup

- Final assembly date
- Final assembly clock number
- Model number
- Spec number
- Serial number

3. Acquire display data from the old controller for reference purposes.

When possible, write down the old controller display data in Appendix B. This data is not required for the new controller but may be needed for future reference. If the old controller is not functional, the information is no longer retrievable.

4. Remove the generator set from service.

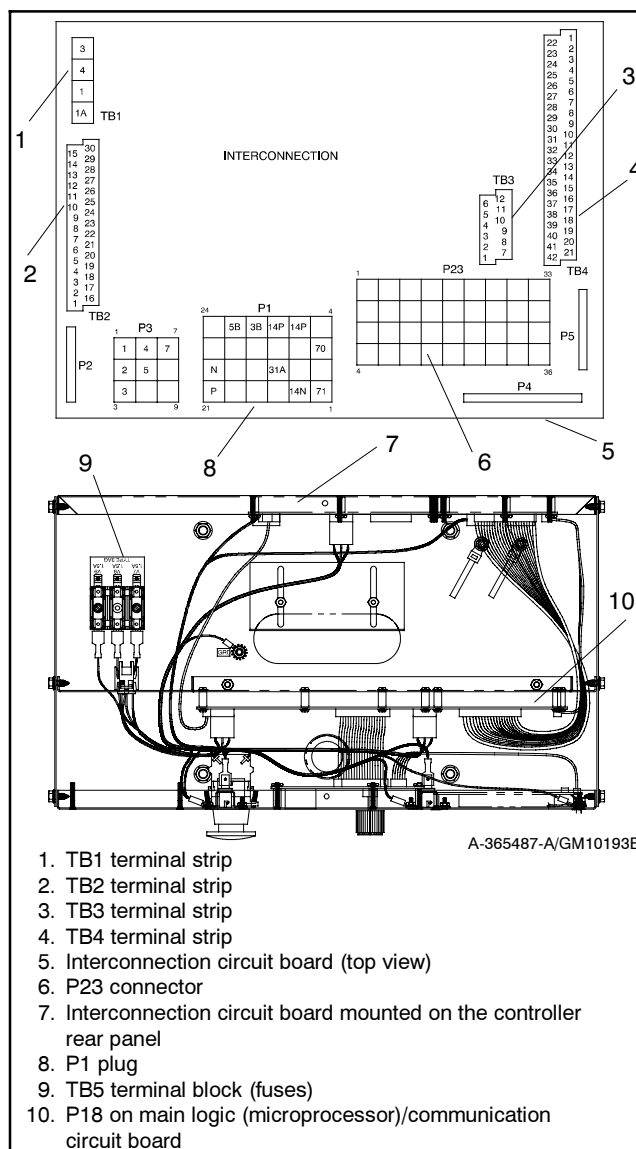
- a. Place the generator set master switch in the OFF position.
- b. Disconnect power to battery charger, if equipped.

c. Disconnect the generator set engine starting battery(ies), negative (-) lead first.

5. Disconnect the existing 550 controller electrical connections.

- a. Remove the controller cover. If access to the interconnection circuit board on the rear panel and/or the main logic/communication circuit board on the front panel is difficult, partially disassemble the controller box. Remove the two controller panel top screws and center bottom screw and then loosen the bottom panel screw on each side to swing the controller panel down. See Figure 6-2.

**Note:** Clearly mark all disconnected leads from the 550 controller with tape to simplify reconnection.



**Figure 6-2** Disconnecting Controller Circuit Board External Wiring Connections

b. Disconnect the 550 controller harness leads. Listed below are some common leads and plugs that require removal or disconnection. Items below in **bold** are shown in Figure 6-2. These connections are typical and may not apply to all situations. See the corresponding wiring diagram found in the wiring diagrams manual.

- AC fuse terminal block **TB5** leads V7, V8, and V9
- All external connections to terminal strips **TB1, TB2, TB3, and TB4**
- CT/meter scale terminal block lead V0
- P24 connector to the CT burden resistor board
- Plug **P1** on the burden resistor board and the 350–3250 kW voltage regulator interface board
- Plug **P23** to the controller connection strip in the junction box
- Plug P22 to the engine wiring harness
- Plug **P18** communication connection
- Prime power kit
- Any other external leads to the controller

6. Remove the existing 550 controller.

- a. Remove the junction box panel(s) to gain access to the controller vibromount screws.
- b. Remove the four controller vibromount screws from underneath the junction box top panel.
- c. Lift off the existing 550 controller.

7. Install the replacement 550 controller.

- a. Place the replacement 550 controller on the junction box top panel holes.
- b. Align the 550 controller vibromounts with the mounting holes and install four screws.
- c. Change the controller’s front display lamps, if required. See Figure 6-1 for location. See Figure 6-3 for lamp identification. The factory ships the 550 controller with 12-volt lamps. Replace the bulbs in the controller with the lamps provided in the replacement kit if the generator set has a 24-volt engine electrical system. Determine the engine electrical system voltage using the generator set nameplate information.

| Lamp Part Number | Voltage | Bulb Part Number |
|------------------|---------|------------------|
| 255126           | 12      | 1892             |
| 283420           | 24      | 313              |

**Figure 6-3** Lamp Identification

8. Connect the replacement 550 controller.

a. Remove the controller cover. If access to the interconnection circuit board on the rear panel and/or the communication circuit board on the front panel is difficult, partially disassemble the controller box. Remove the two controller panel top screws and center bottom screw and then loosen the bottom screw on each side to swing the controller panel down. See Figure 6-2.

b. Reconnect the controller wiring that was previously removed. See the corresponding wiring diagram found in the wiring diagrams manual. Listed below are some common leads and plugs that may require reconnection. These connections are typical and may not apply to all situations.

- AC fuse terminal block **TB5** leads V7, V8, and V9
- All external connections to terminal strips **TB1, TB2, TB3, and TB4**
- CT/meter scale terminal block lead V0
- P24 connector to the CT burden resistor board
- Plug **P1** on the burden resistor board and the 350–3250 kW voltage regulator interface board
- Plug **P23** to the controller connection strip in the junction box
- Plug P22 to the engine wiring harness
- Prime power kit
- Any other external leads to the controller

c. Swing the rear controller panel up and replace and tighten the screws, as necessary.

d. Replace the junction box panel(s) and screws.

9. Restore power to the generator set.

- a. Check that the generator set master switch is in the OFF position.
- b. Reconnect the generator set engine starting battery, negative (-) lead last.
- c. Reconnect power to the battery charger, if equipped.

10. Install the program/data files.

- a. Connect the PC serial port to the controller RS-232 port using a null modem RS-232 cable with a 9-pin male plug on the controller end. See TT-1285 for details.
- b. Install the Program Loader program into the PC using the procedure outlined in TT-1285.
- c. Insert the personality profile backup disk and load the data. See TT-1285 for details.

11. Establish the controller identity in menu 20.

The controller displays the following error message: GENSET S/N WARNING.

This procedure includes instructions on how to unlock and lock the factory setup after entering menu 20. Use the down arrow key to go to the setup lock menu for determining the setup status.

**Note:** After completing the factory setup always return the controller to the setup lock position to prevent inadvertent program changes.

- a. Press the RESET MENU key on the controller keypad.
- b. Use the controller keypad to go to menu 14, Programming Mode, and select programming mode—local. Use the information from the 550 controller operation manual as necessary.

**Note:** The factory default access code is the number 0.

- c. Press the RESET MENU key on the controller keypad.
- d. Use the controller keypad to go to menu 20, Factory Setup. See Figure 6-4 for displays.
- e. Arrow down to the SETUP LOCK display.

If the SETUP LOCK display indicates YES, go to step f.

If the SETUP LOCK display indicates NO, go to step g.

- f. Unlock the setup.

- (1) Arrow down to the FINAL ASSEMBLY, CLOCK NO. display. Record the clock number on the controller display.
- (2) Arrow right to ENTER CODE display.
- (3) Use the controller keypad to enter the clock number previously recorded.
- (4) Press the ENTER key. Changes to menu 20, Factory Setup, are now possible.

g. Initialize the EEPROM.

- (1) Arrow down to the CODE VERSION display.
- (2) Arrow right to the INITIALIZE EEPROM display.
- (3) Press the YES key to initialize the EEPROM.
- (4) Press the ENTER key.

h. Wait for completion of the system reset (approx. 5–10 seconds).

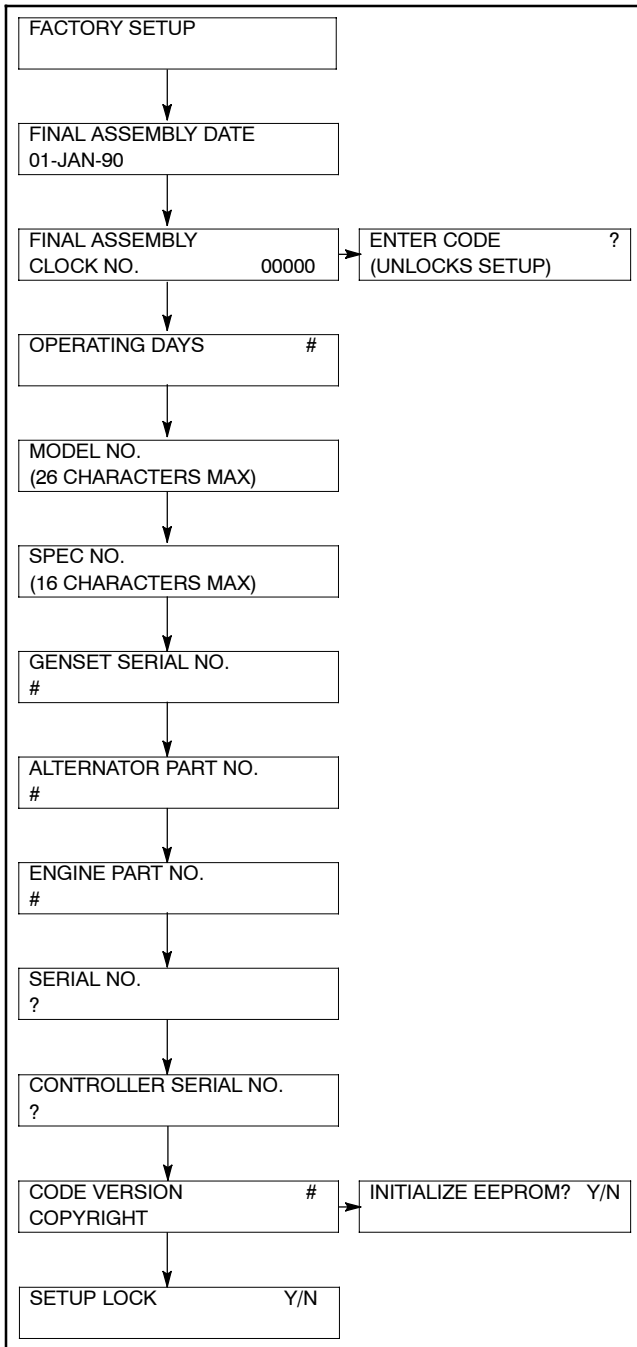
i. Go to menu 20, Factory Setup. See Figure 6-4 or Figure 6-5 for displays.

j. Enter the final assembly date.

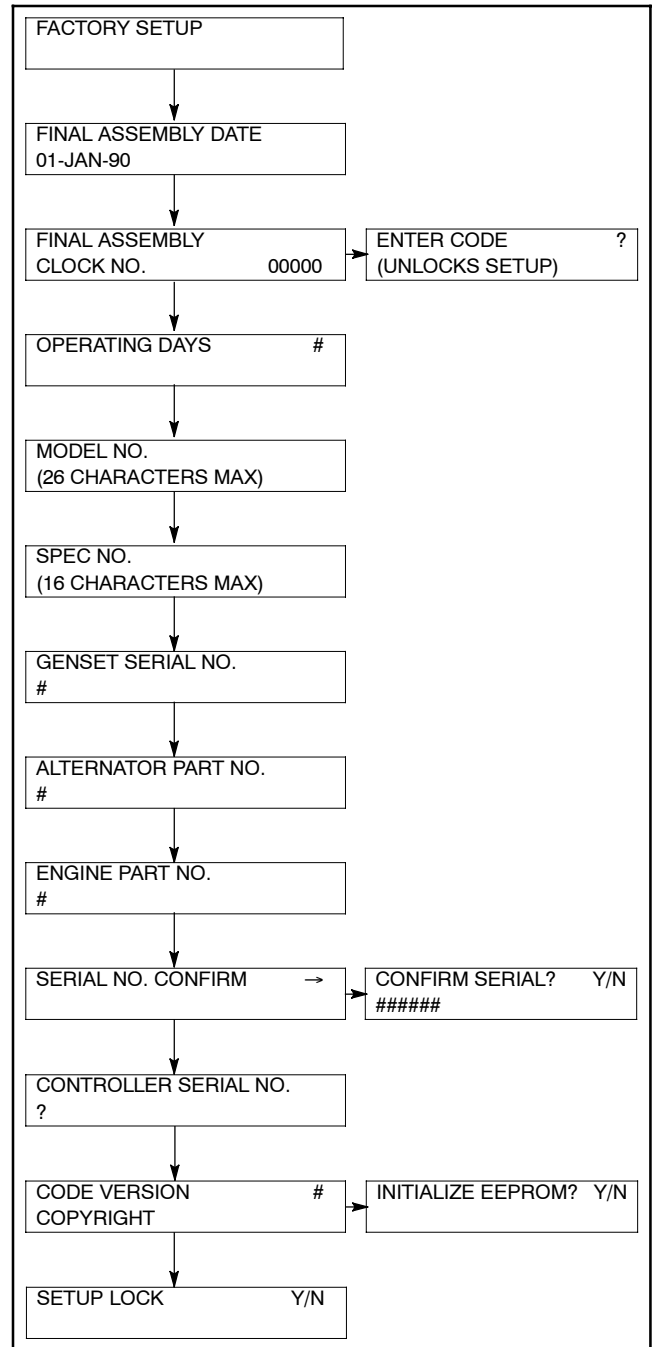
- (1) Arrow down to the FINAL ASSEMBLY DATE display.
- (2) Enter the final assembly date using the data recorded from the old controller. If data from the old controller is not available, keep the default setting.
- (3) Press the ENTER key if making a new entry.

k. Enter the final assembly clock number.

- (1) Arrow down to the FINAL ASSEMBLY CLOCK NO. display.
- (2) Enter the final assembly clock number using the data recorded from the old controller. If data from the old controller is not available, keep the default setting.
- (3) Press the ENTER key if making a new entry.



**Figure 6-4** Menu 20, Factory Setup  
(Version 2.69 and Lower)



**Figure 6-5** Menu 20, Factory Setup  
(Version 2.70 and Higher)

- l. Confirm the serial number. If the controller firmware is Version 2.69 and Lower go to step m. If the controller firmware is Version 2.70 or higher go to step n.
- m. Enter the serial number (Version 2.69 and Lower). See Figure 6-4.
  - (1) Arrow down to the SERIAL NO. display.
  - (2) Enter the serial number of the generator set using the data recorded from the old controller or as shown on the generator set nameplate. If the serial number is six digits, enter a *leading zero* to create a seven-digit serial number.
  - (3) Press the ENTER key. The GENSET S/N WARNING display no longer appears.
- n. Confirm the serial number (Version 2.70 and Higher). See Figure 6-5.
  - (1) Arrow down to the SERIAL NO. CONFIRM display.
  - (2) Arrow right to access the confirmation submenu.
  - (3) Press the YES key, if the display matches the generator set nameplate serial number.

**Note:** If the serial numbers do not match, the wrong personality parameter file is installed. Refer to the Program Loader documentation for instructions on reloading the personality parameter file.

  - (4) Press the Enter key.
- 12. Perform the menu 13, Communications, entries.
  - a. Press the RESET MENU key on controller keypad.
  - b. Use the controller keypad to go to menu 13, Communications.
  - c. Complete the communication entries as necessary for remote programming. Use the information from the 550 controller operation manual as necessary. Use the information from the Monitor II software, version 2.2.5 or greater as necessary.
- 13. Perform the menu 14, Programming Mode, entries.
  - a. Press the RESET MENU key on controller keypad.
  - b. Use the controller keypad to go to menu 14, Programming Mode, and select programming mode—remote. Use the information from the Monitor II software, version 2.2.5 or greater.
- 14. Perform the menu 20, Factory Setup, entries using the Monitor II software generator info window. Use the information from the Monitor II software, version 2.2.5 or greater.
  - a. Enter the model number.
    - (1) Go to the MODEL NO. display.
    - (2) Enter the model number using the data recorded from the old controller or as shown on the generator set nameplate.
  - b. Enter the spec (specification) number.
    - (1) Go to the SPEC NO. display.
    - (2) Enter the spec number using the data recorded from the old controller or as shown on the generator set nameplate.
- 15. Perform the menu 14, Programming Mode, entries.
  - a. Press the RESET MENU key on the controller keypad.
  - b. Use the controller keypad to go to menu 14, Programming Mode and select programming mode—local. Use the information from the 550 controller operation manual as necessary.
- 16. Lock the menu 20, Factory Setup, entries.
  - a. Press the SETUP MENU key on the controller keypad.
  - b. Use the controller keypad to go to menu 20, Factory Setup.
  - c. Arrow down to the SETUP LOCK display.
  - d. Press the YES key to lock the setup and prevent alterations to menu 20, Factory Setup.
- 17. Enter the menu 6, Time and Date, settings.
  - a. Press the RESET MENU key on the controller keypad.
  - b. Use the controller keypad to go to menu 6, Time and Date. Use the information from the 550 controller operation manual as necessary to set the time and date.

18. Perform the menu 7, Generator System, entries for English or metric displays.
    - a. Press the RESET MENU key on the controller keypad.
    - b. Use the controller keypad to go to menu 7, Generator System. Use the information from the 550 controller operation manual as necessary to change Metric Unit, yes or no.
  19. Perform the menu 12, Calibration, entries.
    - a. Press the RESET MENU key on the controller keypad.
    - b. Use the controller keypad to go to menu 12, Calibration. Use the information from the 550 controller operation manual as necessary to scale AC analog inputs.
    - c. With the information previously recorded from step 2b, scale the auxiliary analog inputs. Use the information from the 550 controller operation manual as necessary.
  20. Perform the menu 14, Programming Mode, entries.
    - a. Press the RESET MENU key on the controller keypad.
    - b. Use the controller keypad to go to menu 14, Programming Mode.
      - Select programming mode—remote when adding user parameter from a backup disk or PC. Use the information from the Monitor II software, version 2.2.5 or greater.
      - Select programming mode—local for keypad entries. Use the information from the 550 controller operation manual as necessary.
  21. Add the user parameters.
    - a. Choose one of the following methods to load the user parameters.
      - Backup disk. Use a PC to load the data from the user parameter backup disk. Enable menu 14, Programming Mode—Remote. See the information from the Monitor II software manual.
      - Paper form. Use a PC to enter the user parameter data from the filled-out 550 controller operation manual, Appendix C, User-Defined Settings form or other similar form. Enable menu 14, Programming Mode—Remote. See the information supplied with the Monitor II software manual.
  - Controller menu. Use the controller keypad to manually enter the user parameter data from the filled-out 550 controller operation manual, Appendix C, User-Defined Settings form. Enable menu 14, Programming Mode—Local. Use the information from the 550 controller operation manual as necessary.
  - b. Create a new user parameter data backup disk if any changes are made. See the Monitor II software manual.
  - c. Disconnect the PC null modem RS-232 cable.
  - d. Install the P18 communication connection, as necessary.
  - e. Swing the front controller panel up and replace and tighten the screws, as necessary.
  - f. Replace the controller cover and hardware. Tighten all controller screws.
22. Restore the generator set to service.
  - a. Perform the menu 13, Communication, entries.
    - (1) Press the RESET MENU key on controller keypad.
    - (2) Use the controller keypad to go to menu 13, Communications.
    - (3) With the information previously recorded, complete the communication entries as necessary for the application. Use the information from the 550 controller operation manual as necessary.
  - b. Perform the menu 14, Programming Mode entries.
    - (1) Press the RESET MENU key on controller keypad.
    - (2) Use the controller keypad to go to menu 14, Programming Mode.
    - (3) Change the entries for the application as necessary. Use the information from the 550 controller operation manual as necessary.
  - c. The generator set system is now ready to function.
  - d. Move the generator set master switch to AUTO for startup by remote transfer switch or remote start/stop switch.



# Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

|           |  |          |  |                      |  |
|-----------|--|----------|--|----------------------|--|
| A, amp    | ampere   | cfm      | cubic feet per minute  | est.                 | estimated  |
| ABDC      | after bottom dead center   | CG       | center of gravity  | E-Stop               | emergency stop                                       |
| AC        | alternating current  | CID      | cubic inch displacement  | etc.                 | et cetera (and so forth)                             |
| A/D       | analog to digital  | CL       | centerline   | exh.                 | exhaust  |
| ADC       | advanced digital control;<br>analog to digital converter                                   | cm       | centimeter   | ext.                 | external   |
| adj.      | adjust, adjustment   | CMOS     | complementary metal oxide<br>substrate (semiconductor)                               | F                    | Fahrenheit, female                                   |
| ADV       | advertising dimensional<br>drawing   | cogen.   | cogeneration   | fglass.              | fiberglass   |
| Ah        | amp-hour   | com      | communications (port)  | FHM                  | flat head machine (screw)                            |
| AHWT      | anticipatory high water<br>temperature   | coml     | commercial   | fl. oz.              | fluid ounce  |
| AISI      | American Iron and Steel<br>Institute   | Coml/Rec | Commercial/Recreational  | flex.                | flexible   |
| ALOP      | anticipatory low oil pressure  | conn.    | connection   | freq.                | frequency  |
| alt.      | alternator   | cont.    | continued  | FS                   | full scale   |
| Al        | aluminum   | CPVC     | chlorinated polyvinyl chloride   | ft.                  | foot, feet   |
| ANSI      | American National Standards<br>Institute (formerly American<br>Standards Association, ASA) | crit.    | critical   | ft. lb.              | foot pounds (torque)                                 |
| AO        | anticipatory only  | CRT      | cathode ray tube   | ft./min.             | feet per minute                                      |
| APDC      | Air Pollution Control District   | CSA      | Canadian Standards<br>Association  | ftp                  | file transfer protocol                               |
| API       | American Petroleum Institute   | CT       | current transformer  | g                    | gram   |
| approx.   | approximate, approximately   | Cu       | copper   | ga.                  | gauge (meters, wire size)                            |
| AQMD      | Air Quality Management District  | cUL      | Canadian Underwriter's<br>Laboratories   | gal.                 | gallon   |
| AR        | as required, as requested  | CUL      | Canadian Underwriter's<br>Laboratories   | gen.                 | generator  |
| AS        | as supplied, as stated, as<br>suggested  | cu. in.  | cubic inch   | genset               | generator set  |
| ASE       | American Society of Engineers  | cw.      | clockwise  | GFI                  | ground fault interrupter                             |
| ASME      | American Society of<br>Mechanical Engineers  | CWC      | city water-cooled  | GND, ⊕               | ground   |
| assy.     | assembly   | cyl.     | cylinder   | gov.                 | governor   |
| ASTM      | American Society for Testing<br>Materials  | D/A      | digital to analog  | gph                  | gallons per hour                                     |
| ATDC      | after top dead center  | DAC      | digital to analog converter  | gpm                  | gallons per minute                                   |
| ATS       | automatic transfer switch  | dB       | decibel  | gr.                  | grade, gross   |
| auto.     | automatic  | dB(A)    | decibel (A weighted)   | GRD                  | equipment ground                                     |
| aux.      | auxiliary  | DC       | direct current   | gr. wt.              | gross weight   |
| avg.      | average  | DCR      | direct current resistance  | H x W x D            | height by width by depth                             |
| AVR       | automatic voltage regulator  | deg., °  | degree   | HC                   | hex cap  |
| AWG       | American Wire Gauge  | dept.    | department   | HCHT                 | high cylinder head temperature                       |
| AWM       | appliance wiring material  | DFMEA    | Design Failure Mode and<br>Effects Analysis  | HD                   | heavy duty   |
| bat.      | battery  | dia.     | diameter   | HET                  | high exhaust temp., high<br>engine temp.             |
| BBDC      | before bottom dead center  | DI/EO    | dual inlet/end outlet  | hex                  | hexagon  |
| BC        | battery charger, battery<br>charging   | DIN      | Deutsches Institut für Normung<br>e. V. (also Deutsche Industrie<br>Normenausschuss) | Hg                   | mercury (element)                                    |
| BCA       | battery charging alternator  | DIP      | dual inline package  | HH                   | hex head   |
| BCI       | Battery Council International  | DPDT     | double-pole, double-throw  | HHC                  | hex head cap   |
| BDC       | before dead center   | DS       | disconnect switch  | HP                   | horsepower   |
| BHP       | brake horsepower   | DVR      | digital voltage regulator  | hr.                  | hour   |
| blk.      | black (paint color), block<br>(engine)   | E, emer. | emergency (power source)   | HS                   | heat shrink  |
| blk. htr. | block heater   | ECM      | electronic control module,<br>engine control module                                  | hsg.                 | housing  |
| BMEP      | brake mean effective pressure  | EDI      | electronic data interchange  | HVAC                 | heating, ventilation, and air<br>conditioning        |
| bps       | bits per second  | EFR      | emergency frequency relay  | HWT                  | high water temperature                               |
| br.       | brass  | e.g.     | for example ( <i>exempli gratia</i> )  | Hz                   | hertz (cycles per second)                            |
| BTDC      | before top dead center   | EG       | electronic governor  | IC                   | integrated circuit                                   |
| Btu       | British thermal unit   | EGSA     | Electrical Generating Systems<br>Association   | ID                   | inside diameter, identification                      |
| Btu/min.  | British thermal units per minute   | EIA      | Electronic Industries<br>Association   | IEC                  | International Electrotechnical<br>Commission         |
| C         | Celsius, centigrade  | EI/EO    | end inlet/end outlet   | IEEE                 | Institute of Electrical and<br>Electronics Engineers |
| cal.      | calorie  | EMI      | electromagnetic interference   | IMS                  | improved motor starting                              |
| CAN       | controller area network  | emiss.   | emission   | in.                  | inch   |
| CARB      | California Air Resources Board   | eng.     | engine   | in. H <sub>2</sub> O | inches of water                                      |
| CB        | circuit breaker  | EPA      | Environmental Protection<br>Agency   | in. Hg               | inches of mercury                                    |
| cc        | cubic centimeter   | ES       | engineering special,<br>engineered special   | in. lb.              | inch pounds  |
| CCA       | cold cranking amps   | ESD      | electrostatic discharge  | Inc.                 | incorporated   |
| ccw.      | counterclockwise   |          |  | ind.                 | industrial   |
| CEC       | Canadian Electrical Code   |          |  | int.                 | internal   |
| cert.     | certificate, certification, certified  |          |  | int./ext.            | internal/external                                    |
| cfh       | cubic feet per hour  |          |  | I/O                  | input/output   |
|           |  |          |  | IP                   | iron pipe  |
|           |  |          |  | ISO                  | International Organization for<br>Standardization    |
|           |  |          |  | J                    | joule  |
|           |  |          |  | JIS                  | Japanese Industry Standard                           |

|                      |  |           |   |         |  |
|----------------------|--|-----------|---|---------|--|
| k                    | kilo (1000)  | MTBO      | mean time between overhauls                         | rms     | root mean square   |
| K                    | kelvin   | mtg.      | mounting  | rnd.    | round  |
| kA                   | kiloampere   | MTU       | Motoren-und Turbinen-Union                          | ROM     | read only memory   |
| KB                   | kilobyte (2 <sup>10</sup> bytes)                     | MW        | megawatt  | rot.    | rotate, rotating   |
| KBus                 | Kohler communication protocol                        | mW        | milliwatt   | rpm     | revolutions per minute   |
| kg                   | kilogram   | μF        | microfarad  | RS      | right side   |
| kg/cm <sup>2</sup>   | kilograms per square centimeter                      | N, norm.  | normal (power source)                               | RTU     | remote terminal unit   |
| kgm                  | kilogram-meter                                       | NA        | not available, not applicable                       | RTV     | room temperature vulcanization   |
| kg/m <sup>3</sup>    | kilograms per cubic meter                            | nat. gas  | natural gas   | RW      | read/write   |
| kHz                  | kilohertz  | NBS       | National Bureau of Standards                        | SAE     | Society of Automotive Engineers  |
| kJ                   | kilojoule  | NC        | normally closed                                     | scfm    | standard cubic feet per minute   |
| km                   | kilometer  | NEC       | National Electrical Code                            | SCR     | silicon controlled rectifier   |
| kOhm, kΩ             | kilo-ohm   | NEMA      | National Electrical Manufacturers Association       | s, sec. | second   |
| kPa                  | kilopascal   | NFPA      | National Fire Protection Association                | SI      | <i>Systeme internationale d'unites</i> , International System of Units |
| kph                  | kilometers per hour                                  | Nm        | newton meter  | SI/EO   | side in/end out  |
| kV                   | kilovolt   | NO        | normally open                                       | sil.    | silencer   |
| kVA                  | kilovolt ampere                                      | no., nos. | number, numbers                                     | SN      | serial number  |
| kVAR                 | kilovolt ampere reactive                             | NPS       | National Pipe, Straight                             | SNMP    | simple network management protocol                                     |
| kW                   | kilowatt   | NPSC      | National Pipe, Straight-coupling                    | SPDT    | single-pole, double-throw  |
| kWh                  | kilowatt-hour  | NPT       | National Standard taper pipe thread per general use | SPST    | single-pole, single-throw  |
| kWm                  | kilowatt mechanical                                  | NPTF      | National Pipe, Taper-Fine                           | spec    | specification  |
| kWth                 | kilowatt-thermal                                     | NR        | not required, normal relay                          | specs   | specification(s)   |
| L                    | liter  | ns        | nanosecond  | sq.     | square   |
| LAN                  | local area network                                   | OC        | overcrank   | sq. cm  | square centimeter  |
| L x W x H            | length by width by height                            | OD        | outside diameter                                    | sq. in. | square inch  |
| lb.                  | pound, pounds  | OEM       | original equipment manufacturer                     | SS      | stainless steel  |
| lbm/ft <sup>3</sup>  | pounds mass per cubic feet                           | OF        | overfrequency                                       | std.    | standard   |
| LCB                  | line circuit breaker                                 | opt.      | option, optional                                    | stl.    | steel  |
| LCD                  | liquid crystal display                               | OS        | oversize, overspeed                                 | tach.   | tachometer   |
| ld. shd.             | load shed  | OSHA      | Occupational Safety and Health Administration       | TD      | time delay   |
| LED                  | light emitting diode                                 | OV        | overvoltage   | TDC     | top dead center  |
| Lph                  | liters per hour                                      | oz.       | ounce   | TDEC    | time delay engine cooldown   |
| Lpm                  | liters per minute                                    | p., pp.   | page, pages   | TDEN    | time delay emergency to normal   |
| LOP                  | low oil pressure                                     | PC        | personal computer                                   | TDES    | time delay engine start  |
| LP                   | liquefied petroleum                                  | PCB       | printed circuit board                               | TDNE    | time delay normal to emergency   |
| LPG                  | liquefied petroleum gas                              | pF        | picofarad   | TDOE    | time delay off to emergency  |
| LS                   | left side  | PF        | power factor  | TDON    | time delay off to normal   |
| L <sub>wa</sub>      | sound power level, A weighted                        | ph., ∅    | phase   | temp.   | temperature  |
| LWL                  | low water level                                      | PHC       | Phillips® head Crimptite® (screw)                   | term.   | terminal   |
| LWT                  | low water temperature                                | PHH       | Phillips® hex head (screw)                          | THD     | total harmonic distortion  |
| m                    | meter, milli (1/1000)                                | PHM       | pan head machine (screw)                            | TIF     | telephone influence factor   |
| M                    | mega (10 <sup>6</sup> when used with SI units), male | PLC       | programmable logic control                          | TIR     | total indicator reading  |
| m <sup>3</sup>       | cubic meter  | PMG       | permanent magnet generator                          | tol.    | tolerance  |
| m <sup>3</sup> /hr.  | cubic meters per hour                                | pot       | potentiometer, potential                            | turbo.  | turbocharger   |
| m <sup>3</sup> /min. | cubic meters per minute                              | ppm       | parts per million                                   | typ.    | typical (same in multiple locations)                                   |
| mA                   | milliampere  | PROM      | programmable read-only memory                       | UF      | underfrequency   |
| man.                 | manual   | psi       | pounds per square inch                              | UHF     | ultrahigh frequency  |
| max.                 | maximum  | psig      | pounds per square inch gauge                        | UL      | Underwriter's Laboratories, Inc.                                       |
| MB                   | megabyte (2 <sup>20</sup> bytes)                     | pt.       | pint  | UNC     | unified coarse thread (was NC)   |
| MCCB                 | molded-case circuit breaker                          | PTC       | positive temperature coefficient                    | UNF     | unified fine thread (was NF)   |
| MCM                  | one thousand circular mils                           | PTO       | power takeoff                                       | univ.   | universal  |
| megger               | megohmmeter  | PVC       | polyvinyl chloride                                  | US      | undersize, underspeed  |
| MHz                  | megahertz  | qt.       | quart, quarts                                       | UV      | ultraviolet, undervoltage  |
| mi.                  | mile   | qty.      | quantity  | V       | volt   |
| mil                  | one one-thousandth of an inch                        | R         | replacement (emergency) power source                | VAC     | volts alternating current  |
| min.                 | minimum, minute                                      | rad.      | radiator, radius                                    | VAR     | voltampere reactive  |
| misc.                | miscellaneous  | RAM       | random access memory                                | VDC     | volts direct current   |
| MJ                   | megajoule  | RDO       | relay driver output                                 | VFD     | vacuum fluorescent display   |
| mJ                   | millijoule   | ref.      | reference   | VGA     | video graphics adapter   |
| mm                   | millimeter   | rem.      | remote  | VHF     | very high frequency  |
| mOhm, mΩ             | milliohm   | Res/Coml  | Residential/Commercial                              | W       | watt   |
| MOhm, MΩ             | megohm   | RFI       | radio frequency interference                        | WCR     | withstand and closing rating   |
| MOV                  | metal oxide varistor                                 | RH        | round head  | w/      | with   |
| MPa                  | megapascal   | RHM       | round head machine (screw)                          | w/o     | without  |
| mpg                  | miles per gallon                                     | rly.      | relay   | wt.     | weight   |
| mph                  | miles per hour                                       |           |   | xfmr    | transformer  |
| MS                   | military standard                                    |           |   |         |  |
| ms                   | millisecond  |           |   |         |  |
| m/sec.               | meters per second                                    |           |   |         |  |
| MTBF                 | mean time between failure                            |           |   |         |  |

## Appendix B Display Items for Reference

| <b>Menu 4<br/>Operational Records</b>  |  | <b>Menu 5<br/>Event History</b>  |   |  |
|--|--|--|---|--|
| <ul style="list-style-type: none"> <li>● Factory Test Date</li> <li>● Total Run Time</li> <li>● Total Run Time Loaded Hours</li> <li>● Total Run Time Unloaded Hours</li> <li>● Total Run Time kW Hours</li> <li>● No. of Starts</li> <li>● Engine Start Countdown                             <ul style="list-style-type: none"> <li>○ Run Time</li> </ul> </li> <li>● Records-Maintenance                             <ul style="list-style-type: none"> <li>○ Reset Records</li> </ul> </li> <li>● Run Time Since Maintenance Total Hours</li> <li>● Run Time Since Maintenance Loaded Hours</li> <li>● Run Time Since Maintenance Unloaded Hours</li> <li>● Run Time Since Maintenance kW Hours</li> <li>● Operating Days Last Maintenance</li> <li>● No. of Starts Last Maintenance</li> <li>● Last Start Date</li> <li>● Length of Run (Un)loaded Hours</li> </ul> |  | <ul style="list-style-type: none"> <li>● (Message Text)</li> <li>● (Scroll through up to 100 stored events)</li> </ul> |   |  |
|  |  |  | <b>Menu 20<br/>Factory Setup</b>  |  |
|  |  |  | <ul style="list-style-type: none"> <li>● Final Assembly Date</li> <li>● Final Assembly Clock No.</li> <li>● Operating Days</li> </ul> |  |

## Appendix C Controller User-Defined Settings

Use the table below to record user-defined settings during the generator set controller setup and calibration. The controller default settings and ranges provide

guidelines. The table contains all faults with ranges and time delays including items that do not have adjustments.

| Status or Fault                             | Refer to Menu | Digital Display       | Relay Driver Output (RDO) | Range Setting   | Default Selection  | Inhibit Time Delay* (sec.) | Time Delay (sec.) | User-Defined Settings |
|---|---------------|-----------------------|---------------------------|---|--|----------------------------|-------------------|-----------------------|
| AC Sensing Loss                             | 10            | AC Sensing Loss       | RDO-25                    |   |  |                            |                   | Not adjustable        |
| Access Code (password)                      | 14            |                       |                           |   | 0 (zero)   |                            |                   |                       |
| Analog Aux. Inputs 1-7                      | 9             | User-Defined A1-A7    |                           | Default values with Warning Enabled: HI warning 90%, LO warning 10%, HI shutdown 100%, LO shutdown 1%           | 30 sec. inhibit, 5 sec. delay                                | 0-60                       | 0-60              |                       |
| Analog Aux. Input 1                         | 9             | Coolant Temperature   |                           | Default values with Warning Enabled: HI/LO warning and HI/LO shutdown are all engine dependant                  | 30 sec. inhibit, 0 sec. delay                                | 0-60                       | 0-60              |                       |
| Analog Aux. Input 2                         | 9             | Oil Pressure          |                           | Default values with Warning Enabled: HI/LO warning and HI/LO shutdown are all engine dependant (255 psi max.)   | 30 sec. inhibit, 0 sec. delay warning, 5 sec. delay shutdown | 0-60                       | 0-60              |                       |
| Cyclic Cranking                             | 8             |                       |                           | 1-6 crank cycles<br>1-60 sec. crank on<br>1-60 sec. pause   | 3 cycles<br>15 sec.<br>15 sec.                               |                            |                   |                       |
| Defined Common Faults                       | 10            | User-Defined          | RDO-18                    | Default shutdowns include:<br>Emergency stop<br>High coolant temp<br>Low oil pressure<br>Overcrank<br>Overspeed | 30 sec. inhibit, 5 sec. delay                                | 0-60                       | 0-60              |                       |
| Digital Aux. Inputs 1-21                    | 9             | User-Defined D1-D21   |                           |   | 30 sec. inhibit, 5 sec. delay                                | 0-60                       | 0-60              |                       |
| EPS (Emergency Power System) Supplying Load | 10            | EPS Supplying Load    | RDO-15                    |   | 5% of rated line current                                     |                            |                   |                       |
| High Battery Voltage                        | 10            | High Battery Voltage  | RDO-13                    | 14.5-16.5 (12V)<br>29-33 (24V)  | 16 (12V)<br>32 (24V)   |                            | 10                |                       |
| High Coolant Temperature Shutdown           | 10            | Hi Cool Temp Shutdown | RDO-03                    |   |  | 30                         | 5                 | Not adjustable        |
| High Coolant Temperature Warning            | 10            | Hi Cool Temp Warning  | RDO-06                    |   |  | 30                         |                   | Not adjustable        |
| High Oil Temperature Shutdown               | 10            | Hi Oil Temp Shutdown  | RDO-17                    |   |  | 30                         | 5                 | Not adjustable        |

\* Inhibited time delay is the time delay period after crank disconnect.

| Status or Fault   | Refer to Menu | Digital Display                 | Relay Driver Output (RDO) | Range Setting                  | Default Selection                      | Inhibit Time Delay* (sec.) | Time Delay (sec.) | User-Defined Settings |
|---|---------------|---------------------------------|---------------------------|--------------------------------|--|----------------------------|-------------------|-----------------------|
| Idle (speed)<br>Mode Function<br>Digital Auz.<br>Input 21 | 9             | Idle Mode<br>Active             | RDO-21                    |                                | 0 sec.<br>inhibit,<br>60 sec.<br>delay |                            | 0-600             |                       |
| Load Shed<br>kW Overload                                  | 10            | Load Shed<br>KW Over            | RDO-30                    |                                | 100% of kW<br>rating                   |                            | 5                 |                       |
| Load Shed<br>Underfrequency                               | 10            | Load Shed<br>Under<br>Frequency | RDO-31                    |                                | 59, (60 Hz)<br>49, (50 Hz)             |                            | 5                 |                       |
| Low Battery<br>Voltage                                    | 10            | Low Battery<br>Voltage          | RDO-12                    | 10-12.5 (12V)<br>20-25 (24V)   | 12 (12V)<br>24 (24V)                   |                            | 10                |                       |
| Low Coolant<br>Level                                      | 10            | Low Coolant<br>Level            | RDO-14                    |                                |  | 30                         | 5                 | Not adjustable        |
| (Low) Oil<br>Pressure<br>Shutdown                         | 10            | Oil Pressure<br>Shutdown        | RDO-04                    |                                |  | 30                         | 5                 | Not adjustable        |
| (Low) Oil<br>Pressure<br>Warning                          | 10            | Oil Pressure<br>Warning         | RDO-07                    |                                |  | 30                         |                   | Not adjustable        |
| No Coolant<br>Temperature<br>Signal                       | 10            | No Cool<br>Temp Signal          |                           |                                |  | 30                         |                   | Not adjustable        |
| No Oil Pressure<br>Signal                                 | 10            | No Oil<br>Pressure<br>Signal    |                           |                                |  | 30                         |                   | Not adjustable        |
| Overcrank<br>Shutdown                                     | 8             | Over Crank                      | RDO-02                    | 0-6 cycles                     | 3 cycles                               |                            |                   |                       |
| Overcurrent   | 10            | Over Current                    |                           |                                | 110%                                   |                            | 10                |                       |
| Overfrequency<br>Shutdown                                 | 7, 10         | Over<br>Frequency               | RDO-28                    | 102%-140%                      | 140% std.<br>103% FAA                  |                            | 10                |                       |
| Overspeed<br>Shutdown                                     | 7, 10         | Over Speed                      | RDO-01                    | 65-70 (60 Hz)<br>55-70 (50 Hz) | 70 (60 Hz)<br>60 (50 Hz)               |                            | 0.25              |                       |
| Overvoltage<br>Shutdown                                   | 7, 8,<br>10   | Over Voltage                    | RDO-20                    | 105%-135%                      | 115%<br>2-sec time<br>delay            |                            | 2-10              |                       |
| Password<br>(access code)                                 | 14            |                                 |                           |                                | 0 (zero)                               |                            |                   | See Access Code entry |
| Time Delay<br>Engine<br>Cooldown<br>(TDEC)                | 8, 10         |                                 | RDO-23                    | 00:00-10:00<br>min:sec         | 5:00                                   |                            |                   |                       |
| Time Delay<br>Engine Start<br>(TES)                       | 8, 10         |                                 |                           | 00:00-5:00<br>min:sec          | 00:01                                  |                            |                   |                       |
| Time Delay<br>Starting Aid                                | 8, 10         |                                 |                           | 0-10 sec.                      |  |                            |                   |                       |
| Underfrequency<br>Shutdown                                | 7, 10         | Under<br>Frequency              | RDO-29                    | 80%-95%                        | 90%                                    |                            | 10                |                       |
| Undervoltage<br>Shutdown                                  | 7, 8,<br>10   | Under<br>Voltage                | RDO-27                    | 70%-95%                        | 85%<br>10-sec time<br>delay            |                            | 5-30              |                       |
| Weak Battery  | 10            | Weak<br>Battery                 | RDO-26                    |                                | 60% of<br>nominal                      |                            | 2                 |                       |

\* Inhibited time delay is the time delay period after crank disconnect.

## Appendix D Relay Driver Output (RDO) Designations

Use the table below to record user-defined description changes to the individual RDO selections.

| <b>RDO Number</b> | <b>Factory Default RDO Designation</b> | <b>User-Defined RDO Designation</b> |
|-------------------|--|-------------------------------------|
| RDO1              | Overspeed                              |                                     |
| RDO2              | Overcrank                              |                                     |
| RDO3              | High coolant temperature shutdown      |                                     |
| RDO4              | Low oil pressure shutdown              |                                     |
| RDO5              | Low coolant temperature                |                                     |
| RDO6              | High coolant temperature               |                                     |
| RDO7              | Low oil pressure warning               |                                     |
| RDO8              | Low fuel                               |                                     |
| RDO9              | Master switch not in auto              |                                     |
| RDO10             | NFPA 110 common alarm                  |                                     |
| RDO11             | Battery charger fault                  |                                     |
| RDO12             | Low battery voltage                    |                                     |
| RDO13             | High battery voltage                   |                                     |
| RDO14             | Emergency stop                         |                                     |
| RDO15             | Generator running                      |                                     |
| RDO16             | Time delay engine cooldown             |                                     |
| RDO17             | System ready                           |                                     |
| RDO18             | Defined common fault                   |                                     |
| RDO19             | Low coolant level                      |                                     |
| RDO20             | Overvoltage                            |                                     |
| RDO21             | Idle mode                              |                                     |
| RDO22             | EPS supplying load                     |                                     |
| RDO23             | Air damper indicator                   |                                     |
| RDO24             | Speed sensor fault                     |                                     |
| RDO25             | Loss of AC sensing                     |                                     |
| RDO26             | ECM loss of communication              |                                     |
| RDO27             | Undervoltage                           |                                     |
| RDO28             | Overfrequency                          |                                     |
| RDO29             | Underfrequency                         |                                     |
| RDO30             | Load shed kW overload                  |                                     |
| RDO31             | Load shed underfrequency               |                                     |



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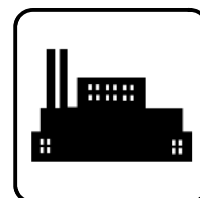
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# Service Parts

Engine



Engine Models:

**Mitsubishi S12A2-Y1PTA**

**S12A2-Y2PTAW**

**Kohler D750/D800 33.9A**

Generator Models:

750/800REOZM

750/800REOZMB

750/800REOZMD

750/800ROZMC

**9001**  
**KOHLER**  
POWER SYSTEMS  
NATIONALLY REGISTERED

**KOHLER**<sup>®</sup>  
POWER SYSTEMS

TP-6282 5/12c

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# Introduction

This manual lists service replacement parts for engines used on the 750/800REOZM/ROZMC and 750/800REOZMB/REOZMD generator sets.

Information in this publication represents data available at the time of print. The generator set manufacturer reserves the right to change this publication and the products represented without notice and without any obligation or liability whatsoever.

This manual includes the following main sections:

**Table of Contents.** Lists the sections of the manual.

**Introduction (and other information sections).** Contains introductory material about part numbers, illustrations, and hardware.

**Group Parts Lists.** Lists the part numbers of parts in the groups.

## Number System Significance

This manual uses the following numbering systems:

**Group Number.** A unique number representing a parts group needed to assemble a generator set function. For example, Group 1 is the Cylinder Head Group.

**Part Number.** The part number identifies an individual assembly, subassembly, component, or accessory kit.

## Illustrations

Illustrations (or exploded-view drawings) best representing the widest range of variations accompany most groups in this manual. Illustrations do not depict all details and may not show all parts. Do not use illustrations for assembly or disassembly.

## How to Find Part Numbers

Use the following steps to locate a service replacement part.

1. **Identify the group** most likely to include the service part number.
2. **Page forward to locate the group** identified in step 1 or find the appropriate page in the Table of Contents.
3. **Find the part on the illustration** and note the item number of the part or **find the part description in the parts list.**

# Specification Number Index

|                         |                      |                                |                 |                           |                  |                         |                         |                |                        |                                  |                                |                    |                        |  |
|-------------------------|----------------------|--------------------------------|-----------------|---------------------------|------------------|-------------------------|-------------------------|----------------|------------------------|----------------------------------|--------------------------------|--------------------|------------------------|--|
| <b>Group Title</b>      | <i>Cylinder Head</i> | <i>Valves and Rocker Cover</i> | <i>Camshaft</i> | <i>Crankcase Assembly</i> | <i>Crankcase</i> | <i>Crankcase Covers</i> | <i>Timing Gear Case</i> | <i>Oil Pan</i> | <i>Engine Mounting</i> | <i>Piston and Connecting Rod</i> | <i>Crankshaft and Flywheel</i> | <i>Timing Gear</i> | <i>Accessory Drive</i> |  |
| <b>Group No.</b>        | <b>1</b>             | <b>4</b>                       | <b>5</b>        | <b>7.1</b>                | <b>7.2</b>       | <b>7.3</b>              | <b>11</b>               | <b>13</b>      | <b>14</b>              | <b>17</b>                        | <b>20</b>                      | <b>23</b>          | <b>25</b>              |  |
| <b>Variation Number</b> |                      |                                |                 |                           |                  |                         |                         |                |                        |                                  |                                |                    |                        |  |

|                             |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|-----------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| <b>Model</b>                |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| <b>750/800REOZM/ROZMC</b>   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| S12A2-Y1PTA                 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| <b>750/800REOZMB/REOZMD</b> |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| S12A2-Y2PTAW                | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |

|                         |                        |                              |                       |                      |                     |                 |                     |                  |                               |                   |                            |                   |                                |                 |
|-------------------------|------------------------|------------------------------|-----------------------|----------------------|---------------------|-----------------|---------------------|------------------|-------------------------------|-------------------|----------------------------|-------------------|--------------------------------|-----------------|
| <b>Group Title</b>      | <i>Hourmeter Cover</i> | <i>Intake and Air Heater</i> | <i>Exhaust System</i> | <i>Exhaust Elbow</i> | <i>Turbocharger</i> | <i>Oil Pump</i> | <i>Oil Strainer</i> | <i>Oil Pipes</i> | <i>Turbocharger Oil Lines</i> | <i>Oil Cooler</i> | <i>Oil Cooler Assembly</i> | <i>Oil Filter</i> | <i>Oil Filler and Dipstick</i> | <i>Breather</i> |
| <b>Group No.</b>        | <b>25.3</b>            | <b>30.1</b>                  | <b>32.1</b>           | <b>32.2</b>          | <b>33</b>           | <b>35</b>       | <b>36.1</b>         | <b>36.2</b>      | <b>36.3</b>                   | <b>39.1</b>       | <b>39.2</b>                | <b>40</b>         | <b>42</b>                      | <b>43</b>       |
| <b>Variation Number</b> |                        |                              |                       |                      |                     |                 |                     |                  |                               |                   |                            |                   |                                |                 |

|                             |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|-----------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| <b>Model</b>                |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| <b>750/800REOZM/ROZMC</b>   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| S12A2-Y1PTA                 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| <b>750/800REOZMB/REOZMD</b> |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| S12A2-Y2PTAW                | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 1 | 2 | 1 | 1 |

# Specification Number Index

| Group Title             | <i>Water Pump</i> | <i>Thermostat and Covers</i> | <i>Water Pump Pipes</i> | <i>Air Cooler Pipes</i> | <i>Fan Drive</i> | <i>Intercooler Thermostat</i> | <i>Intercooler Piping</i> | <i>Intercooler Pump</i> | <i>Intercooler Pump Assembly</i> | <i>Fuel Injection Pump</i> | <i>Control Shaft</i> | <i>Nozzle Assembly</i> | <i>Fuel Injection Pipes</i> | <i>Fuel Leakoff Pipes</i> |
|-------------------------|-------------------|------------------------------|-------------------------|-------------------------|------------------|-------------------------------|---------------------------|-------------------------|----------------------------------|----------------------------|----------------------|------------------------|-----------------------------|---------------------------|
| Group No.               | 45                | 46.1                         | 46.2                    | 46.3                    | 48               | 51.1                          | 51.2                      | 53.1                    | 53.2                             | 61.1                       | 61.2                 | 61.3                   | 61.4                        | 61.5                      |
| <b>Variation Number</b> |                   |                              |                         |                         |                  |                               |                           |                         |                                  |                            |                      |                        |                             |                           |

| <b>Model</b>                |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|-----------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| <b>750/800REOZM/ROZMC</b>   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| S12A2-Y1PTA                 | 1 | 1 | 1 | 1 | 1 | — | — | — | — | 1 | 1 | 1 | 1 | 1 |
| <b>750/800REOZMB/REOZMD</b> |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| S12A2-Y2PTAW                | 2 | 2 | 2 | — | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |

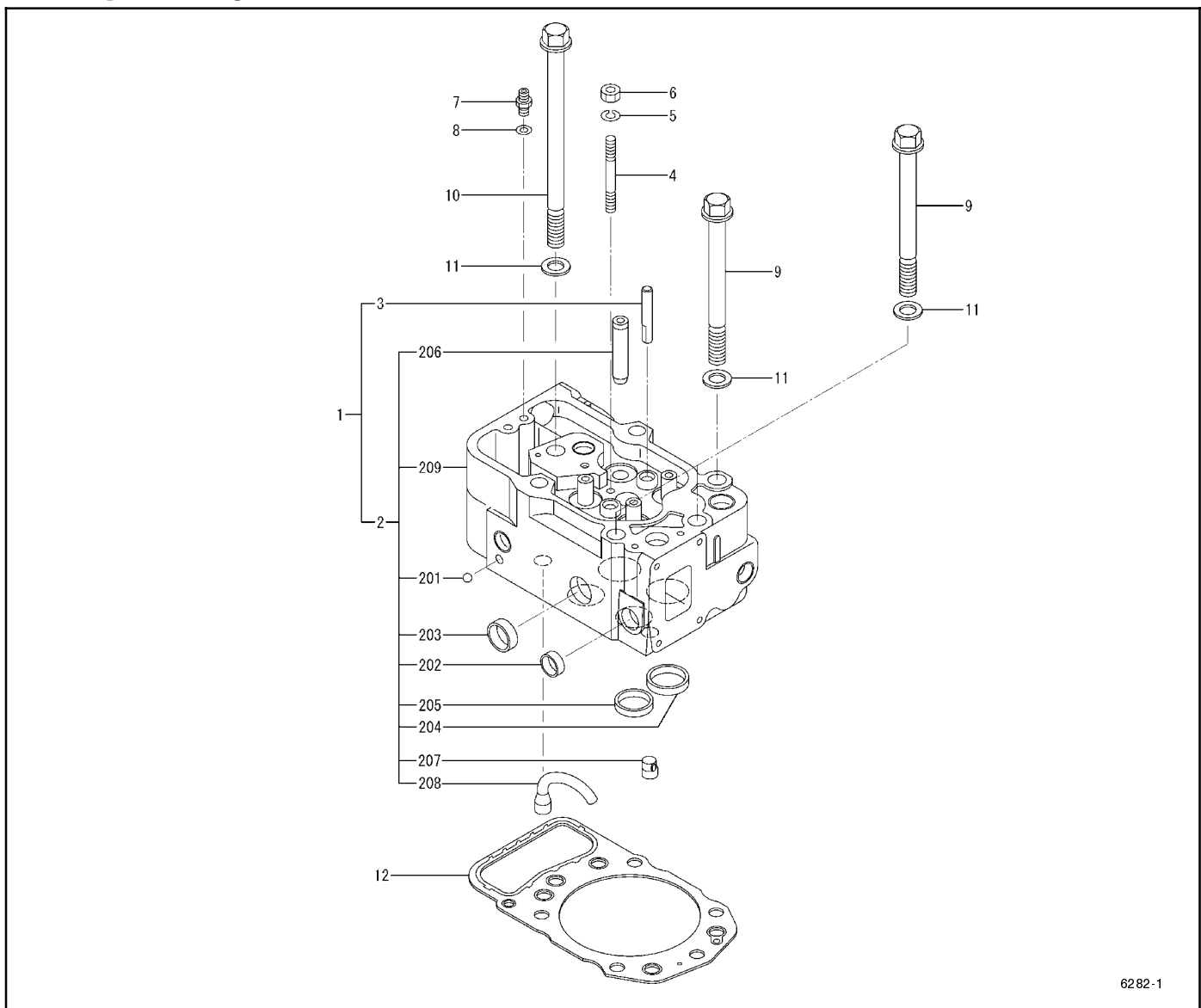
| Group Title             | <i>Injection Pump, Right</i> | <i>Injection Pump, Left</i> | <i>Coupling</i> | <i>Fuel Feed Pump</i> | <i>Coupling Assembly</i> | <i>Fuel Filter</i> | <i>Fuel Filter Piping</i> | <i>Fuel Filter (Wire Element)</i> | <i>Governor Control</i> | <i>Starter</i> | <i>Alternator Mounting</i> | <i>Alternator</i> | <i>Stop System</i> |
|-------------------------|------------------------------|-----------------------------|-----------------|-----------------------|--------------------------|--------------------|---------------------------|-----------------------------------|-------------------------|----------------|----------------------------|-------------------|--------------------|
| Group No.               | 61.6                         | 61.7                        | 61.8            | 61.9                  | 61.10                    | 62                 | 62.1                      | 62.2                              | 63.1                    | 66             | 68.1                       | 68.2              | 87                 |
| <b>Variation Number</b> |                              |                             |                 |                       |                          |                    |                           |                                   |                         |                |                            |                   |                    |

| <b>Model</b>                |   |   |   |   |   |   |   |   |   |   |   |   |   |
|-----------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|
| <b>750/800REOZM/ROZMC</b>   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| S12A2-Y1PTA                 | 1 | 1 | 1 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| <b>750/800REOZMB/REOZMD</b> |   |   |   |   |   |   |   |   |   |   |   |   |   |
| S12A2-Y2PTAW                | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1 |

| Group Title | <i>Overhaul Gasket Kit</i> | <i>Oil Seal Kit</i> |
|-------------|----------------------------|---------------------|
| Group No.   | 94.1                       | 94.2                |

| <b>750/800REOZM/ROZMC</b> |     |     |
|---------------------------|-----|-----|
| S12A2-Y1PTA               | 1   | 1   |
| <b>750/800REOZMB/D</b>    |     |     |
| S12A2-Y2PTAW              | TBD | TBD |

# Group 1: Cylinder Head

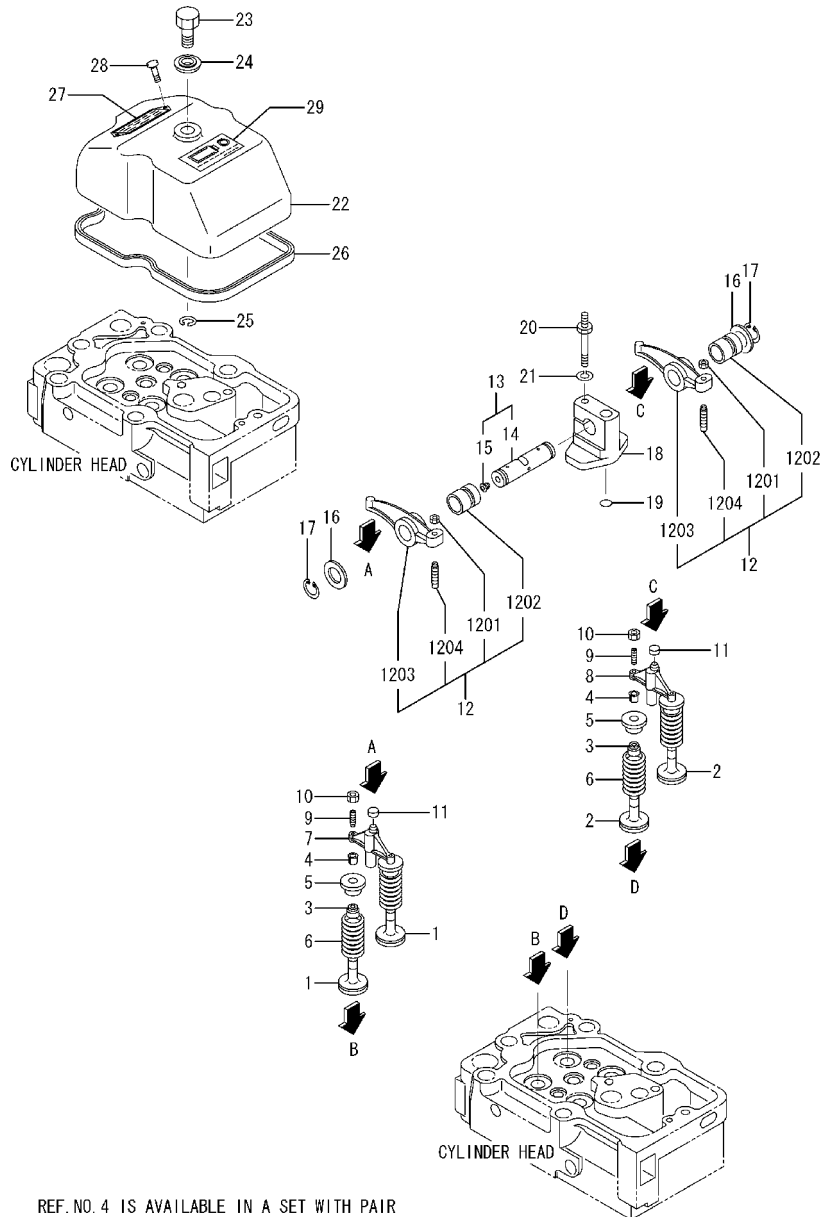


6282-1

| Item | Part No. | Description                  | Qty. |    | Item | Part No. | Description           | Qty. |    |
|------|----------|------------------------------|------|----|------|----------|-----------------------|------|----|
|      |          |                              | 1    | 2  |      |          |                       | 1    | 2  |
| 1    | GM36261  | Head assembly, cylinder      | 12   |    | 206  | GM14569  | Guide, valve          | 48   | 48 |
| 1    | GM57296  | Head assembly, cylinder      |      | 12 | 207  | GM36268  | Director, water       | 12   | 12 |
| 2    | X        | Head subassembly, cylinder   | 12   | 12 | 208  | GM36269  | Director, water       | 12   | 12 |
| 201  | X        | Ball, steel                  | 12   | 12 | 209  | X        | Head, cylinder        | 12   | 12 |
| 202  | GM15518  | Cap, sealing                 | 72   | 72 | 3    | GM14625  | Guide                 | 24   | 24 |
| 203  | GM14491  | Cap, sealing                 | 24   | 24 | 4    | GM36270  | Stud                  | 12   | 12 |
| 204  | GM36262  | Seat, inlet, standard        | 24   |    | 5    | GM15180  | Washer, spring        | 12   |    |
| 204  | GM57297  | Seat, inlet, standard        |      | 24 | 6    | GM15167  | Nut                   | 12   | 12 |
| 204  | GM36263  | Seat, inlet, 0.3 oversized   | AR   |    | 7    | GM36271  | Connector             | 12   | 12 |
| 204  | GM57298  | Seat, inlet, 0.3 oversized   |      | AR | 8    | GM14529  | Washer, sealing       | 12   | 12 |
| 204  | GM36264  | Seat, inlet, 0.6 oversized   | AR   |    | 9    | GM36272  | Bolt, cylinder head   | 60   | 60 |
| 204  | GM57299  | Seat, inlet, 0.6 oversized   |      | AR | 10   | GM36273  | Bolt, cylinder head   | 12   | 12 |
| 205  | GM36265  | Seat, exhaust, standard      | 24   | 24 | 11   | GM36274  | Washer                | 72   | 72 |
| 205  | GM36266  | Seat, exhaust, 0.3 oversized | AR   | AR | 12   | GM36275  | Gasket, cylinder head | 12   |    |
| 205  | GM36267  | Seat, exhaust, 0.6 oversized | AR   | AR | 12   | GM57300  | Gasket, cylinder head |      | 12 |

X Part is not sold separately  
AR As Required

# Group 4: Valve Mechanism and Rocker Cover



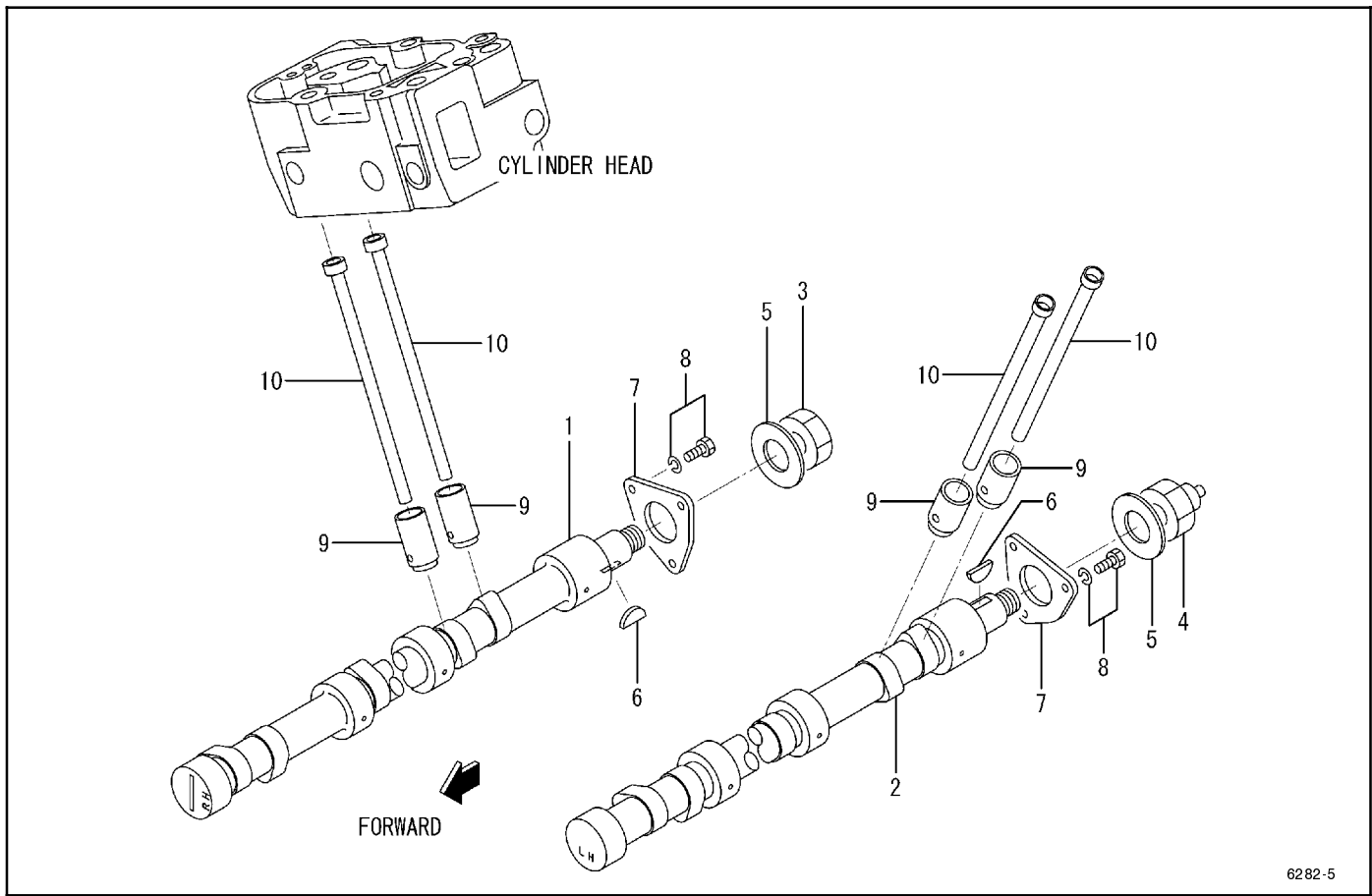
REF. NO. 4 IS AVAILABLE IN A SET WITH PAIR

6282-4.1

| Item | Part No. | Description             | Qty. |    | Item | Part No. | Description                 | Qty. |    |
|------|----------|-------------------------|------|----|------|----------|-----------------------------|------|----|
|      |          |                         | 1    | 2  |      |          |                             | 1    | 2  |
| 1    | GM36276  | Valve, inlet            | 24   | 24 | 15   | GM15242  | Plug, tapered               | 12   | 12 |
| 2    | GM36277  | Valve, exhaust          | 24   | 24 | 16   | GM36284  | Washer                      | 24   | 24 |
| 3    | GM14626  | Seal                    | 48   | 48 | 17   | GM36285  | Ring, snap                  | 24   | 24 |
| 4    | GM14570  | Cotter                  | 96   | 96 | 18   | GM36286  | Bracket, rocker             | 12   | 12 |
| 5    | GM14918  | Rotator                 | 48   | 48 | 19   | GM21611  | O-ring                      | 12   | 12 |
| 6    | GM36278  | Spring, valve           | 48   | 48 | 20   | GM36287  | Bolt                        | 12   | 12 |
| 7    | GM36279  | Bridge, inlet           | 12   | 12 | 21   | GM15180  | Washer, spring              | 12   | 12 |
| 8    | GM36280  | Bridge, exhaust         | 12   | 12 | 22   | GM36288  | Cover, rocker               | 12   | 12 |
| 9    | GM14893  | Screw                   | 24   | 24 | 23   | GM36289  | Screw                       | 12   | 12 |
| 10   | GM15166  | Nut                     | 24   | 24 | 24   | GM35822  | Packing, rocker cover screw | 12   | 12 |
| 11   | GM14557  | Cap                     | 24   | 24 | 25   | GM36290  | Ring, snap                  | 12   | 12 |
| 12   | GM36281  | Rocker assembly         | 24   |    | 26   | GM35821  | Packing, rocker cover       | 12   | 12 |
| 12   | GM57301  | Rocker assembly         |      | 24 | 27   | X        | Plate, caution              | 1    |    |
| 1201 | GM15167  | Nut                     | 24   | 24 | 28   | GM21588  | Rivet, screw                | 2    |    |
| 1202 | GM36282  | Bushing, rocker         | 24   | 24 | 29   | GM34066  | Plate, caution              | 1    |    |
| 1203 | X        | Rocker                  | 24   | 24 |      |          |                             |      |    |
| 1204 | GM14892  | Screw                   | 24   | 24 |      |          |                             |      |    |
| 13   | GM36283  | Shaft, assembly, rocker | 12   | 12 |      |          |                             |      |    |
| 14   | X        | Shaft, rocker           | 12   | 12 |      |          |                             |      |    |

X Part is not sold separately

# Group 5: Camshaft

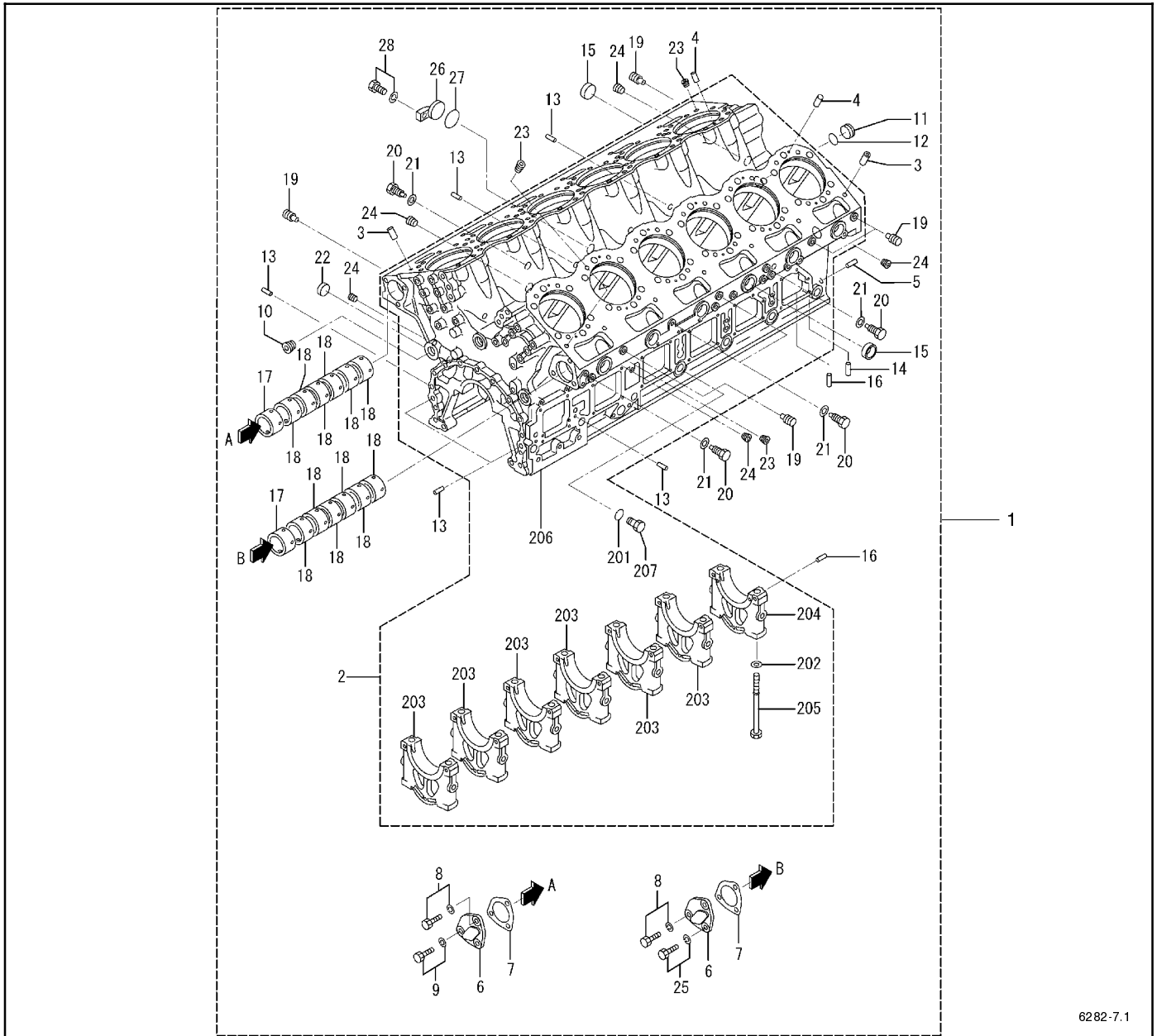


6282-5

| Item | Part No. | Description          | Qty. |
|------|----------|----------------------|------|
|      |          |                      | Var. |
| 1    | GM36291  | Camshaft, right side | 1    |
| 2    | GM36292  | Camshaft, left side  | 1    |
| 3    | GM36293  | Nut                  | 1    |
| 4    | GM36294  | Connector            | 1    |
| 5    | GM31402  | Washer               | 2    |
| 6    | GM15192  | Key, woodruff        | 2    |
| 7    | GM36295  | Plate                | 2    |
| 8    | GM36453  | Bolt, w/washer       | 6    |
| 9    | GM36296  | Tappet               | 24   |
| 10   | GM36297  | Rod, push            | 24   |



# Group 7.1: Crankcase Assembly

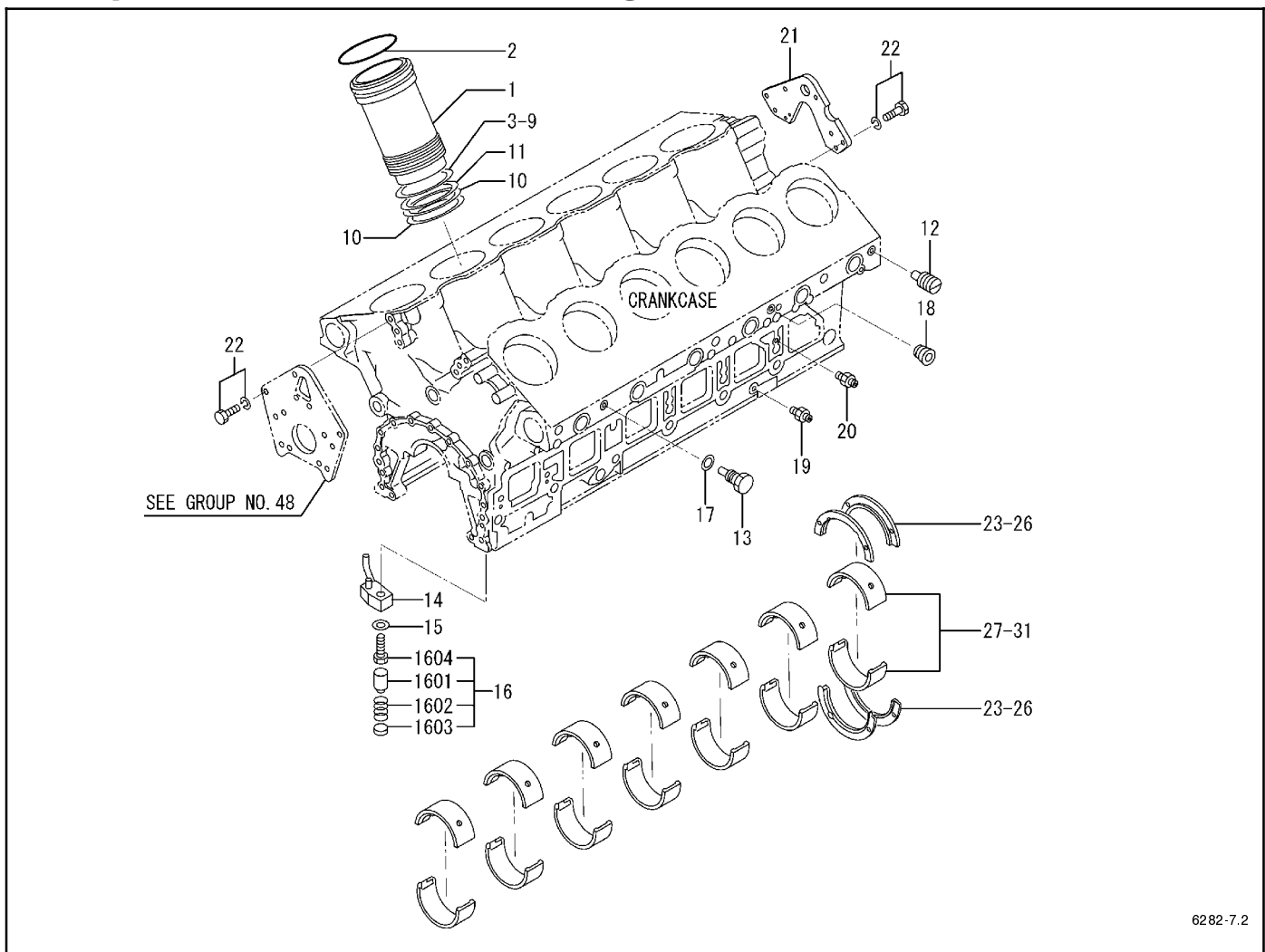


6282-7.1

| Item | Part No. | Description           | Qty.<br>Var. | Item | Part No. | Description       | Qty.<br>Var. |
|------|----------|-----------------------|--------------|------|----------|-------------------|--------------|
| 1    | GM36298  | Crankcase assembly    | 1            | 12   | GM14511  | O-ring            | 3            |
| 2    | X        | Crankcase subassembly | 1            | 13   | GM15188  | Pin, dowel        | 10           |
| 201  | GM14507  | Seal                  | 14           | 14   | GM36305  | Pin, dowel        | 2            |
| 202  | GM14571  | Washer                | 14           | 15   | GM21603  | Cap, sealing      | 12           |
| 203  | X        | Cap, main bearing     | 6            | 16   | GM14619  | Pin, dowel        | 4            |
| 204  | X        | Cap, main bearing     | 1            | 17   | GM36306  | Bushing, camshaft | 2            |
| 205  | GM36299  | Bolt, bearing cap     | 14           | 18   | GM36307  | Bushing, camshaft | 12           |
| 206  | X        | Crankcase             | 1            | 19   | GM36319  | Screw             | 6            |
| 207  | GM36300  | Bolt, side            | 14           | 20   | GM36320  | Screw             | 10           |
| 3    | GM14563  | Pin, dowel            | 12           | 21   | GM14528  | Washer, sealing   | 10           |
| 4    | GM36301  | Pin, dowel            | 12           | 22   | GM14491  | Cap, sealing      | 1            |
| 5    | GM14562  | Pin, dowel            | 2            | 23   | GM15520  | Plug, tapered     | 5            |
| 6    | GM36302  | Cover                 | 2            | 24   | GM14497  | Plug, tapered     | 11           |
| 7    | GM36303  | Packing               | 2            | 25   | GM36395  | Bolt, w/washer    | 1            |
| 8    | GM15983  | Bolt w/washer         | 4            | 26   | GM36308  | Cover             | 1            |
| 9    | GM15982  | Bolt w/washer         | 1            | 27   | GM36309  | O-ring            | 1            |
| 10   | GM36304  | Plug, tapered         | 3            | 28   | GM15159  | Bolt w/washer     | 1            |
| 11   | GM14610  | Plate                 | 3            |      |          |                   |              |

X Part is not sold separately

# Group 7.2: Crankcase Bearings

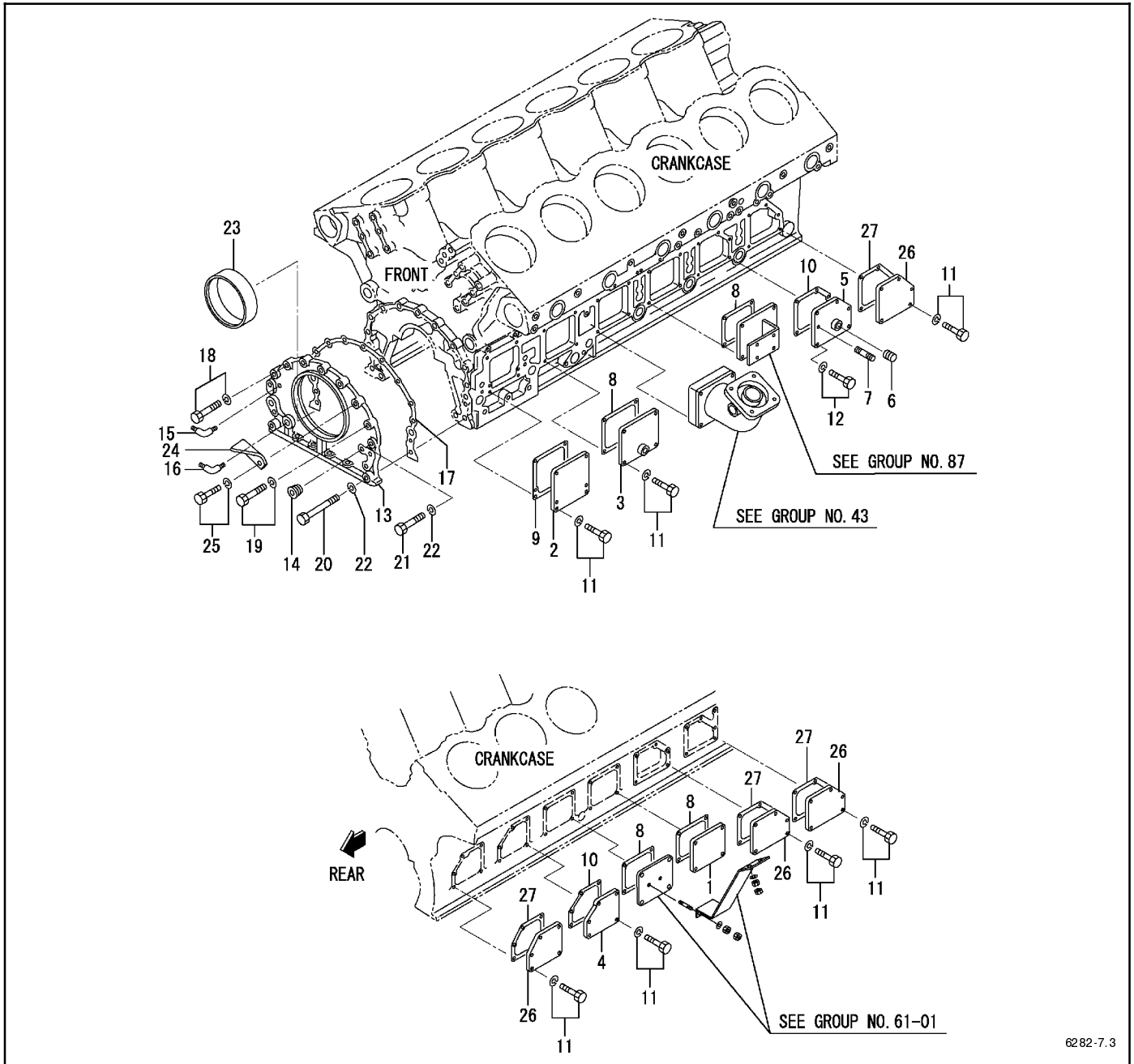


6282-7.2

| Item | Part No. | Description          | Qty. |    | Item | Part No. | Description                        | Qty. |    |
|------|----------|----------------------|------|----|------|----------|------------------------------------|------|----|
|      |          |                      | 1    | 2  |      |          |                                    | 1    | 2  |
| 1    | GM36310  | Liner, cylinder      | 12   | 12 | 1602 | X        | Spring, coil                       | 12   | 12 |
| 2    | GM36311  | O-ring, liner        | 12   | 12 | 1603 | GM34084  | Plug                               | 12   | 12 |
| 3    | GM36312  | Ring, liner, 0.05 mm | AR   | AR | 1603 | X        | Plug                               | 12   | 12 |
| 4    | GM36313  | Ring, liner, 0.10 mm | AR   | AR | 1604 | X        | Body, check valve                  | 12   | 12 |
| 5    | GM36314  | Ring, liner, 0.15 mm | AR   | AR | 17   | GM14528  | Washer, sealing                    | 8    | 8  |
| 6    | GM36315  | Ring, liner, 0.20 mm | AR   | AR | 18   | GM14497  | Plug, tapered                      | 11   | 11 |
| 7    | GM36316  | Ring, liner, 0.25 mm | AR   | AR | 19   | GM36323  | Connector                          | 2    | 2  |
| 8    | GM36317  | Ring, liner, 0.30 mm | AR   | AR | 20   | GM31459  | Connector                          | 1    | 1  |
| 9    | GM36318  | Ring, liner, 0.40 mm | AR   | AR | 21   | GM36324  | Hanger                             | 1    | 1  |
| 10   | GM14572  | O-ring               | 24   | 24 | 22   | GM36453  | Bolt, w/washer                     | 8    | 8  |
| 11   | GM14573  | O-ring               | 12   | 12 | 23   | GM36325  | Plate, thrust, standard            | 4    | 4  |
| 12   | GM36319  | Screw                | 6    |    | 24   | GM36326  | Plate, thrust, 0.25 oversized      | 4    | 4  |
| 13   | GM36320  | Screw                | 8    |    | 25   | GM36327  | Plate, thrust, 0.50 oversized      | 4    | 4  |
| 14   | GM36321  | Nozzle, oil jet      | 12   | 12 | 26   | GM36328  | Plate, thrust, 0.75 oversized      | 4    | 4  |
| 15   | GM36322  | Spring, conical disk | 12   |    | 27   | GM36329  | Bearing set, main, standard        | 7    | 7  |
| 15   | GM14887  | Washer               |      | 12 | 28   | GM36330  | Bearing set, main, 0.25 undersized | 7    | 7  |
| 16   | GM34081  | Valve, check         | 12   | 12 | 29   | GM36331  | Bearing set, main, 0.50 undersized | 7    | 7  |
| 1601 | GM34082  | Piston, check valve  | 12   |    | 30   | GM36332  | Bearing set, main, 0.75 undersized | 7    | 7  |
| 1601 | X        | Piston, check valve  |      | 12 | 31   | GM36333  | Bearing set, main, 1.00 undersized | 7    | 7  |
| 1602 | GM34083  | Spring, coil         | 12   |    |      |          |                                    |      |    |

X Part is not sold separately  
AR As Required

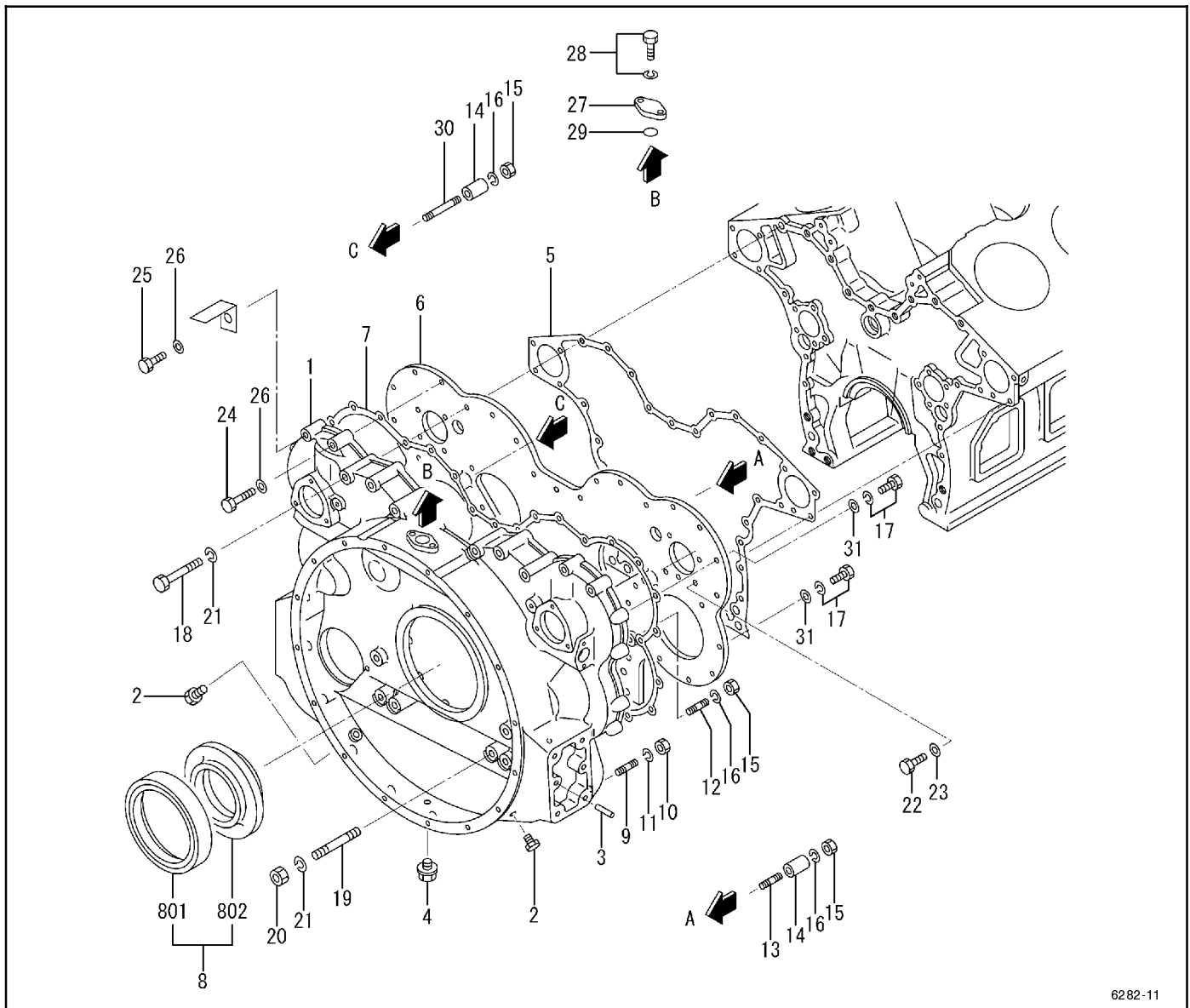
# Group 7.3: Crankcase Covers



6282-7.3

| Item | Part No. | Description   | Qty. |    | Item | Part No. | Description      | Qty. |   |
|------|----------|---------------|------|----|------|----------|------------------|------|---|
|      |          |               | 1    | 2  |      |          |                  | 1    | 2 |
| 1    | GM14564  | Cover, side   | 1    | 1  | 15   | GM14496  | Plug             | 1    | 1 |
| 2    | GM36334  | Cover, side   | 1    | 1  | 16   | GM36343  | Elbow            | 1    | 1 |
| 3    | GM36335  | Cover, side   | 1    | 1  | 17   | GM36344  | Packing          | 1    | 1 |
| 4    | GM36336  | Cover, side   | 1    | 1  | 18   | GM36453  | Bolt, w/washer   | 7    | 7 |
| 5    | GM36337  | Cover, side   | 1    | 1  | 19   | GM36395  | Bolt, w/washer   | 2    | 2 |
| 6    | GM14496  | Plug, tapered | 1    | 1  | 20   | GM36345  | Bolt             | 1    | 1 |
| 7    | GM36338  | Stud          | 4    | 4  | 21   | GM36346  | Bolt             | 1    | 1 |
| 8    | GM34094  | Packing       | 4    | 4  | 22   | GM15180  | Washer, spring   | 2    | 2 |
| 8    | GM57302  | Packing       |      | 4  | 23   | GM36995  | Seal, oil        | 1    | 1 |
| 9    | GM36339  | Gasket        | 1    | 1  | 24   | GM36347  | Pointer          | 1    | 1 |
| 10   | GM36340  | Gasket        | 2    | 2  | 25   | GM36453  | Bolt, w/washer   | 2    | 2 |
| 11   | GM15160  | Bolt w/washer | 38   | 38 | 26   | GM36348  | Cover, side      | 4    | 3 |
| 12   | GM15159  | Bolt w/washer | 2    | 2  | 26   | GM57303  | Cover, side      |      | 1 |
| 13   | GM36341  | Cover, front  | 1    | 1  | 27   | GM36349  | Gasket, side oil | 4    | 4 |
| 14   | GM14497  | Plug, tapered | 1    | 1  |      |          |                  |      |   |
| 15   | GM36342  | Elbow         | 1    |    |      |          |                  |      |   |

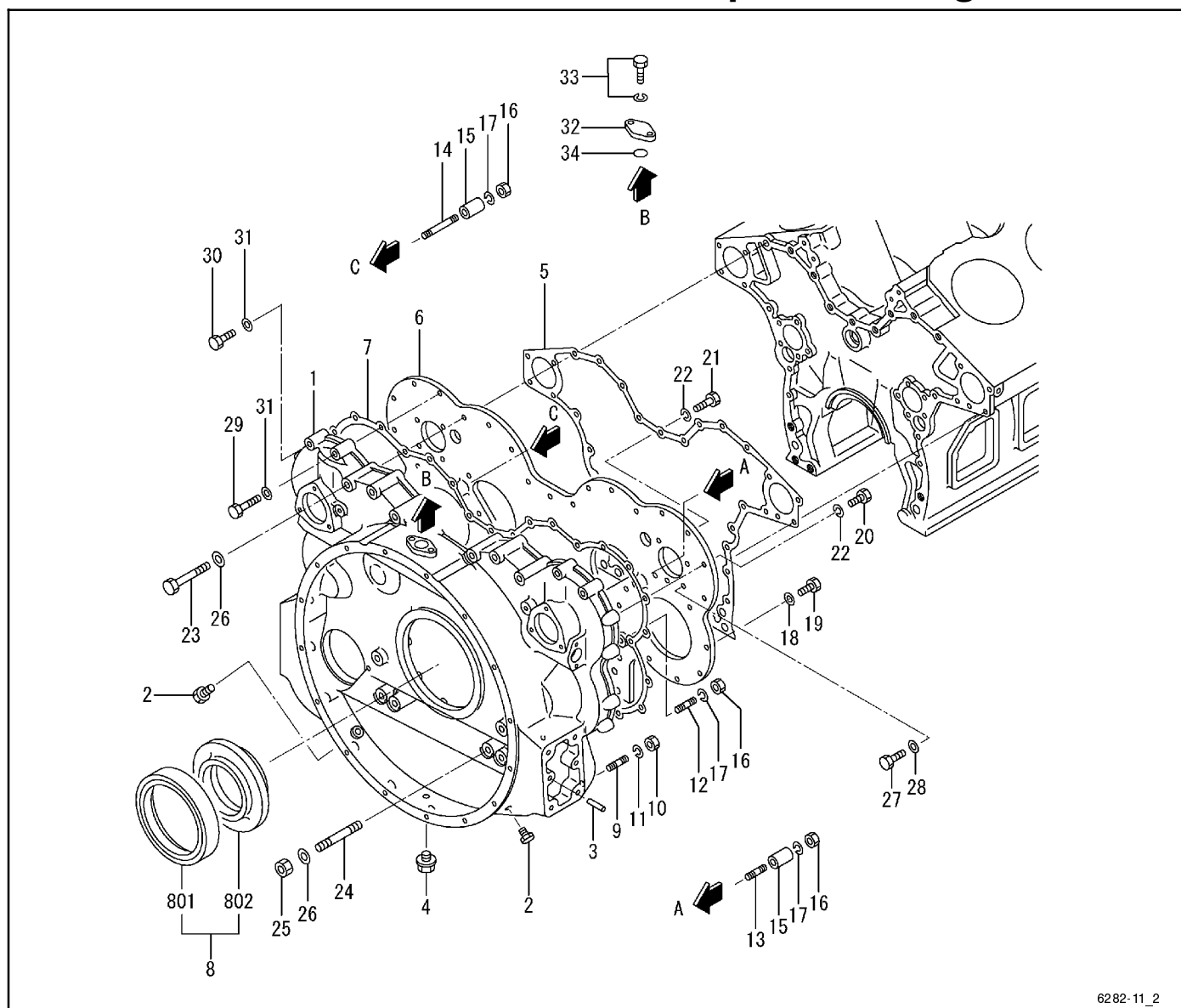
# Group 11: Timing Gear Case



6282-11

| Item | Part No. | Description        | Qty.<br>Var. | Item | Part No. | Description    | Qty.<br>Var. |
|------|----------|--------------------|--------------|------|----------|----------------|--------------|
| 1    | GM36350  | Case, timing gear  | 1            | 16   | GM15180  | Washer, spring | 4            |
| 2    | GM14901  | Plug               | 2            | 17   | GM36359  | Boit, w/washer | 10           |
| 3    | GM15188  | Pin, dowel         | 4            | 18   | GM15124  | Boit           | 13           |
| 4    | GM14459  | Plug               | 1            | 19   | GM36360  | Stud           | 2            |
| 5    | GM36351  | Packing            | 1            | 20   | GM36361  | Nut, jam       | 2            |
| 6    | GM36352  | Plate, rear        | 1            | 21   | GM15182  | Washer, spring | 15           |
| 7    | GM36353  | Packing            | 1            | 22   | GM36362  | Boit           | 22           |
| 8    | GM36354  | Seal assembly, oil | 1            | 23   | GM36363  | Washer         | 22           |
| 801  | GM36993  | Seal, oil          | 1            | 24   | GM15114  | Boit           | 2            |
| 802  | GM36355  | Slinger            | 1            | 25   | GM15959  | Boit           | 2            |
| 9    | GM34106  | Stud               | 6            | 26   | GM36363  | Washer         | 4            |
| 10   | GM15167  | Nut                | 6            | 27   | GM36364  | Cover          | 1            |
| 11   | GM15180  | Washer, spring     | 6            | 28   | GM15151  | Boit w/washer  | 2            |
| 12   | GM36356  | Stud               | 2            | 29   | GM14514  | O-ring         | 1            |
| 13   | GM36357  | Stud               | 1            | 30   | GM36365  | Stud           | 1            |
| 14   | GM36358  | Spacer             | 2            | 31   | GM36363  | Washer         | 10           |
| 15   | GM15167  | Nut                | 4            |      |          |                |              |

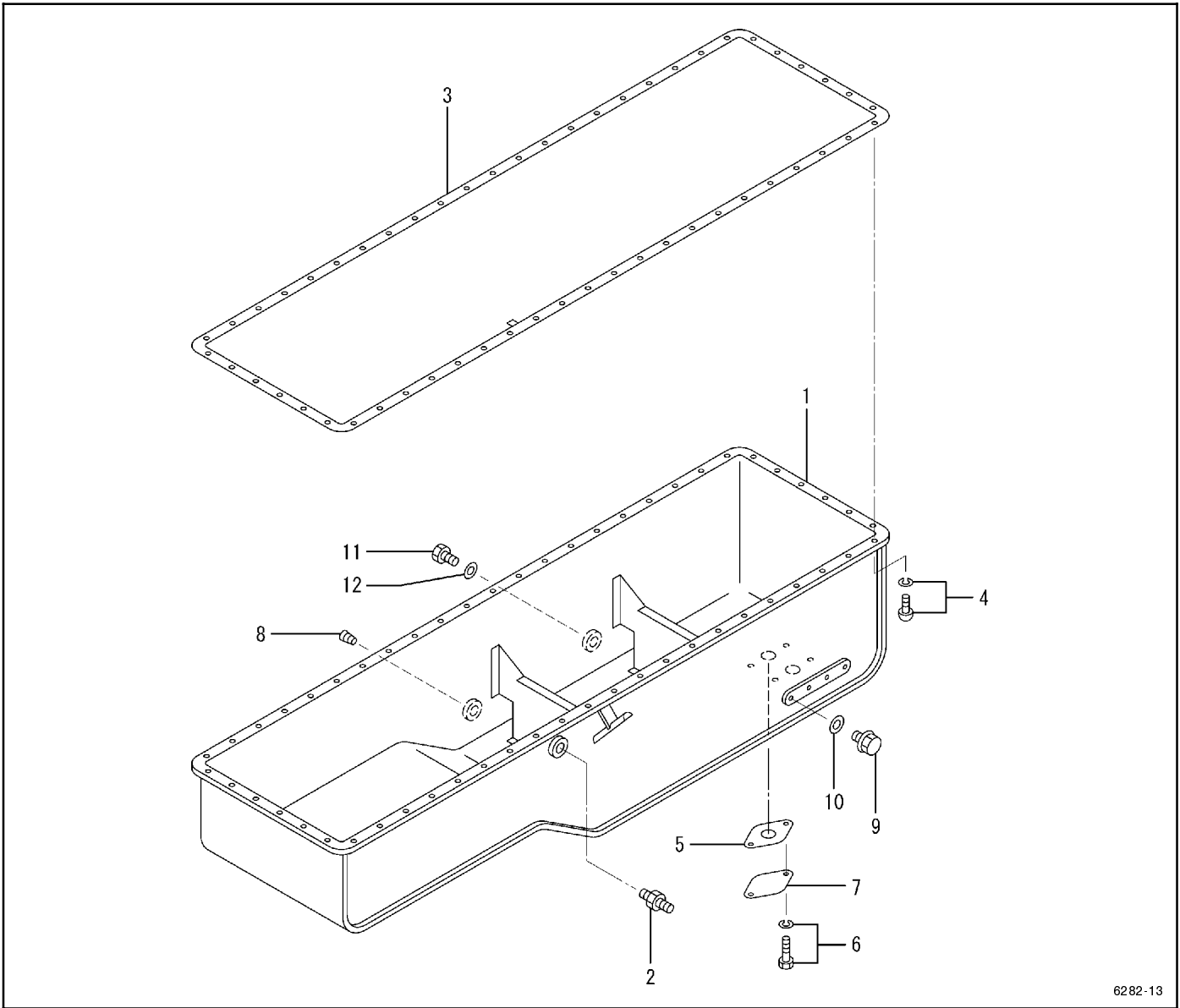
# Group 11: Timing Gear Case



6282-11\_2

| Item | Part No. | Description        | Qty.<br>Var. | Item | Part No. | Description    | Qty.<br>Var. |
|------|----------|--------------------|--------------|------|----------|----------------|--------------|
| 1    | GM36350  | Case, timing gear  | 1            | 17   | GM15180  | Washer, spring | 4            |
| 2    | GM14901  | Plug               | 3            | 18   | GM36363  | Washer         | 10           |
| 3    | GM15188  | Pin, dowel         | 4            | 19   | GM57307  | Bolt           | 8            |
| 4    | GM14459  | Plug               | 1            | 20   | GM36654  | Bolt, reamer   | 1            |
| 5    | GM36351  | Packing            | 1            | 21   | GM36944  | Bolt           | 1            |
| 6    | GM36352  | Plate, rear        | 1            | 22   | GM15180  | Washer, spring | 2            |
| 7    | GM36353  | Packing            | 1            | 23   | GM15124  | Bolt           | 13           |
| 8    | GM36354  | Seal assembly, oil | 1            | 24   | GM36360  | Stud           | 2            |
| 801  | GM36993  | Seal, oil          | 1            | 25   | GM36361  | Nut, jam       | 2            |
| 802  | GM36355  | Slinger            | 1            | 26   | GM14559  | Washer         | 15           |
| 9    | GM34106  | Stud               | 6            | 27   | GM36362  | Bolt           | 22           |
| 10   | GM15167  | Nut                | 6            | 28   | GM36363  | Washer         | 22           |
| 11   | GM15180  | Washer, spring     | 6            | 29   | GM15114  | Bolt           | 2            |
| 12   | GM36356  | Stud               | 2            | 30   | GM15959  | Bolt           | 2            |
| 13   | GM36357  | Stud               | 1            | 31   | GM36363  | Washer         | 4            |
| 14   | GM57305  | Stud               | 1            | 32   | GM36364  | Cover          | 1            |
| 15   | GM57306  | Spacer             | 2            | 33   | GM15151  | Bolt           | 2            |
| 16   | GM15167  | Nut                | 4            | 34   | GM14514  | O-ring         | 1            |

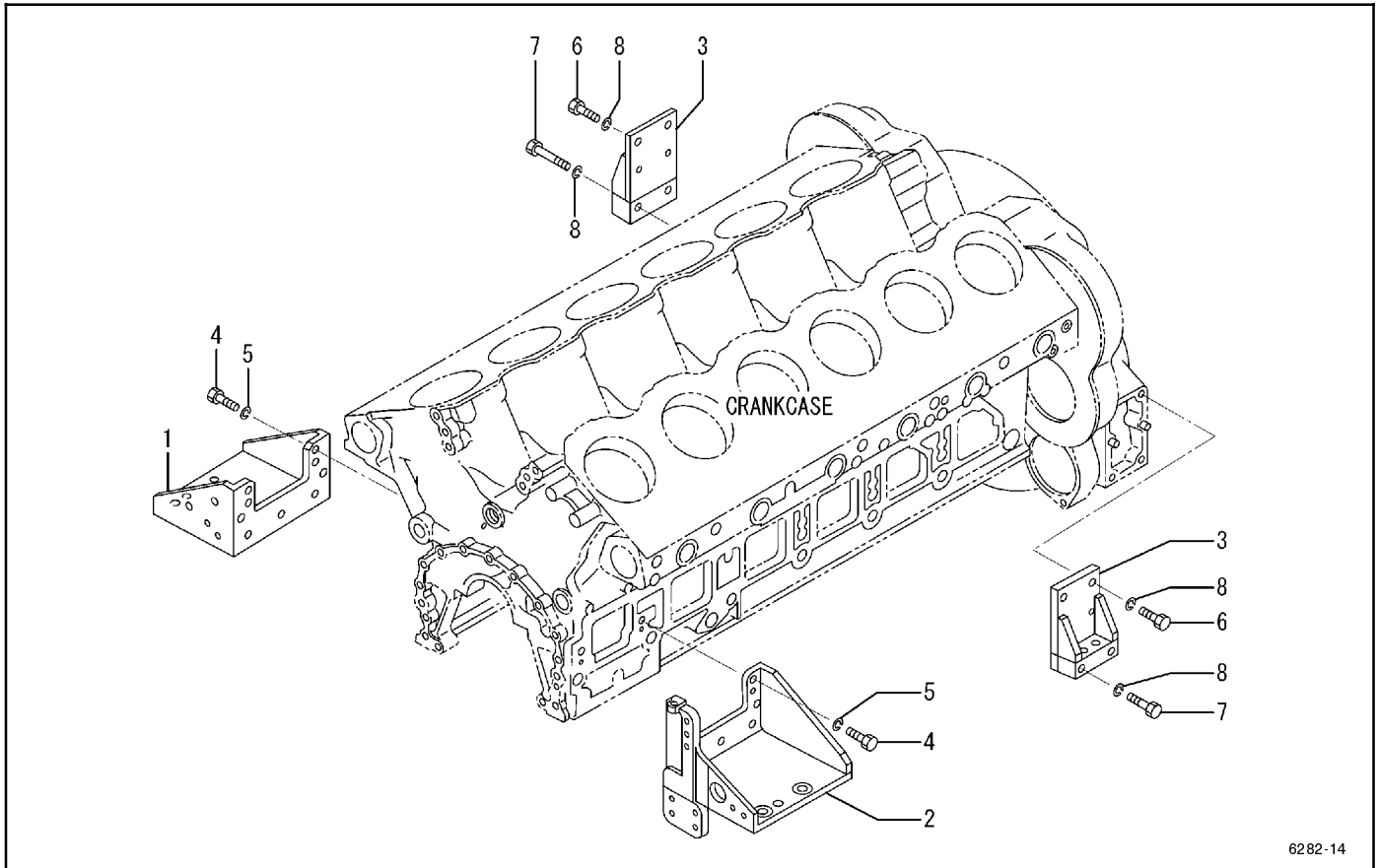
# Group 13: Oil Pan



6282-13

| Item | Part No. | Description     | Qty. |
|------|----------|-----------------|------|
|      |          |                 | Var. |
| 1    | GM36366  | Pan, oil        | 1    |
| 2    | GM31459  | Connector       | 1    |
| 3    | GM34108  | Packing         | 1    |
| 4    | GM15160  | Bolt w/washer   | 54   |
| 5    | GM34109  | Packing         | 2    |
| 6    | GM15141  | Bolt w/washer   | 4    |
| 7    | GM14895  | Cover           | 2    |
| 8    | GM15245  | Plug            | 1    |
| 9    | GM15239  | Plug, drain     | 4    |
| 10   | GM14532  | Washer, sealing | 4    |
| 11   | GM15241  | Plug, drain     | 1    |
| 12   | GM14534  | Washer, sealing | 1    |

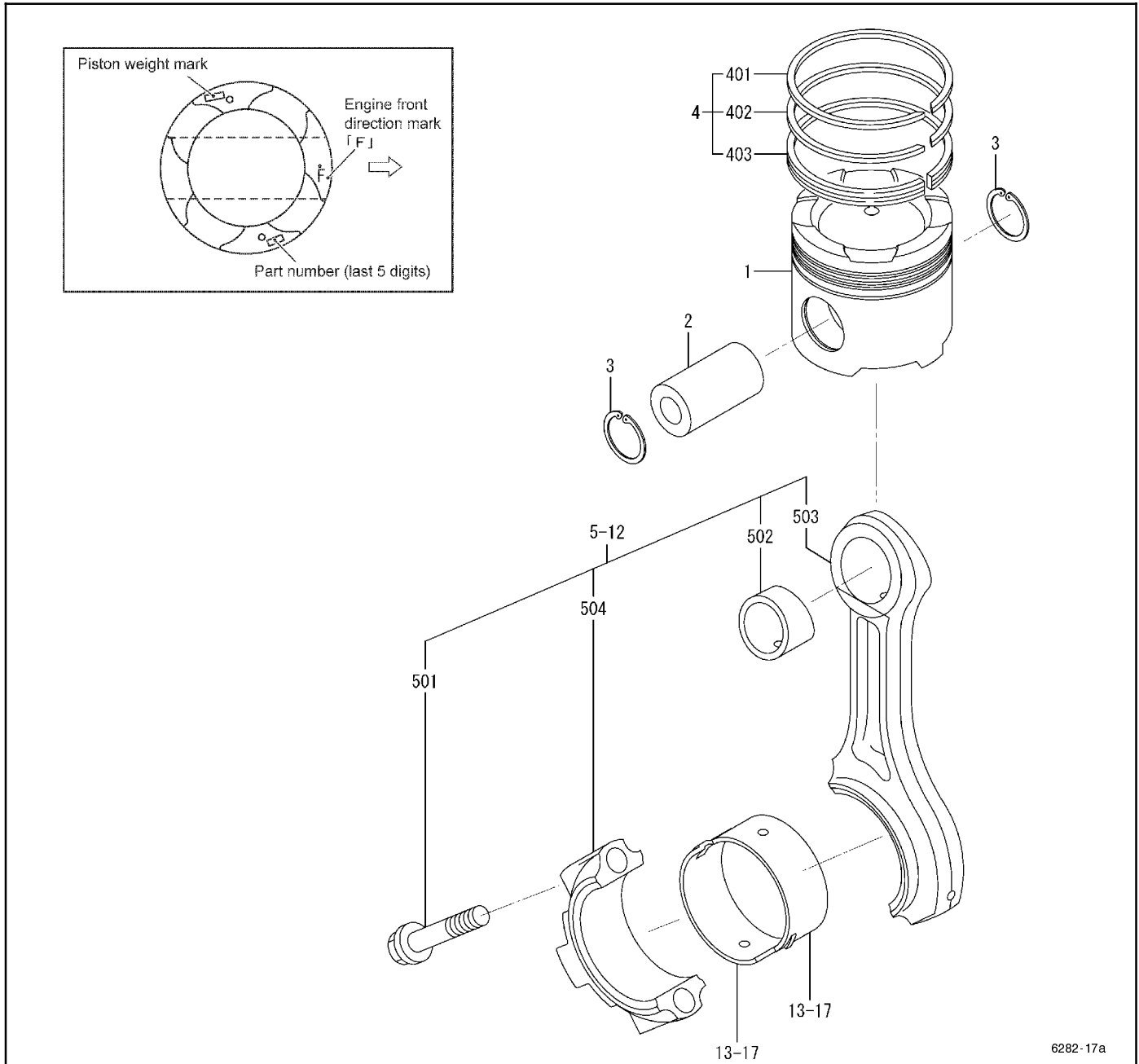
# Group 14: Engine Mounting



6282-14

| Item | Part No. | Description       | Qty. |    |
|------|----------|-------------------|------|----|
|      |          |                   | 1    | 2  |
| 1    | GM36367  | Bracket, mounting | 1    |    |
| 1    | GM57308  | Bracket, mounting |      | 1  |
| 2    | GM36368  | Bracket, mounting | 1    | 1  |
| 3    | GM34112  | Bracket, mounting | 2    | 2  |
| 4    | GM36369  | Bolt              | 10   | 10 |
| 5    | GM15184  | Washer, spring    | 10   | 10 |
| 6    | GM15132  | Bolt              | 4    | 4  |
| 7    | GM15133  | Bolt              | 4    | 4  |
| 8    | GM15183  | Washer, lock      | 8    | 8  |

# Group 17: Piston and Connecting Rod





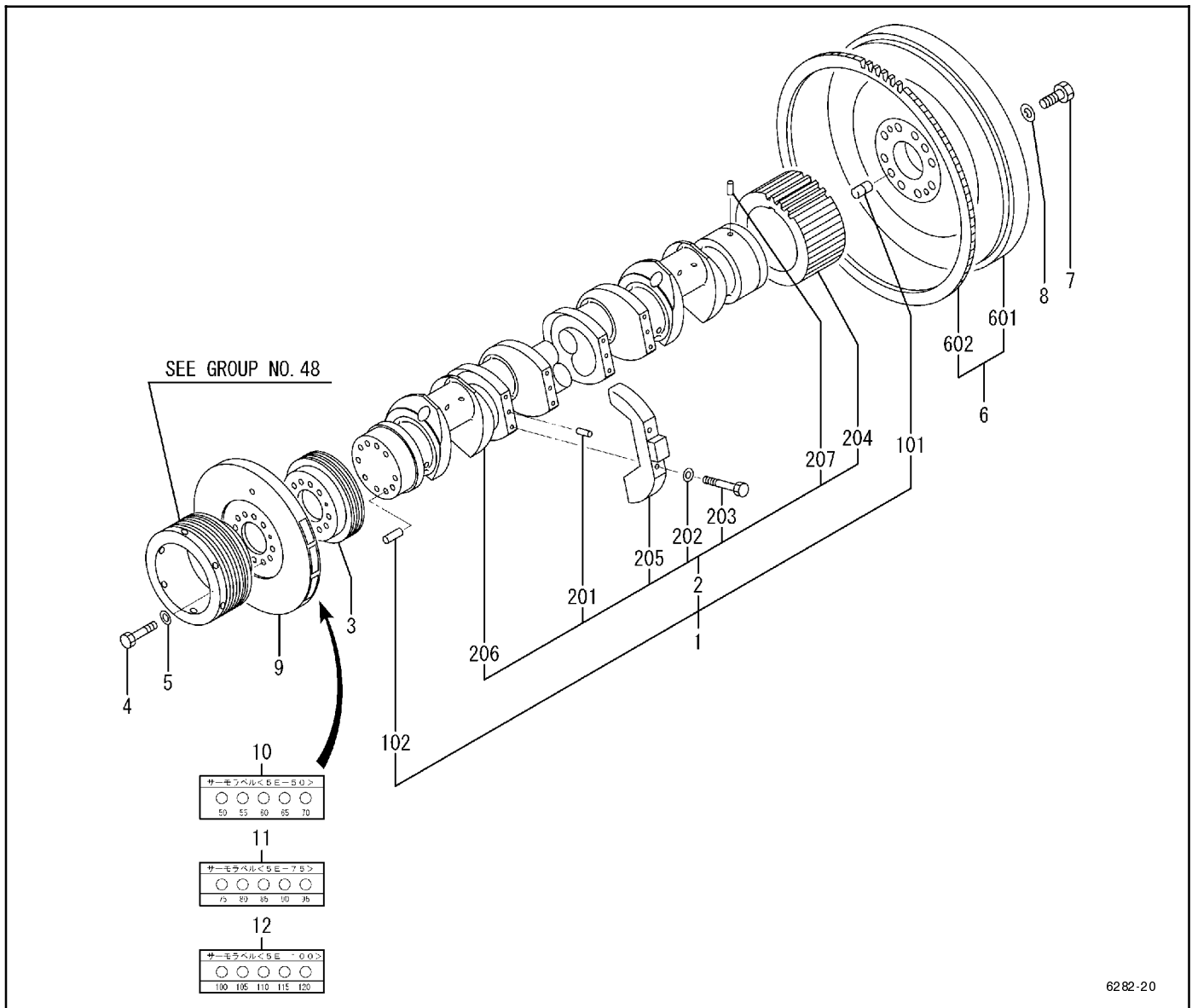
## Group 17: Piston and Connecting Rod

| Item | Part No. | Description                       | Qty. |    |
|------|----------|-----------------------------------|------|----|
|      |          |                                   | Var. |    |
|      |          |                                   | 1    | 2  |
| 1    | GM36370  | Piston*                           | 12   |    |
| 1    | GM57309  | Piston*                           |      | 12 |
| 2    | GM36371  | Pin, piston                       | 12   |    |
| 2    | GM34114  | Pin, piston                       |      | 12 |
| 3    | GM15221  | Ring, snap                        | 24   | 24 |
| 4    | GM36372  | Ring set, piston                  | 12   |    |
| 4    | GM14647  | Ring set, piston                  |      | 12 |
| 401  | X        | Ring, compression                 | 12   | 12 |
| 402  | X        | Ring, compression                 | 12   | 12 |
| 403  | X        | Ring, oil                         | 12   | 12 |
| 5    | GM36373  | Connecting rod assembly, standard | 12   |    |
| 5    | X        | Connecting rod assembly, standard |      | 12 |
| 501  | GM14575  | Bolt                              | 24   | 24 |
| 502  | GM36374  | Bushing, connecting rod           | 12   | 12 |
| 503  | X        | Connecting rod                    | 12   | 12 |
| 504  | X        | Cap, connecting rod               | 12   | 12 |
| 6    | GM57310  | Connecting rod assembly, 7.1 kg   |      | 12 |
| 6    | GM36375  | Connecting rod assembly, 7.2 kg   | 12   |    |
| 6    | GM57311  | Connecting rod assembly, 7.2 kg   |      | 12 |
| 7    | GM36376  | Connecting rod assembly, 7.3 kg   | 12   |    |
| 7    | GM57312  | Connecting rod assembly, 7.3 kg   |      | 12 |
| 8    | GM36377  | Connecting rod assembly, 7.4 kg   | 12   |    |
| 8    | GM57313  | Connecting rod assembly, 7.4 kg   |      | 12 |
| 9    | GM36378  | Connecting rod assembly, 7.5 kg   | 12   |    |
| 9    | GM57314  | Connecting rod assembly, 7.5 kg   |      | 12 |
| 10   | GM36379  | Connecting rod assembly, 7.6 kg   | 12   |    |
| 10   | GM57315  | Connecting rod assembly, 7.6 kg   |      | 12 |
| 11   | GM36380  | Connecting rod assembly, 7.7 kg   | 12   |    |
| 11   | GM57316  | Connecting rod assembly, 7.7 kg   |      | 12 |
| 12   | GM36381  | Connecting rod assembly, 7.8 kg   | 12   |    |
| 12   | GM57317  | Connecting rod assembly, 7.8 kg   |      | 12 |
| 13   | GM34117  | Bearing, standard                 | 24   | 24 |
| 14   | GM34118  | Bearing, 0.25 undersized          | 24   | 24 |
| 15   | GM34119  | Bearing, 0.50 undersized          | 24   | 24 |
| 16   | GM34120  | Bearing, 0.25 undersized          | 24   | 24 |
| 17   | GM34121  | Bearing, 1.00 undersized          | 24   | 24 |

X Part is not sold separately

\* Include weight when ordering. Weight is stamped on top of piston.

# Group 20: Crankshaft, Flywheel, and Damper

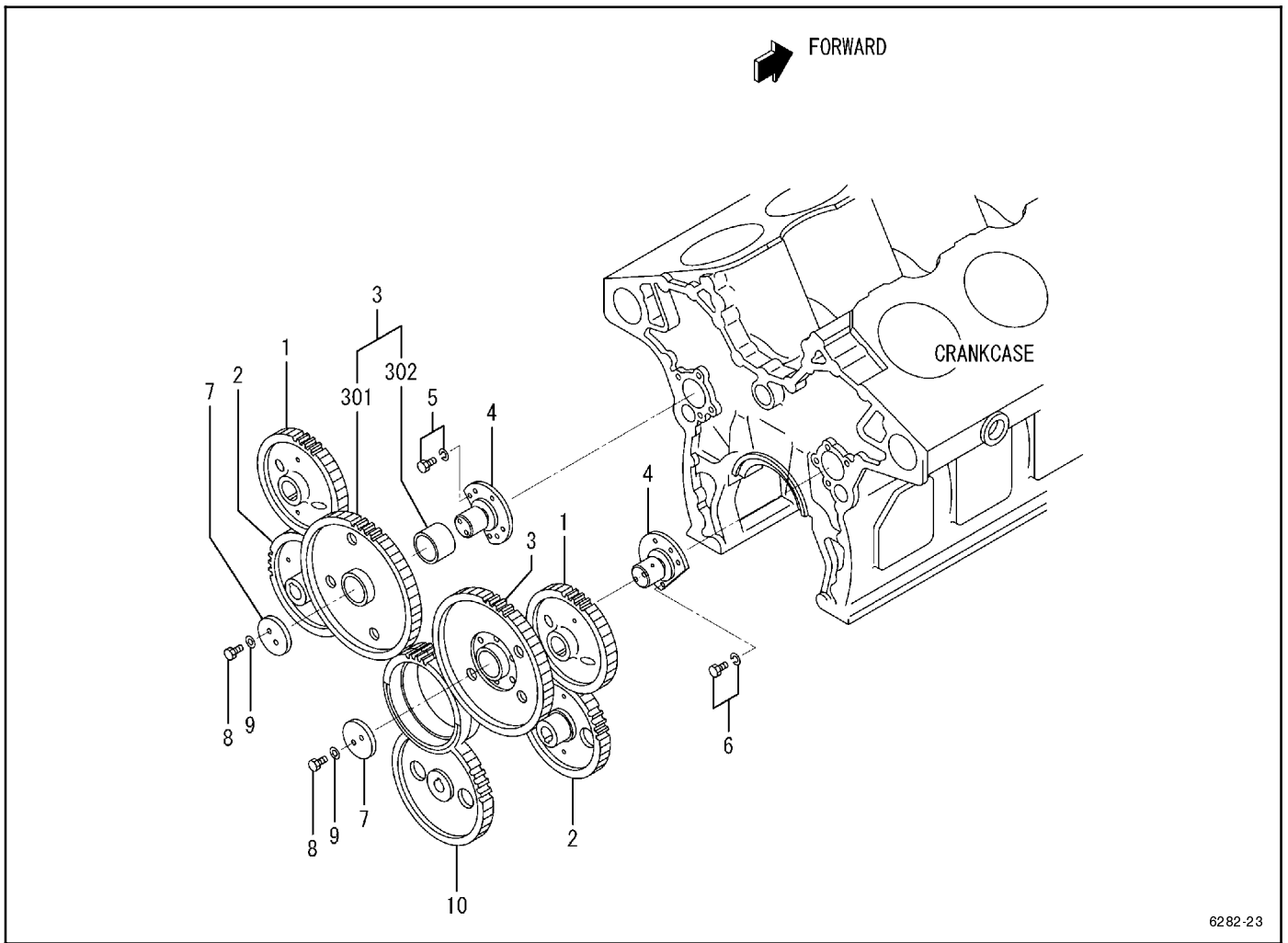


6282-20

| Item | Part No. | Description            | Qty. |    | Item | Part No. | Description                    | Qty. |   |
|------|----------|------------------------|------|----|------|----------|--------------------------------|------|---|
|      |          |                        | 1    | 2  |      |          |                                | 1    | 2 |
| 1    | GM36382  | Crankshaft assembly    | 1    | 1  | 4    | GM15965  | Bolt                           | 8    |   |
| 101  | GM14582  | Dowel pin              | 2    | 2  | 4    | GM57318  | Bolt                           |      | 8 |
| 102  | GM36383  | Pin, dowel             | 2    | 2  | 5    | GM36389  | Washer                         | 8    | 8 |
| 2    | X        | Crankshaft subassembly | 1    | 1  | 6    | GM36387  | Flywheel assembly              | 1    | 1 |
| 201  | GM15189  | Pin, dowel             | 12   | 12 | 601  | X        | Flywheel                       | 1    | 1 |
| 202  | GM14559  | Washer                 | 24   | 24 | 602  | GM34126  | Gear, ring                     | 1    | 1 |
| 203  | GM14566  | Bolt                   | 24   | 24 | 7    | GM36388  | Bolt                           | 8    | 8 |
| 204  | GM36384  | Gear, crankshaft       | 1    | 1  | 8    | GM36389  | Washer                         | 8    | 8 |
| 205  | X        | Weight, balance        | 12   | 12 | 9    | GM36390  | Damper                         | 1    | 1 |
| 206  | X        | Crankshaft             | 1    | 1  | 10   | GM34135  | Label set, thermo, 50°C-70°C   | 1    | 1 |
| 207  | GM36385  | Pin, dowel             | 1    | 1  | 11   | GM14584  | Label set, thermo, 75°C-95°C   | 1    | 1 |
| 3    | GM36386  | Pulley, crankshaft     | 1    | 1  | 12   | GM14585  | Label set, thermo, 100°C-120°C | 1    | 1 |

X Part is not sold separately

# Group 23: Timing Gear

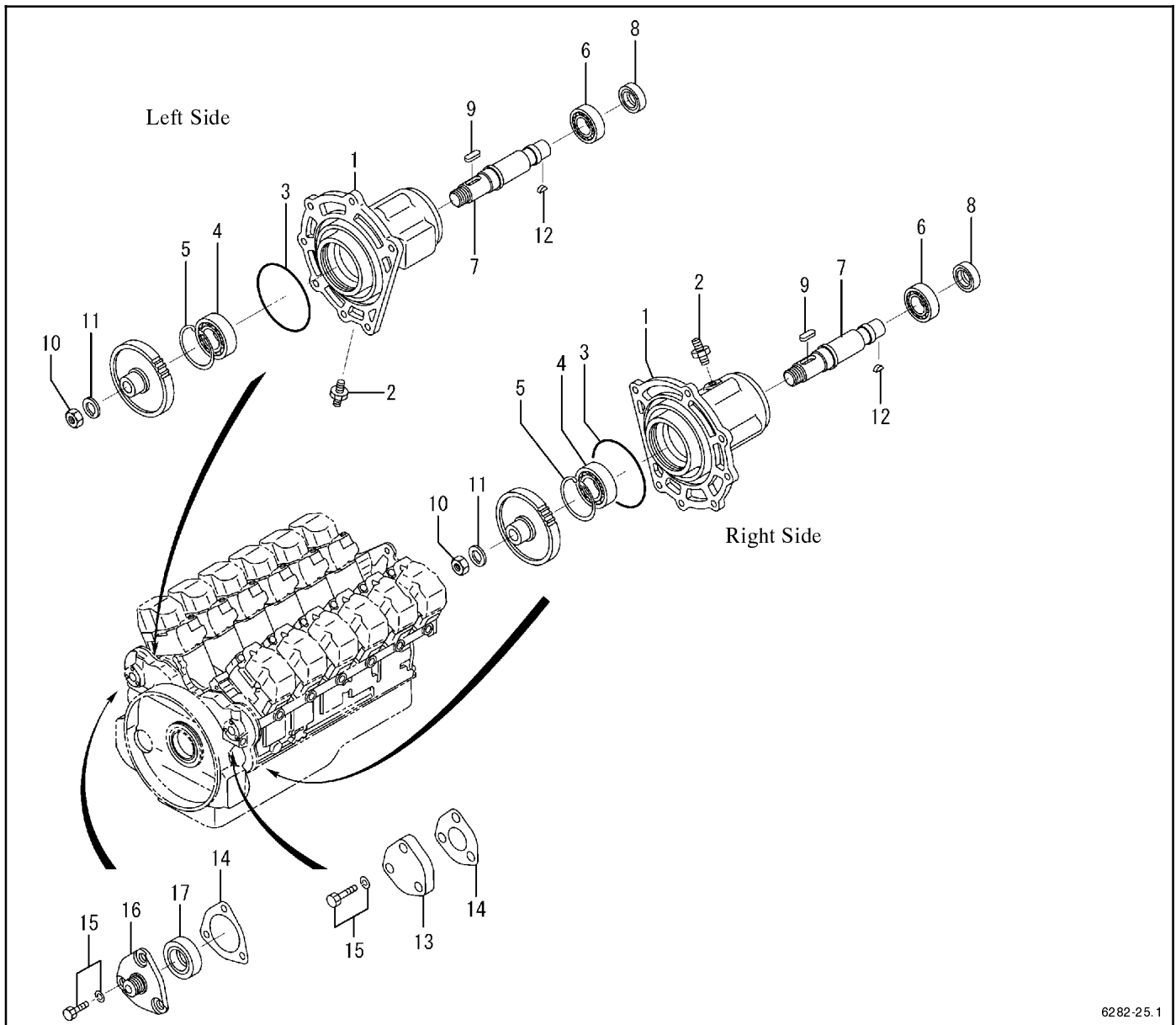


6282-23

| Item | Part No. | Description          | Qty. |   |
|------|----------|----------------------|------|---|
|      |          |                      | 1    | 2 |
| 1    | GM36391  | Gear, camshaft       | 2    | 2 |
| 2    | GM36392  | Gear, injection pump | 2    | 2 |
| 3    | GM36393  | Gear assembly, idler | 2    | 2 |
| 301  | X        | Gear, idler          | 2    | 2 |
| 302  | GM14896  | Bushing              | 2    | 2 |
| 4    | GM36394  | Shaft, idler         | 2    | 2 |
| 5    | GM36395  | Bolt, w/washer       | 7    |   |
| 5    | GM36362  | Bolt                 |      | 7 |
| 5    | GM36363  | Washer               |      | 7 |
| 6    | GM15983  | Bolt w/washer        | 1    |   |
| 6    | GM15131  | Bolt                 |      | 1 |
| 6    | GM36363  | Washer               |      | 1 |
| 7    | GM14568  | Plate                | 2    | 2 |
| 8    | GM22091  | Bolt                 | 4    | 4 |
| 9    | GM31310  | Washer               | 4    | 4 |
| 10   | GM36396  | Gear, oil pump       | 1    | 1 |

X Part is not sold separately

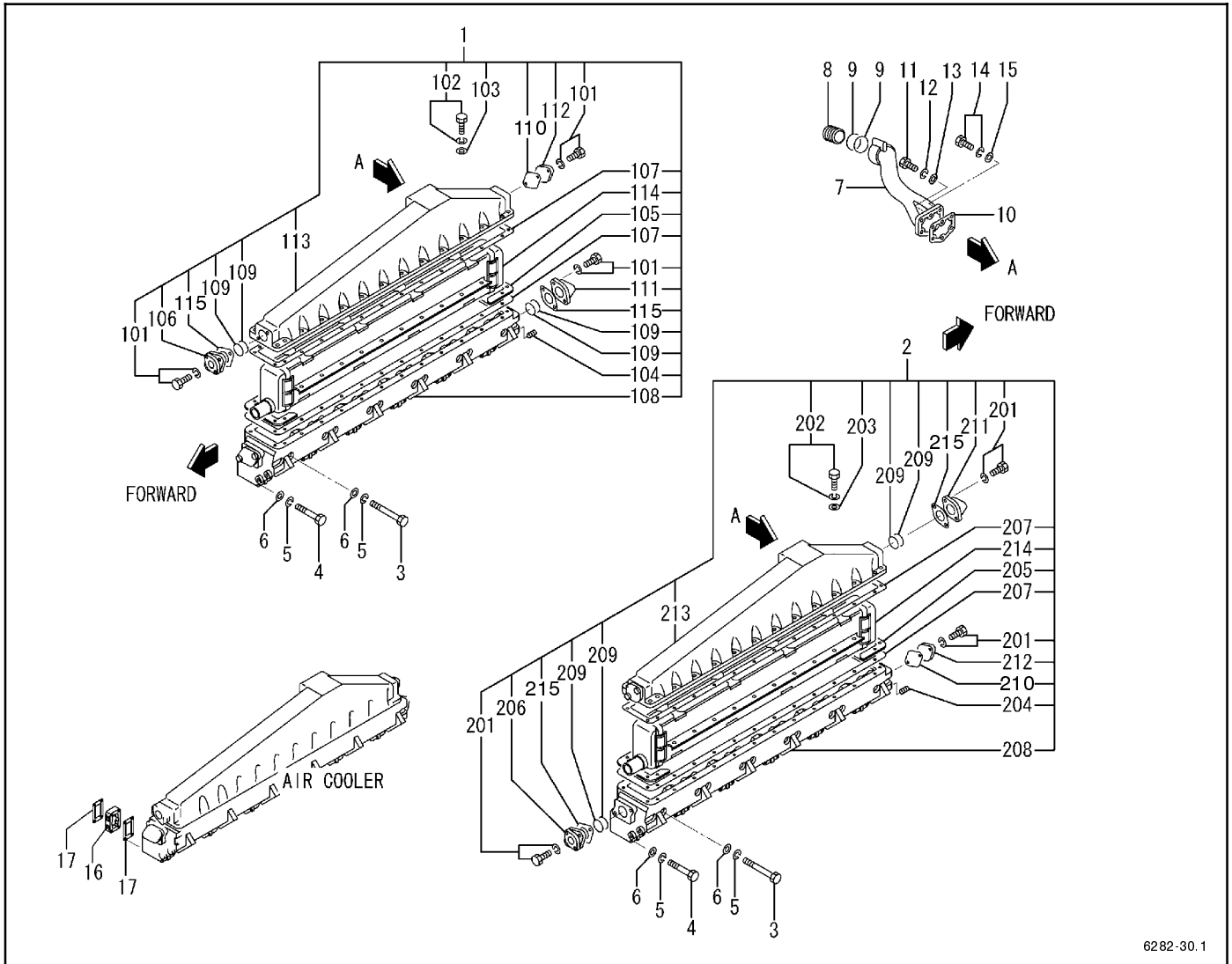
# Group 25: Accessory Drive



6282-25.1

| Item | Part No. | Description        | Qty. |   |
|------|----------|--------------------|------|---|
|      |          |                    | 1    | 2 |
| 1    | GM36397  | Case, drive        | 2    | 2 |
| 2    | GM36398  | Connector          | 2    | 2 |
| 3    | GM36399  | O-ring             | 2    | 2 |
| 4    | GM16039  | Bearing, ball      | 2    | 2 |
| 5    | GM16021  | Ring, snap         | 2    | 2 |
| 6    | GM36400  | Bearing, ball      | 2    | 2 |
| 7    | GM36401  | Shaft, drive       | 2    | 2 |
| 7    | TBD      | Shaft, drive       |      | 2 |
| 8    | GM36402  | Seal, oil          | 2    |   |
| 8    | GM57323  | Seal, oil          |      | 2 |
| 8    | TBD      | Sleeve (not shown) |      | 2 |
| 9    | GM36403  | Key, sunk          | 2    | 2 |
| 10   | GM15988  | Nut, jam           | 2    | 2 |
| 11   | GM31402  | Washer             | 2    | 2 |
| 12   | GM36404  | Key, woodruff      | 2    | 2 |
| 13   | GM36405  | Cover              | 1    | 1 |
| 14   | GM36406  | Packing            | 2    | 2 |
| 15   | GM15159  | Bolt w/washer      | 6    | 6 |
| 16   | GM36407  | Case, oil seal     | 1    | 1 |
| 17   | GM36408  | Seal, oil          | 1    | 1 |

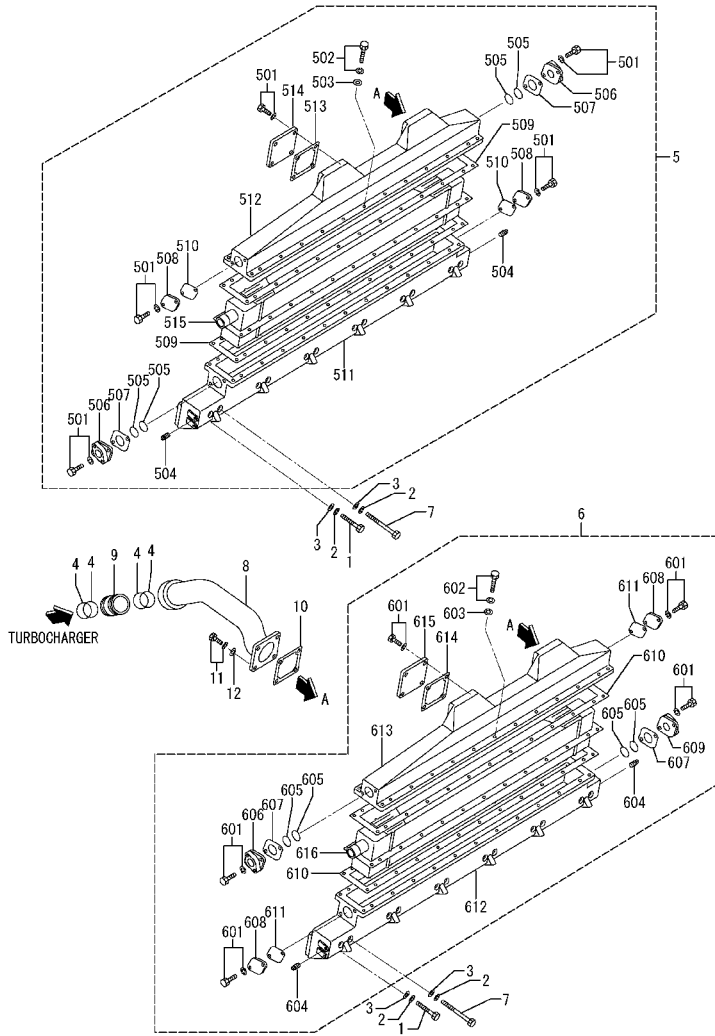
# Group 30.1: Intake System



6282-30.1

| Item | Part No. | Description          | Qty. | Item | Part No. | Description      | Qty. |
|------|----------|----------------------|------|------|----------|------------------|------|
|      |          |                      | Var. |      |          |                  | Var. |
| 1    | GM36409  | Cooler assembly, air | 1    | 208  | GM36411  | Manifold, inlet  | 1    |
| 101  | GM15159  | Bolt w/washer        | 8    | 209  | GM36417  | O-ring           | 4    |
| 102  | GM15161  | Bolt w/washer        | 28   | 210  | GM36412  | Gasket           | 2    |
| 103  | GM15174  | Washer, plain        | 28   | 211  | GM14614  | Connector        | 1    |
| 104  | GM15246  | Plug, tapered        | 2    | 212  | GM14616  | Flange           | 2    |
| 105  | GM36410  | Plate                | 2    | 213  | GM36418  | Cover air cooler | 1    |
| 106  | GM14589  | Connector            | 1    | 214  | GM36413  | Element          | 1    |
| 107  | GM36416  | Gasket               | 2    | 215  | GM36414  | Gasket           | 2    |
| 108  | GM36411  | Manifold, inlet      | 1    | 3    | GM36419  | Bolt             | 24   |
| 109  | GM36417  | O-ring               | 4    | 4    | GM36420  | Bolt             | 24   |
| 110  | GM36412  | Gasket               | 2    | 5    | GM15179  | Washer, spring   | 48   |
| 111  | GM14614  | Connector            | 1    | 6    | GM15174  | Washer, plain    | 48   |
| 112  | GM14616  | Flange               | 2    | 7    | GM36421  | Duct             | 2    |
| 113  | GM36418  | Cover air cooler     | 1    | 8    | GM36422  | Connector        | 2    |
| 114  | GM36413  | Element              | 1    | 9    | GM14648  | O-ring           | 8    |
| 115  | GM36414  | Gasket               | 2    | 10   | GM36423  | Packing          | 2    |
| 2    | GM36415  | Cooler assembly, air | 1    | 11   | GM36634  | Bolt             | 4    |
| 201  | GM15159  | Bolt w/washer        | 8    | 12   | GM15179  | Washer, spring   | 4    |
| 202  | GM15161  | Bolt w/washer        | 28   | 13   | GM15174  | Washer, plain    | 4    |
| 203  | GM15174  | Washer, plain        | 28   | 14   | GM15981  | Bolt w/washer    | 8    |
| 204  | GM15246  | Plug, tapered        | 2    | 15   | GM15174  | Washer, plain    | 8    |
| 205  | GM36410  | Plate                | 2    | 16   | GM36424  | Spacer           | 12   |
| 206  | GM14589  | Connector            | 1    | 17   | GM36425  | Packing          | 24   |
| 207  | GM36416  | Gasket               | 2    |      |          |                  |      |

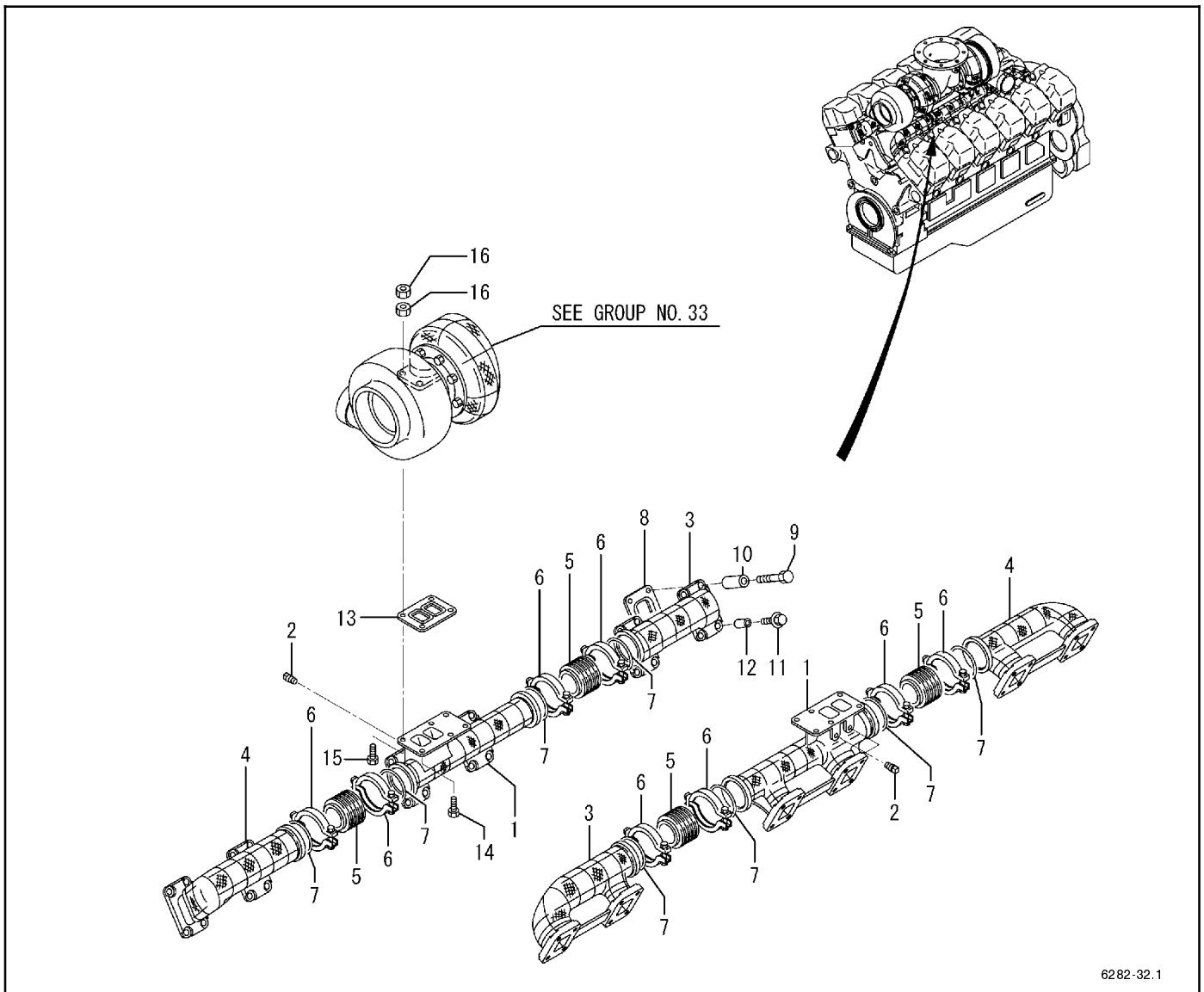
# Group 30.1: Intake System, continued



6282-30.1\_2

| Item | Part No. | Description                      | Qty. | Var. | Item | Part No. | Description         | Qty. | Var. |
|------|----------|----------------------------------|------|------|------|----------|---------------------|------|------|
| 1    | GM36420  | Bolt                             | 24   |      | 602  | GM15161  | Bolt w/washer       | 26   |      |
| 2    | GM15179  | Washer, spring                   | 48   |      | 603  | GM15174  | Washer, plain       | 26   |      |
| 3    | GM15174  | Washer, plain                    | 48   |      | 604  | GM15246  | Plug, tapered       | 5    |      |
| 4    | GM14648  | O-ring                           | 8    |      | 605  | GM14504  | O-ring              | 4    |      |
| 5    | GM57324  | Cooler assembly, air, right hand | 1    |      | 606  | GM34153  | Connector           | 1    |      |
| 501  | GM15159  | Bolt w/washer                    | 12   |      | 607  | GM34158  | Gasket              | 2    |      |
| 502  | GM15161  | Bolt w/washer                    | 26   |      | 608  | GM14616  | Flange              | 2    |      |
| 503  | GM15174  | Washer, plain                    | 26   |      | 609  | GM34157  | Connector           | 1    |      |
| 504  | GM15246  | Plug, tapered                    | 5    |      | 610  | GM34152  | Gasket              | 2    |      |
| 505  | GM14504  | O-ring                           | 4    |      | 611  | GM34154  | Gasket              | 2    |      |
| 506  | GM34153  | Connector                        | 2    |      | 612  | GM57325  | Manifold, inlet     | 1    |      |
| 507  | GM34158  | Gasket                           | 2    |      | 613  | GM14690  | Cover, air cooler   | 1    |      |
| 508  | GM14616  | Flange                           | 2    |      | 614  | GM14691  | Gasket              | 1    |      |
| 509  | GM34152  | Gasket                           | 2    |      | 615  | GM34155  | Cover               | 1    |      |
| 510  | GM34154  | Gasket                           | 2    |      | 616  | GM34151  | Element, air cooler | 1    |      |
| 511  | GM57325  | Manifold, inlet                  | 1    |      | 7    | GM57327  | Bolt                | 24   |      |
| 512  | GM14690  | Cover, air cooler                | 1    |      | 8    | GM34159  | Duct, inlet         | 2    |      |
| 513  | GM14691  | Gasket                           | 1    |      | 9    | GM14696  | Joint               | 2    |      |
| 514  | GM34155  | Cover                            | 1    |      | 10   | GM14691  | Gasket              | 2    |      |
| 515  | GM34151  | Element, air cooler              | 1    |      | 11   | GM15161  | Bolt w/washer       | 8    |      |
| 6    | GM57326  | Cooler assembly, air, left hand  | 1    |      | 12   | GM15174  | Washer, plain       | 8    |      |
| 601  | GM15159  | Bolt w/washer                    | 12   |      |      |          |                     |      |      |

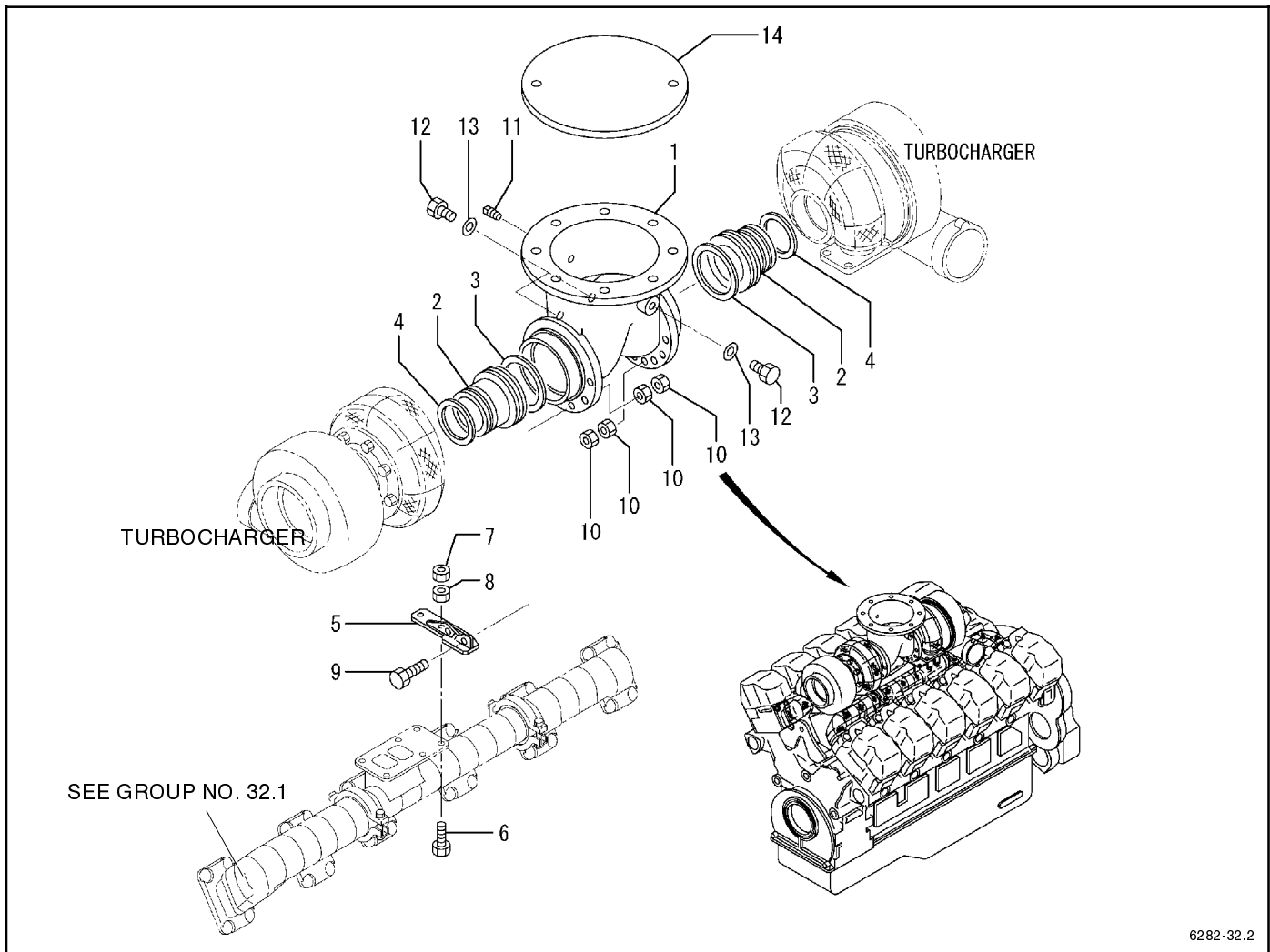
# Group 32.1: Exhaust System



6282-32.1

| Item | Part No. | Description              | Qty. |    |
|------|----------|--------------------------|------|----|
|      |          |                          | 1    | 2  |
| 1    | GM36426  | Manifold, exhaust        | 2    | 2  |
| 2    | GM15242  | Plug, tapered            | 4    | 4  |
| 3    | GM36427  | Manifold, exhaust        | 2    | 2  |
| 4    | GM36428  | Manifold, exhaust        | 2    | 2  |
| 5    | GM31326  | Joint, flexible          | 4    | 4  |
| 6    | GM15081  | Coupling assembly        | 8    | 8  |
| 7    | GM14592  | Gasket joint             | 8    | 8  |
| 8    | GM36429  | Gasket, exhaust manifold | 12   | 12 |
| 9    | GM14595  | Bolt                     | 24   | 24 |
| 10   | GM14464  | Spacer                   | 24   | 24 |
| 11   | GM14596  | Bolt                     | 24   | 24 |
| 12   | GM36430  | Spacer                   | 24   | 24 |
| 13   | GM34183  | Gasket, turbocharger     | 2    | 2  |
| 14   | GM34175  | Bolt                     | 2    | 8  |
| 15   | GM36431  | Bolt                     | 6    |    |
| 16   | GM22119  | Nut, self-locking        | 8    | 8  |

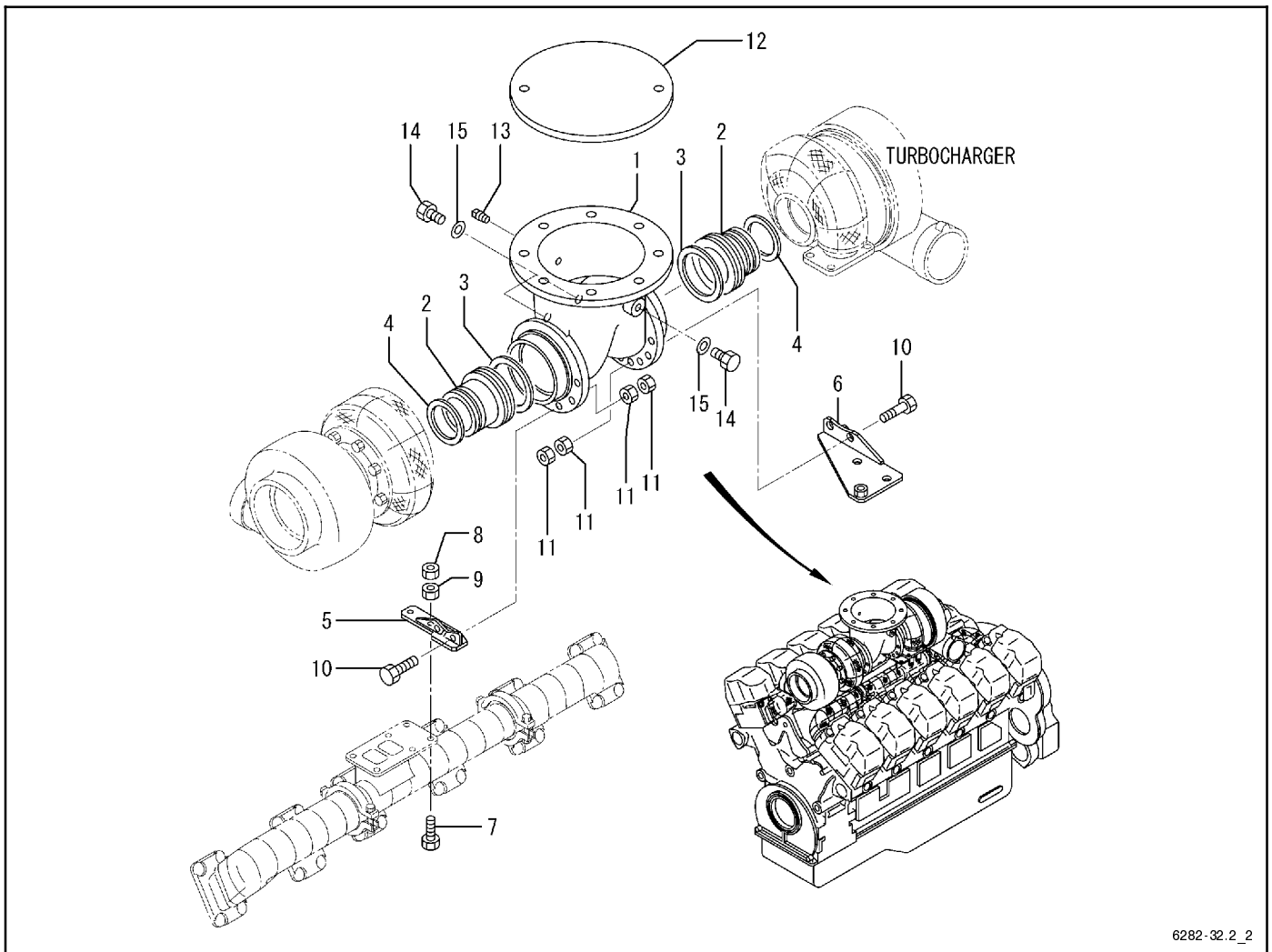
# Group 32.2: Exhaust Elbow



| Item | Part No. | Description         | Qty. |
|------|----------|---------------------|------|
|      |          |                     | Var. |
| 1    | GM36432  | Pipe, exhaust       | 1    |
| 2    | GM36433  | Joint, exhaust pipe | 2    |
| 3    | GM36434  | Ring                | 4    |
| 4    | GM36435  | Ring                | 4    |
| 5    | GM36436  | Bracket             | 2    |
| 6    | GM14552  | Bolt                | 4    |
| 7    | GM15165  | Nut                 | 4    |
| 8    | GM15171  | Nut, jam            | 4    |
| 9    | GM15111  | Bolt                | 4    |
| 10   | GM15165  | Nut                 | 8    |
| 11   | GM15246  | Plug, tapered       | 1    |
| 12   | GM14994  | Plug                | 3    |
| 13   | GM22025  | Gasket              | 3    |
| 14   | GM14597  | Cover               | 1    |



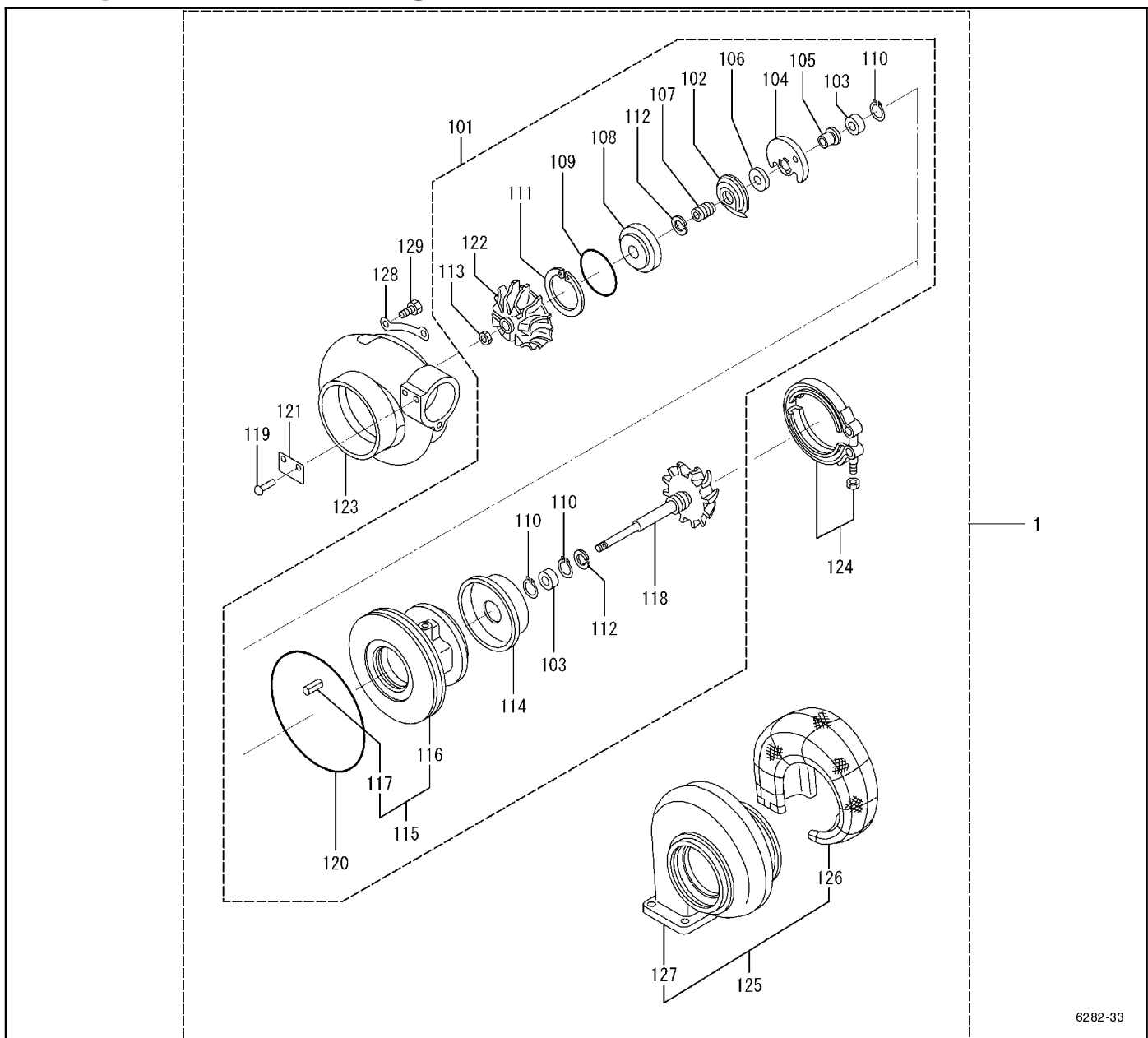
## Group 32.2: Exhaust Elbow



6282-32.2\_2

| Item | Part No. | Description         | Qty.      |
|------|----------|---------------------|-----------|
|      |          |                     | Var.<br>2 |
| 1    | GM36432  | Pipe, exhaust       | 1         |
| 2    | GM36433  | Joint, exhaust pipe | 2         |
| 3    | GM36434  | Ring                | 4         |
| 4    | GM36435  | Ring                | 4         |
| 5    | GM36436  | Bracket             | 1         |
| 6    | GM57328  | Bracket             | 1         |
| 7    | GM14552  | Bolt                | 4         |
| 8    | GM15165  | Nut                 | 4         |
| 9    | GM15171  | Nut, jam            | 4         |
| 10   | GM15111  | Bolt                | 4         |
| 11   | GM15165  | Nut                 | 8         |
| 12   | GM14597  | Cover               | 1         |
| 13   | GM15246  | Plug, tapered       | 1         |
| 14   | GM22026  | Plug, screw         | 3         |
| 15   | GM22025  | Gasket              | 3         |

# Group 33: Turbocharger

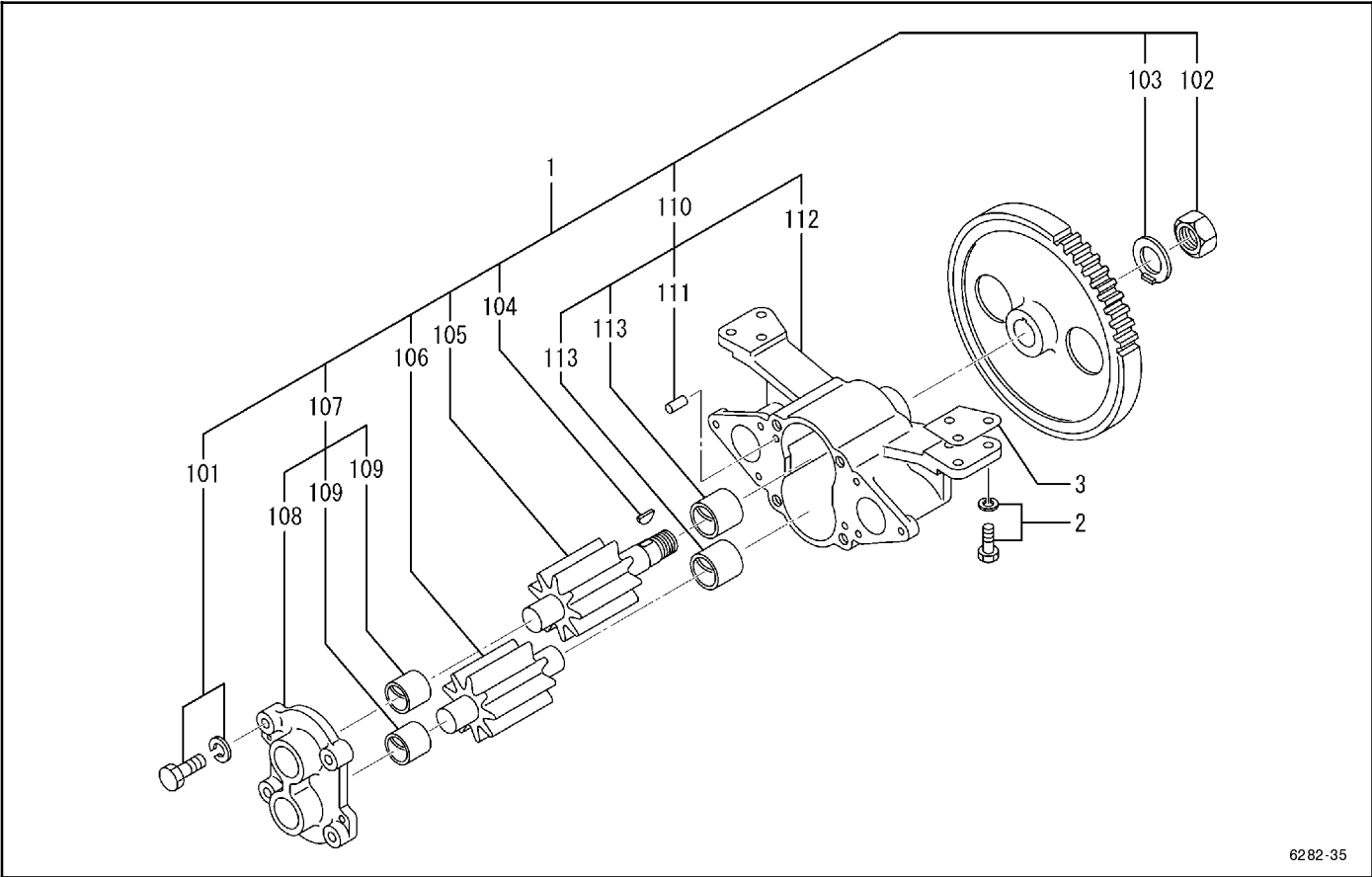


6282-33

| Item | Part No. | Description           | Qty. |   | Item | Part No. | Description               | Qty. |    |
|------|----------|-----------------------|------|---|------|----------|---------------------------|------|----|
|      |          |                       | 1    | 2 |      |          |                           | 1    | 2  |
| 1    | GM36437  | Turbocharger assembly | 2    |   | 115  | GM36439  | Housing assembly, bearing | 2    |    |
| 1    | GM57329  | Turbocharger assembly |      | 2 | 115  | GM22069  | Housing assembly, bearing |      | 2  |
| 101  | GM36438  | Cartridge assembly    | 2    |   | 116  | X        | Housing, bearing          | 2    | 2  |
| 101  | GM57330  | Cartridge assembly    |      | 2 | 117  | GM15949  | Pin, spring               | 2    | 2  |
| 102  | GM15047  | Deflector, oil        | 2    | 2 | 118  | GM22070  | Rotor assembly            | 2    |    |
| 103  | GM15045  | Bearing               | 4    | 4 | 118  | GM57331  | Rotor assembly            |      | 2  |
| 104  | GM15046  | Bearing, thrust       | 2    | 2 | 119  | GM14481  | Rivet, screw              | 4    | 4  |
| 105  | GM15058  | Ring, thrust          | 2    | 2 | 120  | GM15051  | O-ring                    | 2    | 2  |
| 106  | GM15057  | Ring, thrust          | 2    | 2 | 121  | X        | Nameplate                 | 2    | 2  |
| 107  | GM15055  | Sleeve, slinger       | 2    | 2 | 122  | GM36440  | Wheel, compressor         | 2    | 2  |
| 108  | GM15049  | Insert                | 2    | 2 | 123  | GM36441  | Cover, compressor         | 2    | 2  |
| 109  | GM15050  | O-ring (insert)       | 2    | 2 | 124  | GM22067  | V-clamp                   | 2    | 2  |
| 110  | GM15048  | Ring, snap            | 6    | 6 | 125  | X        | Turbine housing assembly  | 2    | 2  |
| 111  | GM15043  | Ring, snap            | 2    | 2 | 126  | GM36442  | Lagging                   | 2    | 2  |
| 112  | GM15052  | Ring, piston          | 4    | 4 | 127  | GM36443  | Housing, turbo            | 2    | 2  |
| 113  | GM22071  | Nut, lock             | 2    | 2 | 128  | GM15053  | Plate, lock               | 8    | 8  |
| 114  | GM22068  | Plate, back turbine   | 2    | 2 | 129  | GM15054  | Bolt                      | 16   | 16 |

X Part is not sold separately

# Group 35: Oil Pump

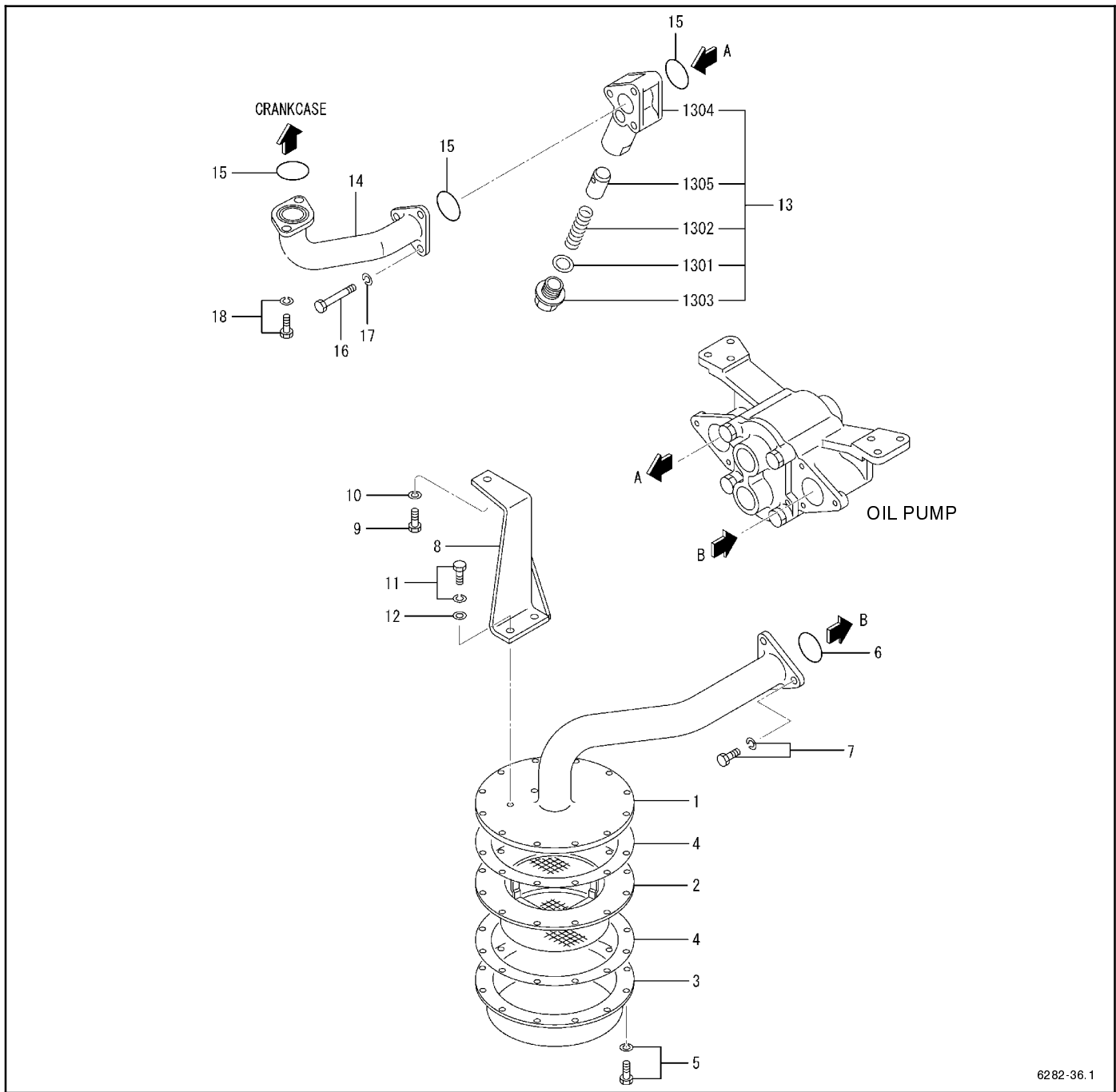


6282-35

| Item | Part No. | Description        | Qty. |
|------|----------|--------------------|------|
|      |          |                    | Var. |
| 1    | GM36444  | Pump assembly, oil | 1    |
| 101  | GM36445  | Bolt, w/washer     | 4    |
| 102  | GM36446  | Nut, jam           | 1    |
| 103  | GM36447  | Washer             | 1    |
| 104  | GM15997  | Key, woodruff      | 1    |
| 105  | GM36448  | Gear, drive        | 1    |
| 106  | GM36449  | Gear, driven       | 1    |
| 107  | GM36450  | Cover assembly     | 1    |
| 108  | X        | Cover              | 1    |
| 109  | GM36452  | Bushing            | 2    |
| 110  | GM36451  | Case assembly      | 1    |
| 111  | GM15186  | Pin                | 2    |
| 112  | X        | Case, oil pump     | 1    |
| 113  | GM36452  | Bushing            | 2    |
| 2    | GM36453  | Bolt, w/washer     | 4    |
| 3    | GM36454  | Shim               | 2    |

X Part is not sold separately

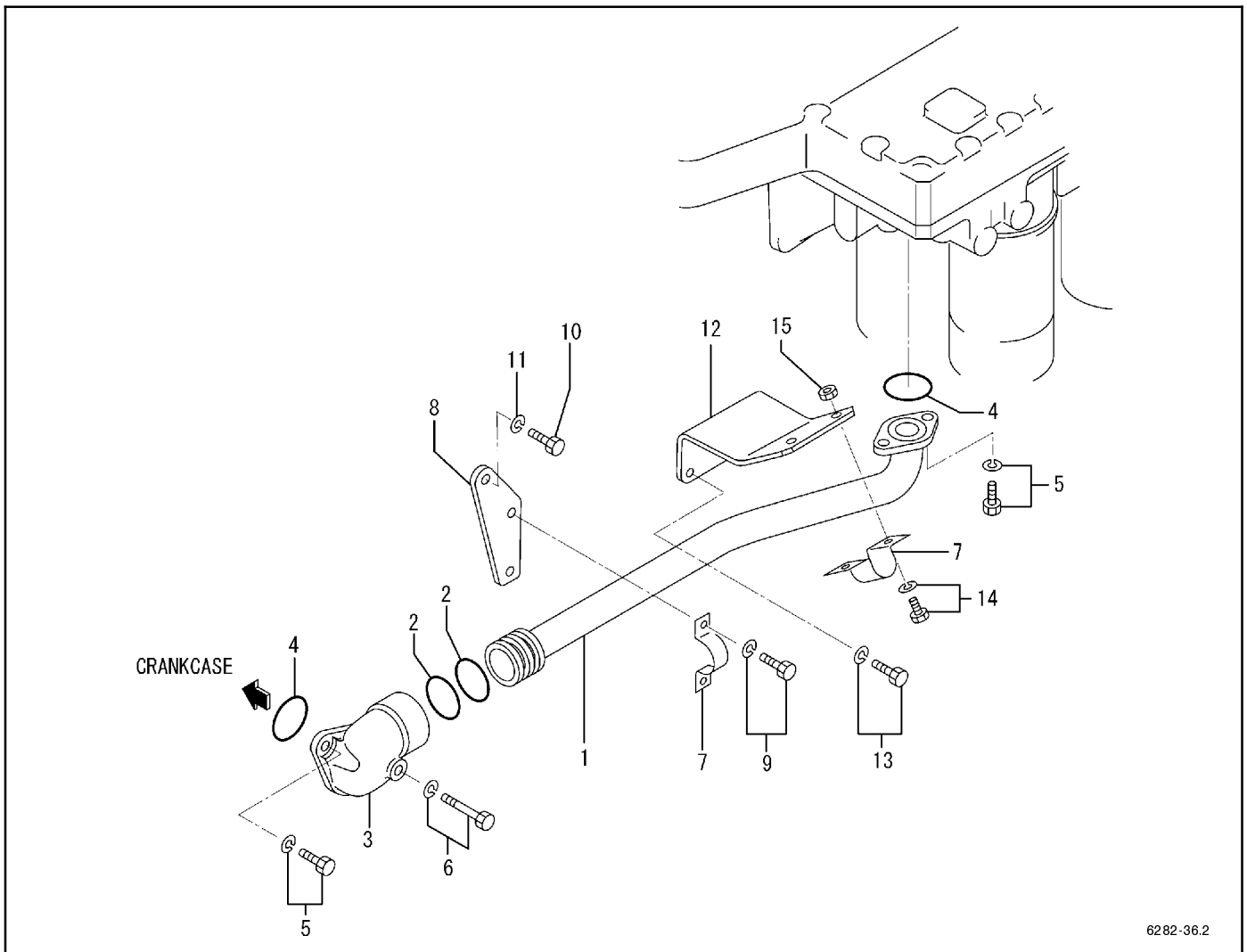
# Group 36.1: Oil Strainer



6282-36.1

| Item | Part No. | Description    | Qty. |    | Item | Part No. | Description            | Qty. |   |
|------|----------|----------------|------|----|------|----------|------------------------|------|---|
|      |          |                | 1    | 2  |      |          |                        | 1    | 2 |
| 1    | GM36455  | Strainer, oil  | 1    | 1  | 12   | GM15174  | Washer, plain          | 2    | 2 |
| 2    | GM36456  | Strainer       | 1    | 1  | 13   | GM36461  | Valve assembly, safety | 1    | 1 |
| 3    | GM36457  | Plate          | 1    | 1  | 1301 | GM36462  | Gasket                 | 1    | 1 |
| 4    | GM36458  | Packing        | 2    |    | 1302 | GM36463  | Spring                 | 1    | 1 |
| 4    | GM57332  | Packing        |      | 2  | 1303 | GM36464  | Plug                   | 1    | 1 |
| 5    | GM31680  | Bolt w/washer  | 12   | 12 | 1304 | GM36465  | Case                   | 1    | 1 |
| 6    | GM21619  | O-ring         | 1    | 1  | 1305 | GM36466  | Valve, safety          | 1    | 1 |
| 7    | GM15159  | Bolt w/washer  | 3    | 3  | 14   | GM36467  | Pipe, oil              | 1    | 1 |
| 8    | GM36459  | Support        | 1    | 1  | 15   | GM21618  | O-ring                 | 3    | 3 |
| 9    | GM36460  | Bolt           | 1    | 1  | 16   | GM36468  | Bolt                   | 3    | 3 |
| 10   | GM15180  | Washer, spring | 1    | 1  | 17   | GM15179  | Washer, spring         | 3    | 3 |
| 11   | GM15139  | Bolt w/washer  | 2    | 2  | 18   | GM15160  | Bolt w/washer          | 3    | 3 |

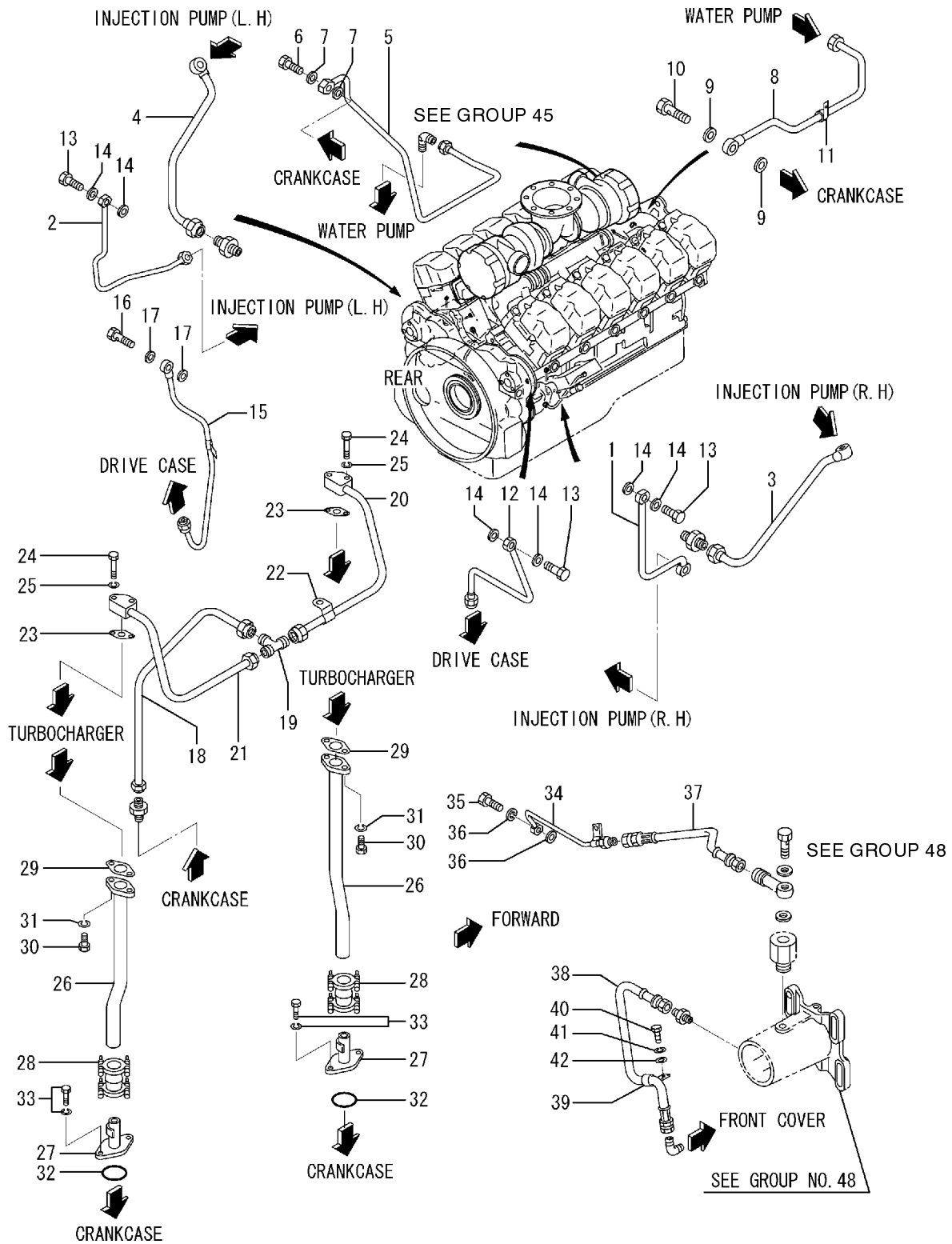
## Group 36.2: Oil Pipe



6282-36.2

| Item | Part No. | Description     | Qty. | Var. |
|------|----------|-----------------|------|------|
| 1    | GM36469  | Pipe, oil       | 1    |      |
| 2    | GM21618  | O-ring          | 2    |      |
| 3    | GM36470  | Connector       | 1    |      |
| 4    | GM21618  | O-ring          | 2    |      |
| 5    | GM15160  | Bolt w/washer   | 3    |      |
| 6    | GM36471  | Bolt w/washer   | 1    |      |
| 7    | GM36472  | Clamp, oil pipe | 2    |      |
| 8    | GM36473  | Stay            | 1    |      |
| 9    | GM15160  | Bolt w/washer   | 2    |      |
| 10   | GM36474  | Bolt            | 1    |      |
| 11   | GM15179  | Washer, spring  | 1    |      |
| 12   | GM36475  | Stay            | 1    |      |
| 13   | GM36706  | Bolt w/washer   | 2    |      |
| 14   | GM15140  | Bolt w/washer   | 2    |      |
| 15   | GM15164  | Nut             | 2    |      |

# Group 36.3: Turbocharger Oil Lines

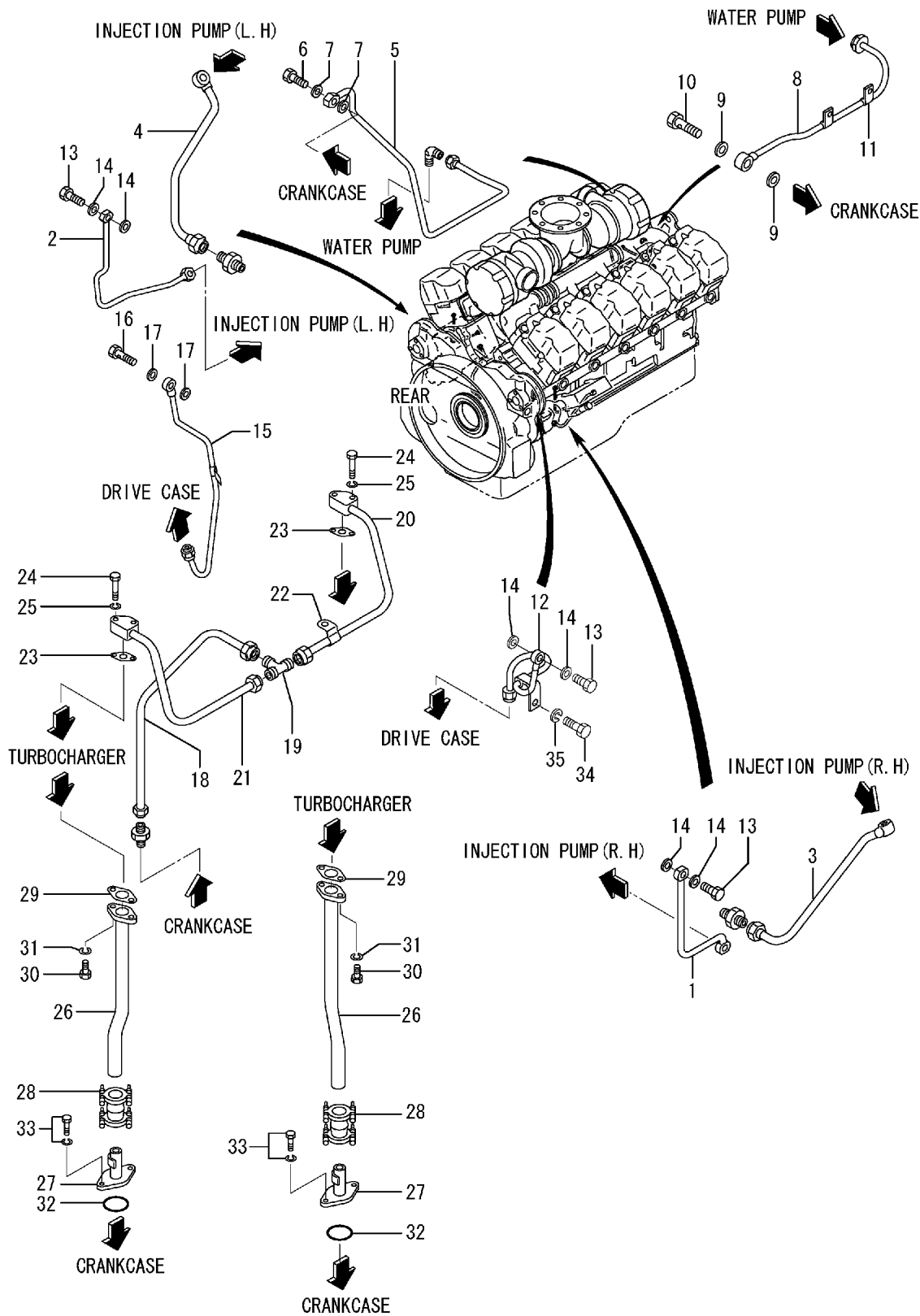


6282-36.3

## Group 36.3: Turbocharger Oil Lines

| Item | Part No. | Description           | Qty.      |
|------|----------|-----------------------|-----------|
|      |          |                       | Var.<br>1 |
| 1    | GM36476  | Pipe, oil             | 1         |
| 2    | GM36477  | Pipe, oil             | 1         |
| 3    | GM36478  | Pipe, oil             | 1         |
| 4    | GM36479  | Pipe, oil             | 1         |
| 5    | GM36480  | Pipe, oil             | 1         |
| 6    | GM36484  | Bolt, eye             | 1         |
| 7    | GM14528  | Washer, sealing       | 2         |
| 8    | GM36481  | Pipe, drain           | 1         |
| 9    | GM14531  | Washer, sealing       | 2         |
| 10   | GM15235  | Bolt, eye             | 1         |
| 11   | GM36482  | Clip                  | 1         |
| 12   | GM36483  | Pipe, oil             | 1         |
| 13   | GM36484  | Bolt, eye             | 3         |
| 14   | GM14528  | Washer, sealing       | 6         |
| 15   | GM36485  | Pipe, oil             | 1         |
| 16   | GM36484  | Bolt, eye             | 1         |
| 17   | GM14528  | Washer, sealing       | 2         |
| 18   | GM36486  | Pipe, oil             | 1         |
| 19   | GM36487  | T-joint               | 1         |
| 20   | GM36488  | Pipe, oil             | 1         |
| 21   | GM36489  | Pipe, oil             | 1         |
| 22   | GM36490  | Clamp                 | 1         |
| 23   | GM34216  | Packing               | 2         |
| 24   | GM36491  | Bolt                  | 4         |
| 25   | GM15179  | Washer, spring        | 4         |
| 26   | GM36492  | Pipe, drain           | 2         |
| 27   | GM36493  | Pipe, drain           | 2         |
| 28   | GM14495  | Coupling, turbo drain | 2         |
| 29   | GM31359  | Packing               | 2         |
| 30   | GM36634  | Bolt                  | 4         |
| 31   | GM15179  | Washer, spring        | 4         |
| 32   | GM21617  | O-ring                | 2         |
| 33   | GM15160  | Bolt w/washer         | 4         |
| 34   | GM36494  | Pipe, oil             | 1         |
| 35   | GM36484  | Bolt, eye             | 1         |
| 36   | GM14528  | Washer, sealing       | 2         |
| 37   | GM36495  | Pipe, flexible        | 1         |
| 38   | GM36496  | Pipe, flexible        | 1         |
| 39   | GM36497  | Clip                  | 1         |
| 40   | GM36498  | Bolt                  | 1         |
| 41   | GM15179  | Washer, spring        | 1         |
| 42   | GM15174  | Washer, plain         | 1         |

# Group 36.3: Turbocharger Oil Lines, continued



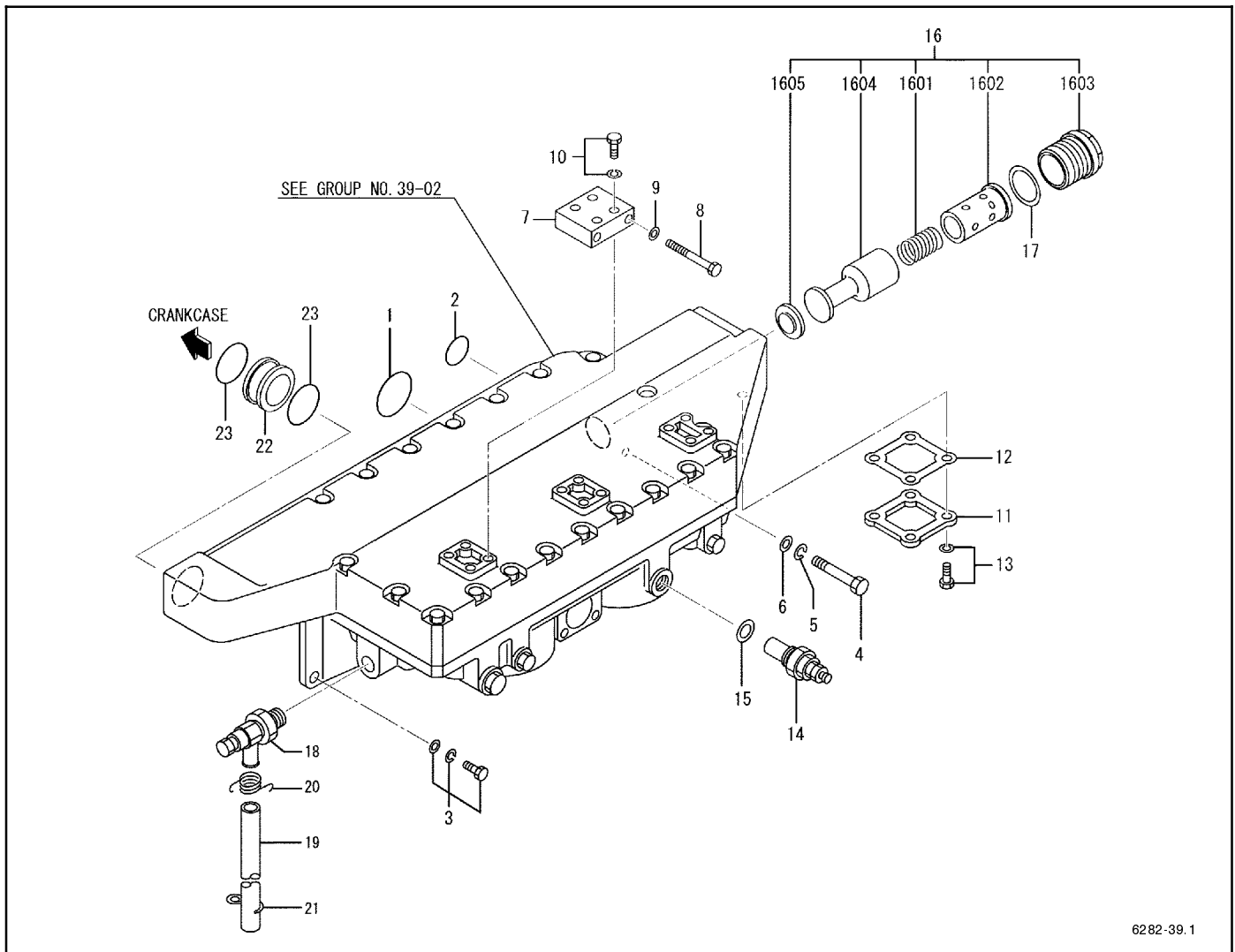
6282-36.3\_2



## Group 36.3: Turbocharger Oil Lines, continued

| Item | Part No. | Description           | Qty.      |
|------|----------|-----------------------|-----------|
|      |          |                       | Var.<br>2 |
| 1    | GM36476  | Pipe, oil             | 1         |
| 2    | GM36477  | Pipe, oil             | 1         |
| 3    | GM36478  | Pipe, oil             | 1         |
| 4    | GM36479  | Pipe, oil             | 1         |
| 5    | GM36480  | Pipe, oil             | 1         |
| 6    | GM36484  | Bolt, eye             | 1         |
| 7    | GM14528  | Washer, sealing       | 2         |
| 8    | GM57333  | Pipe, drain           | 1         |
| 9    | GM14531  | Washer, sealing       | 2         |
| 10   | GM15235  | Bolt, eye             | 1         |
| 11   | GM36482  | Clip                  | 1         |
| 12   | GM57334  | Pipe, oil             | 1         |
| 13   | GM36484  | Bolt, eye             | 3         |
| 14   | GM14528  | Washer, sealing       | 6         |
| 15   | GM57335  | Pipe, oil             | 1         |
| 16   | GM36484  | Bolt, eye             | 1         |
| 17   | GM14528  | Washer, sealing       | 2         |
| 18   | GM36486  | Pipe, oil             | 1         |
| 19   | GM36487  | T-joint               | 1         |
| 20   | GM36488  | Pipe, oil             | 1         |
| 21   | GM36489  | Pipe, oil             | 1         |
| 22   | GM36490  | Clamp                 | 1         |
| 23   | GM34216  | Packing               | 2         |
| 24   | GM36491  | Bolt                  | 4         |
| 25   | GM15179  | Washer, spring        | 4         |
| 26   | GM36492  | Pipe, drain           | 2         |
| 27   | GM36493  | Pipe, drain           | 2         |
| 28   | GM14495  | Coupling, turbo drain | 2         |
| 29   | GM31359  | Packing               | 2         |
| 30   | GM36634  | Bolt                  | 4         |
| 31   | GM15179  | Washer, spring        | 4         |
| 32   | GM21617  | O-ring                | 2         |
| 33   | GM15160  | Bolt w/washer         | 4         |
| 34   | GM22091  | Bolt                  | 1         |
| 35   | GM15179  | Washer, spring        | 1         |

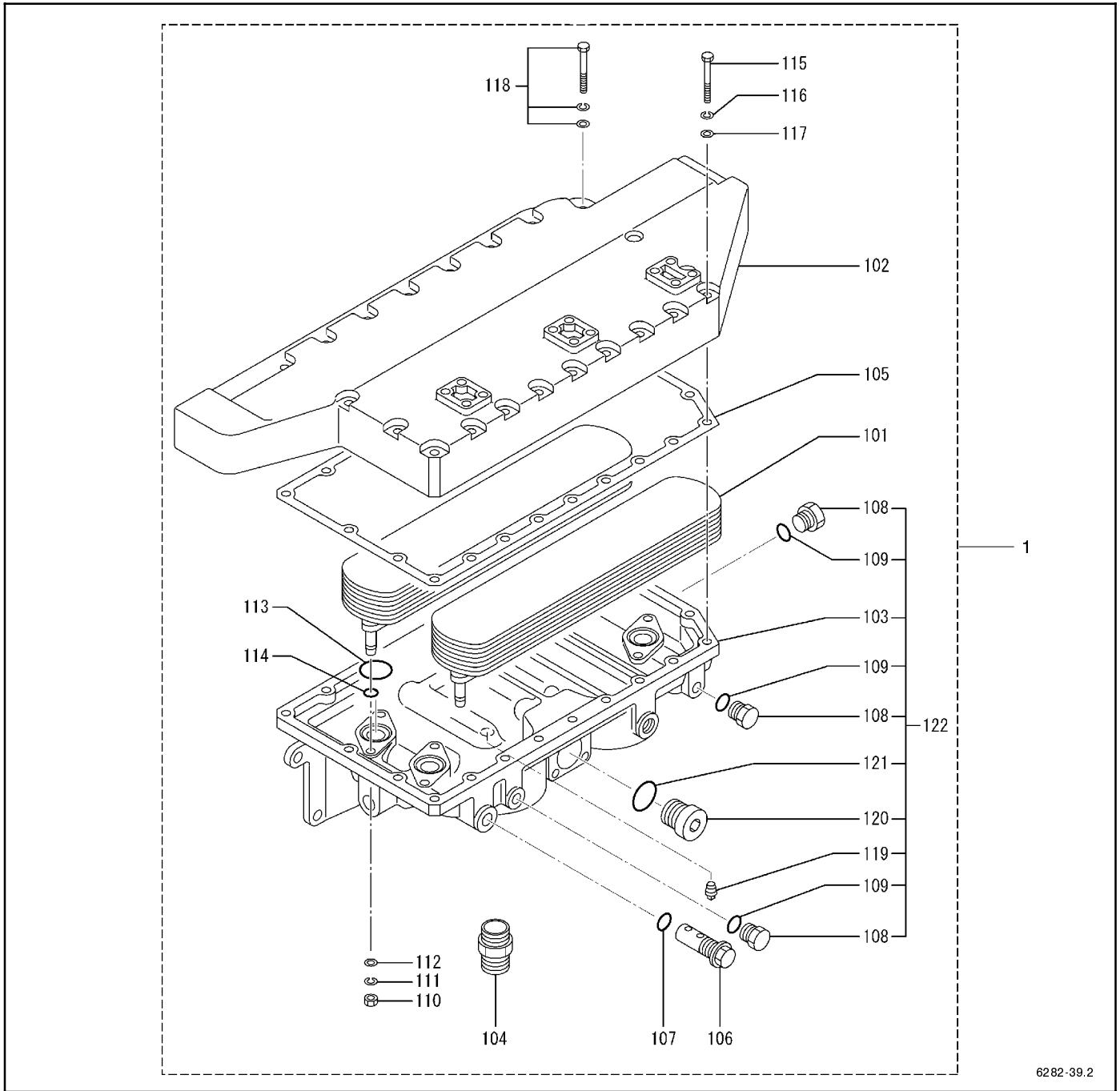
# Group 39.1: Oil Cooler



6282-39.1

| Item | Part No. | Description       | Qty. |    | Item | Part No. | Description            | Qty. |   |
|------|----------|-------------------|------|----|------|----------|------------------------|------|---|
|      |          |                   | 1    | 2  |      |          |                        | 1    | 2 |
| 1    | GM21618  | O-ring            | 2    | 2  | 15   | GM14533  | Washer, sealing        | 1    | 1 |
| 2    | GM15528  | O-ring            | 1    | 1  | 16   | GM36502  | Valve assembly, relief | 1    | 1 |
| 3    | GM36514  | Bolt, w/washer    | 11   | 11 | 1601 | GM36503  | Spring                 | 1    | 1 |
| 4    | GM15130  | Bolt              | 2    | 2  | 1602 | GM36504  | Sleeve                 | 1    | 1 |
| 5    | GM15179  | Washer, spring    | 2    | 2  | 1603 | GM36505  | Plug                   | 1    | 1 |
| 6    | GM15174  | Washer, plain     | 2    | 2  | 1604 | GM36506  | Valve, relief          | 1    | 1 |
| 7    | GM36499  | Bracket           | 3    | 3  | 1605 | GM36507  | Retainer               | 1    | 1 |
| 8    | GM36625  | Bolt              | 6    | 6  | 17   | GM14512  | O-ring                 | 1    | 1 |
| 9    | GM15174  | Washer, plain     | 6    | 6  | 18   | GM14622  | Cock, drain            | 1    | 1 |
| 10   | GM15981  | Bolt w/washer     | 12   | 12 | 18   | GM57191  | Cock, drain            |      | 1 |
| 11   | GM36500  | Cover, side       | 1    | 1  | 19   | GM16023  | Tube, vinyl            | 1    | 1 |
| 12   | GM36501  | Packing           | 1    | 1  | 20   | GM14558  | Clamp                  | 1    | 1 |
| 13   | GM15159  | Bolt w/washer     | 4    | 4  | 21   | GM36552  | Clamp                  | 1    | 1 |
| 14   | GM14488  | Alarm, oil filter | 1    |    | 22   | GM36508  | Joint                  | 1    | 1 |
| 14   | GM21722  | Alarm, oil filter |      | 1  | 23   | GM16005  | O-ring                 | 2    | 2 |

# Group 39.2: Oil Cooler Assembly

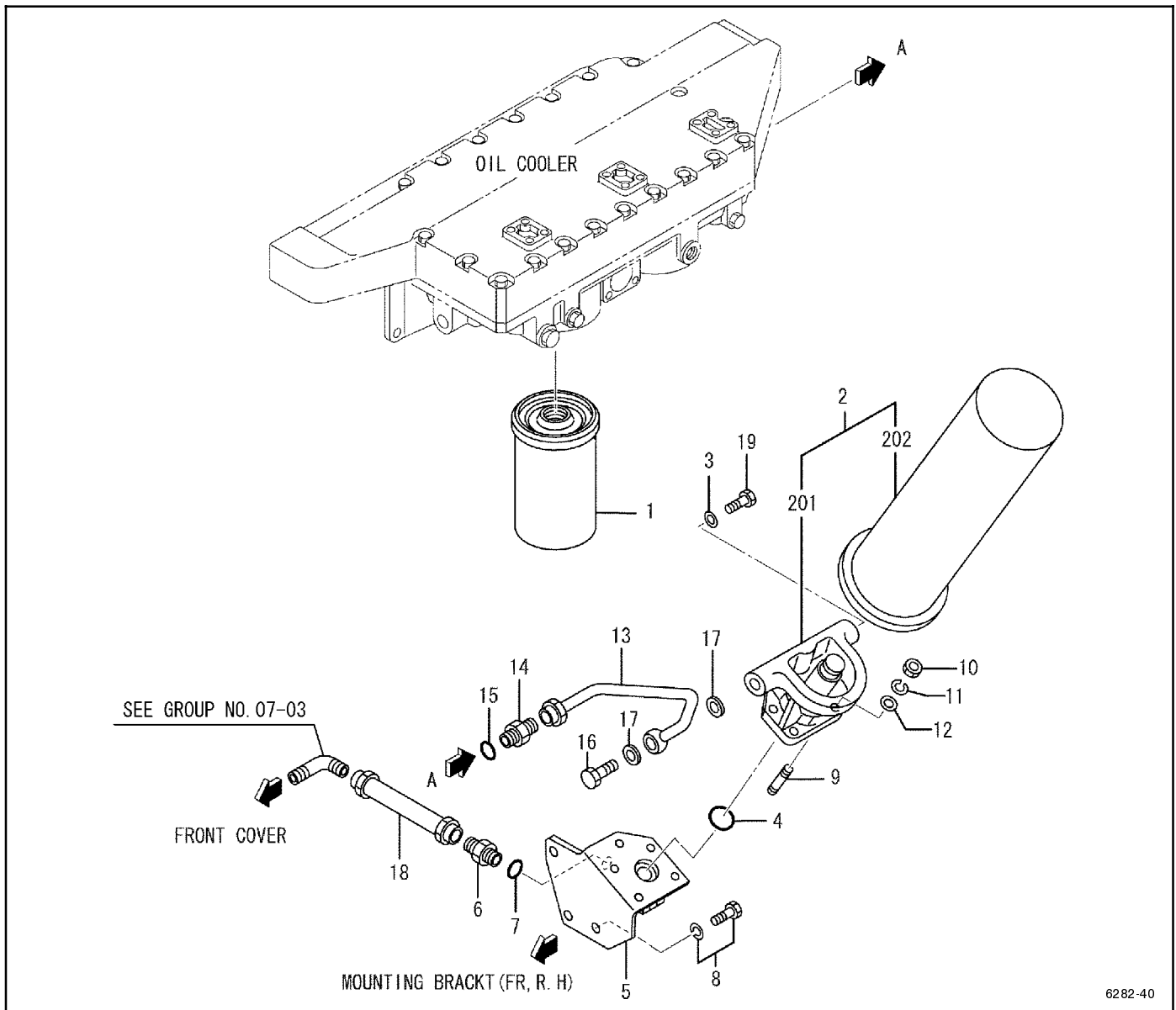


6282-39.2

| Item | Part No. | Description          | Qty. | Var. | Item | Part No. | Description    | Qty. | Var. |
|------|----------|----------------------|------|------|------|----------|----------------|------|------|
| 1    | GM36509  | Cooler assembly, oil | 1    |      | 112  | GM15174  | Washer, plain  | 8    |      |
| 101  | GM36510  | Element              | 2    |      | 113  | GM15266  | O-ring, oil    | 4    |      |
| 102  | GM36511  | Case                 | 1    |      | 114  | GM15264  | O-ring         | 8    |      |
| 103  | GM36512  | Cover, cooler        | 1    |      | 115  | GM36468  | Bolt           | 13   |      |
| 104  | X        | Connector            | 4    |      | 116  | GM15179  | Washer, spring | 13   |      |
| 105  | GM36513  | Gasket               | 1    |      | 117  | GM15174  | Washer, plain  | 13   |      |
| 106  | GM14599  | Valve, bypass        | 1    |      | 118  | GM36514  | Bolt, w/washer | 9    |      |
| 107  | GM14598  | O-ring               | 1    |      | 119  | GM15246  | Plug, tapered  | 1    |      |
| 108  | GM16042  | Plug                 | 3    |      | 120  | GM36515  | Plug           | 1    |      |
| 109  | GM15265  | O-ring               | 3    |      | 121  | GM36516  | O-ring         | 1    |      |
| 110  | GM15164  | Nut                  | 8    |      | 122  | GM36517  | Cover assembly | 1    |      |
| 111  | GM15179  | Washer, spring       | 8    |      |      |          |                |      |      |

X Part is not sold separately

# Group 40: Oil Filter

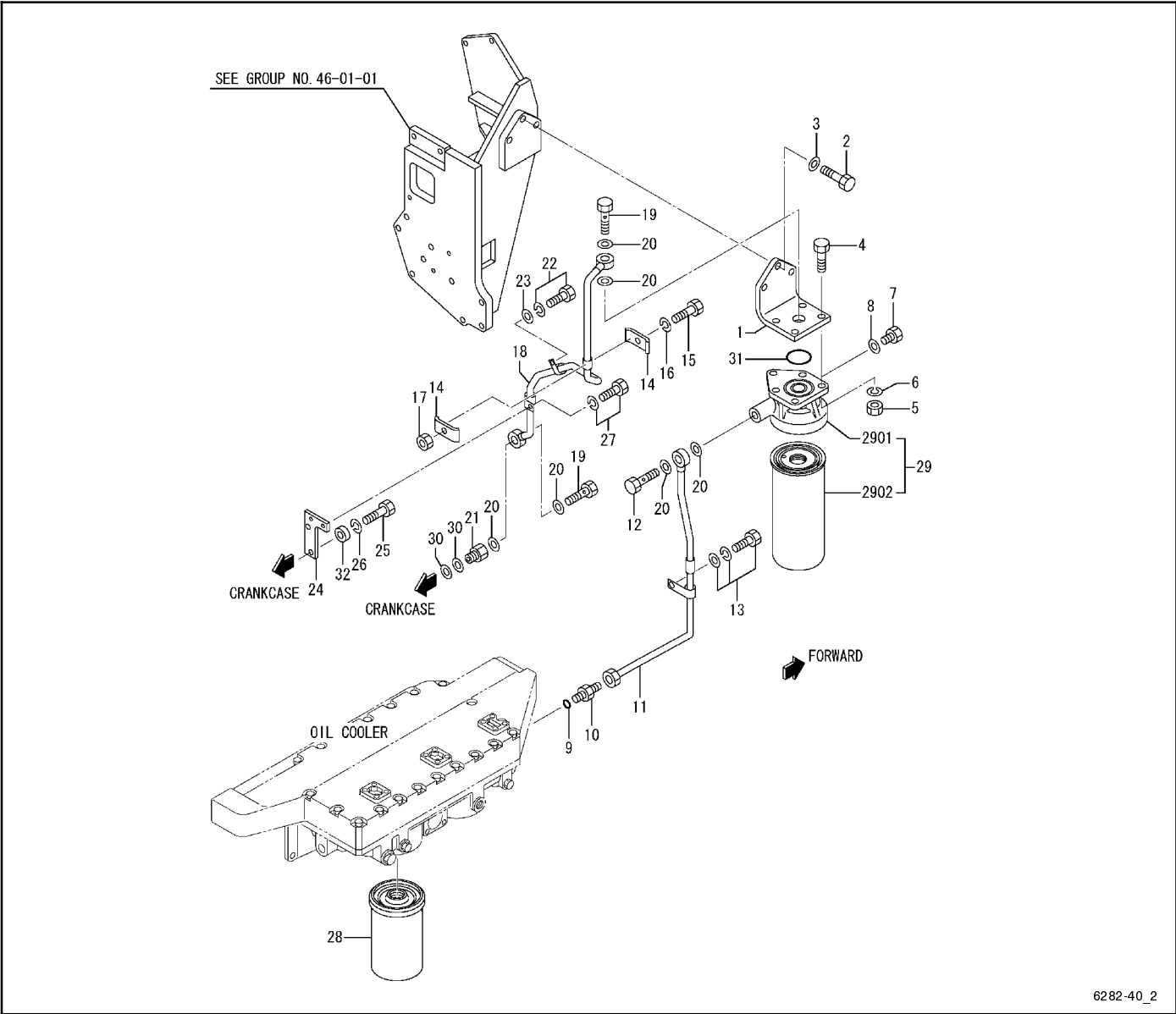


6282-40

| Item | Part No. | Description             | Qty. | Var. | Item | Part No. | Description     | Qty. | Var. |
|------|----------|-------------------------|------|------|------|----------|-----------------|------|------|
| 1    | GM32057  | Filter, oil             | 4    |      | 10   | GM15164  | Nut             | 5    |      |
| 2    | GM36518  | Filter assembly, bypass | 1    |      | 11   | GM15179  | Washer, spring  | 5    |      |
| 201  | X        | Bracket                 | 1    |      | 12   | GM15174  | Washer, plain   | 5    |      |
| 202  | GM13950  | Filter, oil             | 1    |      | 13   | GM36523  | Pipe, bypass    | 1    |      |
| 3    | GM36519  | Washer, sealing         | 1    |      | 14   | GM36524  | Connector       | 1    |      |
| 4    | GM14516  | O-ring                  | 1    |      | 15   | GM15265  | O-ring          | 1    |      |
| 5    | GM36520  | Bracket, oil filter     | 1    |      | 16   | GM36525  | Bolt, union     | 1    |      |
| 6    | GM36521  | Connector               | 1    |      | 17   | GM36519  | Washer, sealing | 2    |      |
| 7    | GM21627  | Washer, sealing         | 1    |      | 18   | GM36526  | Pipe, flexible  | 1    |      |
| 8    | GM15160  | Bolt w/washer           | 3    |      | 19   | GM31295  | Plug, drain     | 1    |      |
| 9    | GM36522  | Stud                    | 5    |      |      |          |                 |      |      |

X Part is not sold separately

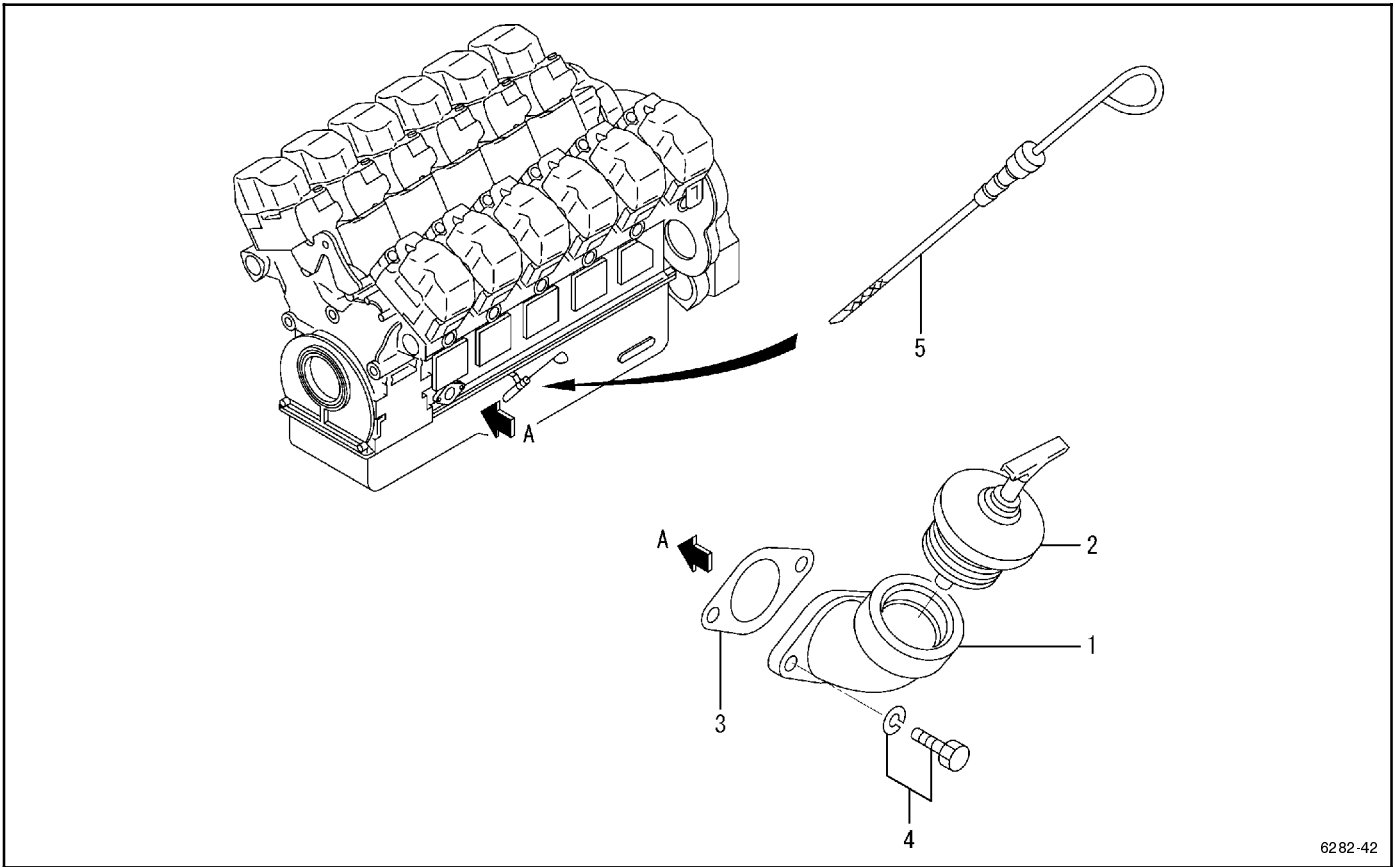
# Group 40: Oil Filter



6282-40\_2

| Item | Part No. | Description         | Qty. | Var. | Item | Part No. | Description             | Qty. | Var. |
|------|----------|---------------------|------|------|------|----------|-------------------------|------|------|
| 1    | GM57336  | Bracket, oil filter | 1    | 2    | 18   | GM57338  | Pipe, bypass            | 1    |      |
| 2    | GM15108  | Bolt                | 3    |      | 19   | GM36525  | Boit, union             | 4    |      |
| 3    | GM34246  | Washer              | 3    |      | 20   | GM36519  | Washer, sealing         | 6    |      |
| 4    | GM15956  | Bolt                | 4    |      | 21   | GM57339  | Connector               | 1    |      |
| 5    | GM15164  | Nut                 | 4    |      | 22   | GM15139  | Bolt w/washer           | 1    |      |
| 6    | GM15179  | Washer, spring      | 4    |      | 23   | GM15174  | Washer, plain           | 1    |      |
| 7    | GM31295  | Plug, drain         | 1    |      | 24   | GM57340  | Stay, pipe              | 1    |      |
| 8    | GM36519  | Washer, sealing     | 1    |      | 25   | GM57307  | Bolt                    | 2    |      |
| 9    | GM15265  | O-ring              | 1    |      | 26   | GM15179  | Washer, spring          | 2    |      |
| 10   | GM36524  | Connector           | 1    |      | 27   | GM15149  | Bolt w/washer           | 1    |      |
| 11   | GM57337  | Pipe, bypass        | 1    |      | 28   | GM32057  | Filter, oil             | 4    |      |
| 12   | GM36525  | Boit, union         | 1    |      | 29   | GM36518  | Filter assembly, bypass | 1    |      |
| 13   | GM15153  | Bolt                | 1    |      | 2901 | GM57341  | Bracket                 | 1    |      |
| 14   | GM34323  | Pipe, fuel fr       | 2    |      | 2902 | GM13950  | Filter, oil             | 1    |      |
| 15   | GM15103  | Bolt                | 1    |      | 30   | GM36519  | Washer, sealing         | 2    |      |
| 16   | GM15179  | Washer, spring      | 1    |      | 31   | GM14516  | O-ring                  | 1    |      |
| 17   | GM15164  | Nut                 | 1    |      | 32   | GM57342  | Spacer                  | 2    |      |

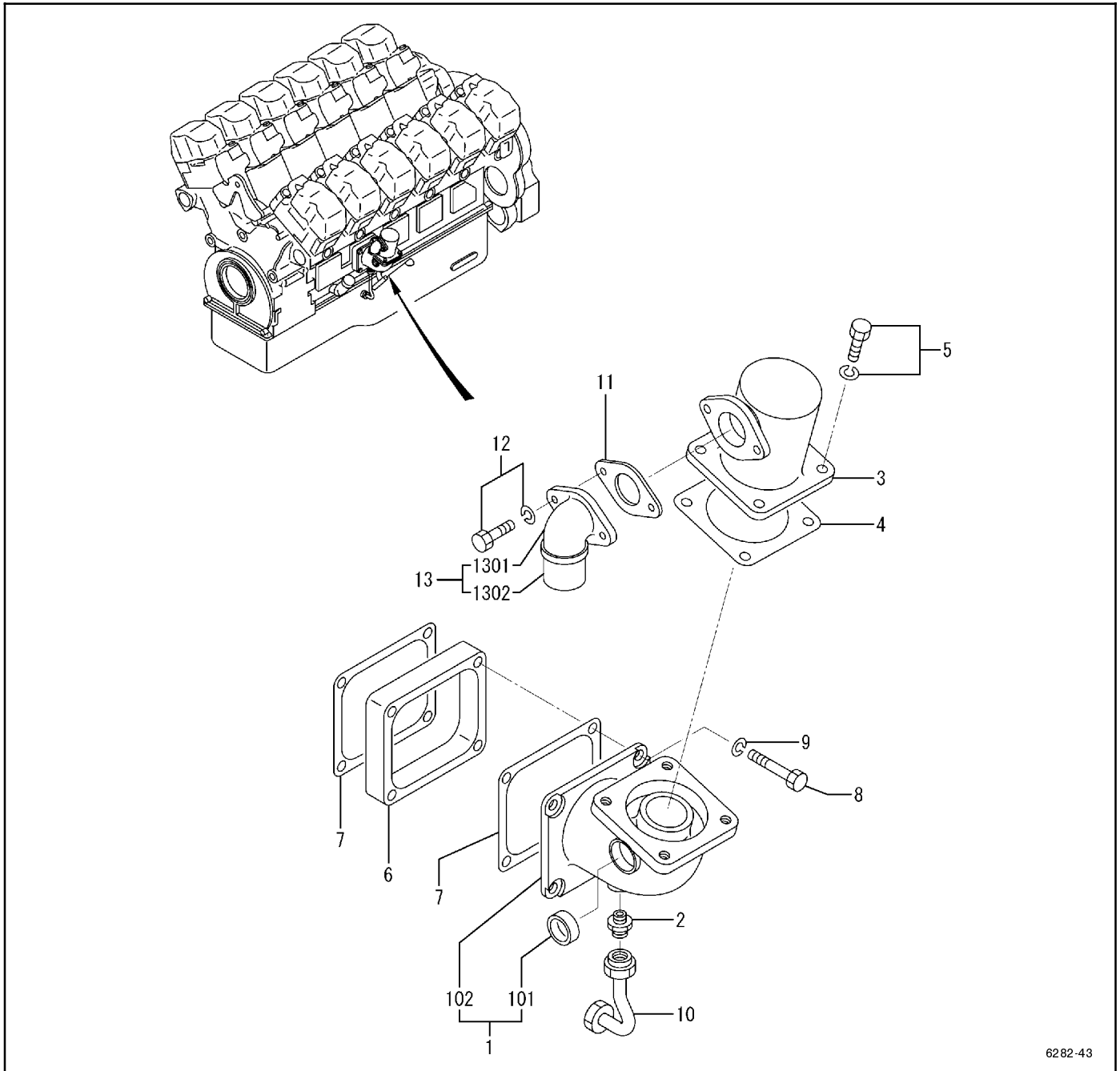
# Group 42: Oil Filler and Dipstick



6282-42

| Item | Part No. | Description   | Qty. |
|------|----------|---------------|------|
|      |          |               | Var. |
| 1    | GM14602  | Elbow         | 1    |
| 2    | GM14633  | Cap, oil      | 1    |
| 3    | GM21668  | Gasket        | 1    |
| 4    | GM15159  | Bolt w/washer | 2    |
| 5    | GM36527  | Gauge, level  | 1    |

# Group 43: Breather



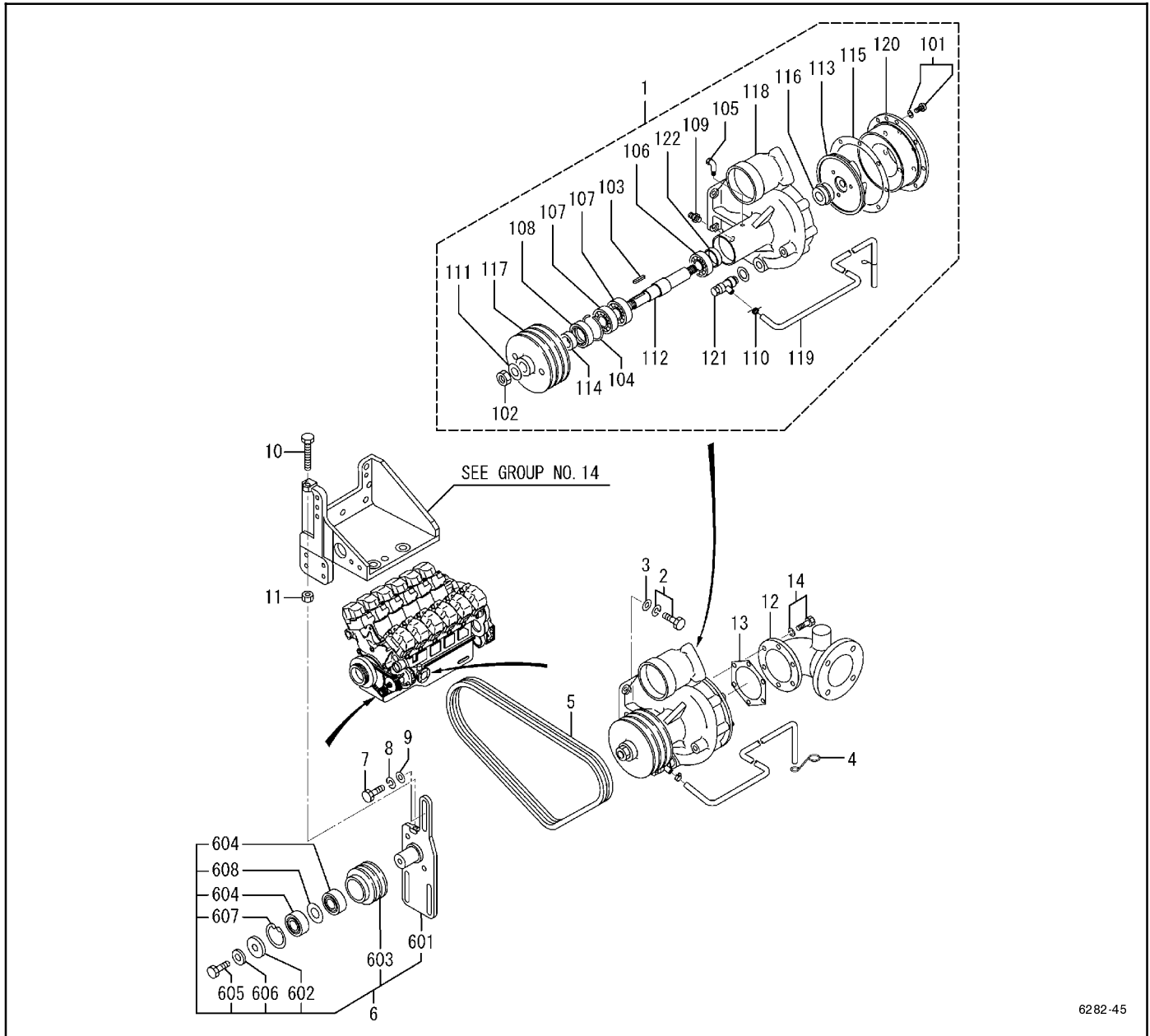
6282-43

| Item | Part No. | Description             | Qty.<br>Var. |
|------|----------|-------------------------|--------------|
| 1    | GM36528  | Case assembly, breather | 1            |
| 101  | GM14491  | Cap, sealing            | 2            |
| 102  | X        | Case                    | 1            |
| 2    | GM31459  | Connector               | 1            |
| 3    | GM36529  | Cover, breather         | 1            |
| 4    | GM36530  | Packing                 | 1            |
| 5    | GM36395  | Bolt, w/washer          | 4            |
| 6    | GM36531  | Cover, side             | 1            |
| 7    | GM34094  | Packing                 | 2            |

| Item | Part No. | Description    | Qty.<br>Var. |
|------|----------|----------------|--------------|
| 8    | GM36532  | Bolt           | 4            |
| 9    | GM15179  | Washer, spring | 4            |
| 10   | GM36533  | Pipe, oil      | 1            |
| 11   | GM31287  | Gasket         | 1            |
| 12   | GM15983  | Bolt w/washer  | 2            |
| 13   | GM36534  | Elbow          | 1            |
| 1301 | GM36535  | Joint          | 1            |
| 1302 | X        | Pipe           | 1            |

X Part is not sold separately

# Group 45: Water Pump



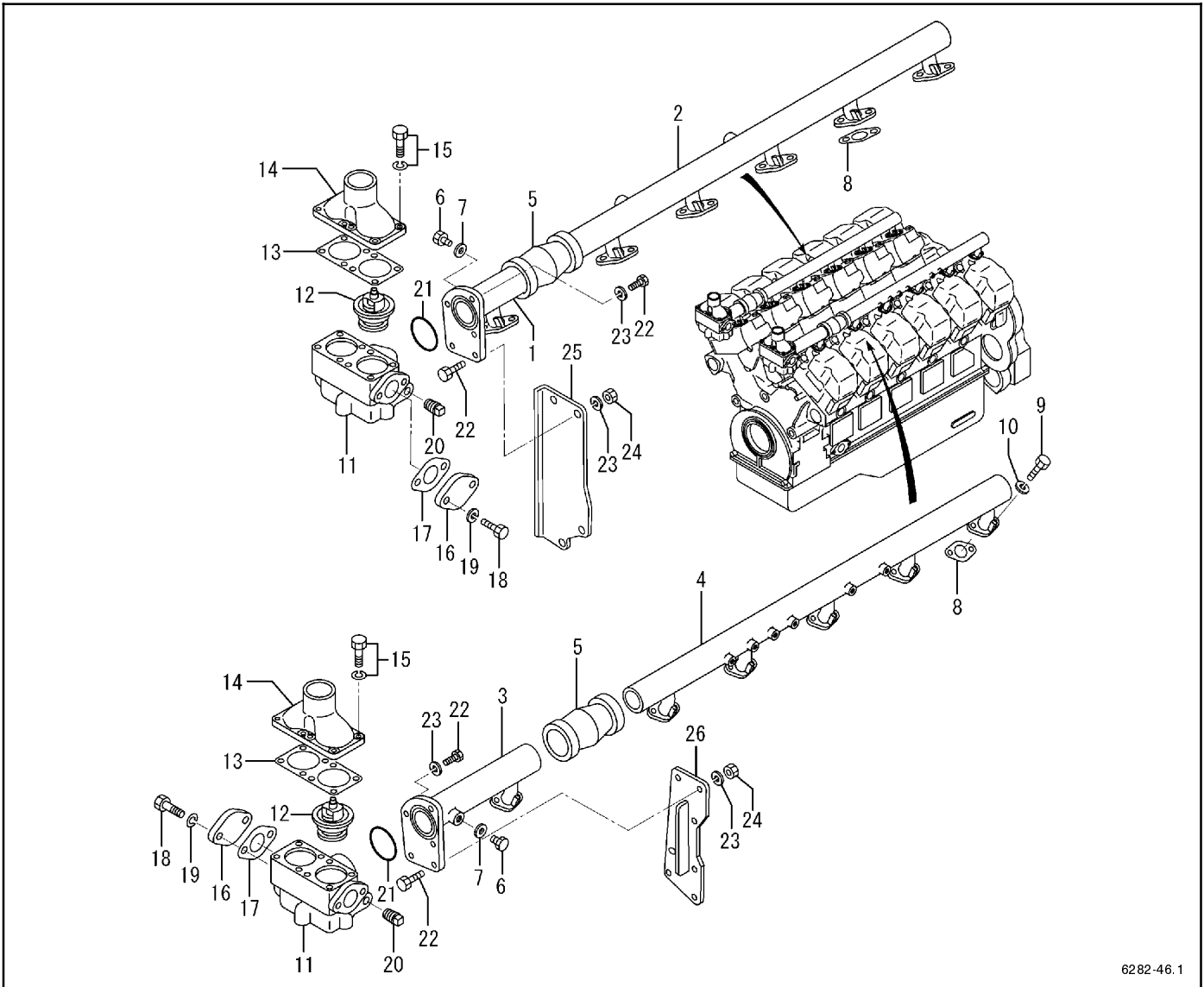
6282-45



## Group 45: Water Pump

| Item | Part No. | Description                  | Qty. |   |
|------|----------|------------------------------|------|---|
|      |          |                              | 1    | 2 |
| 1    | GM36536  | Pump assembly, water         | 1    | 1 |
| 101  | GM15159  | Bolt w/washer                | 8    | 8 |
| 102  | GM15986  | Nut                          | 1    | 1 |
| 103  | GM36537  | Key, sunk                    | 1    | 1 |
| 104  | GM36538  | Ring, snap                   | 1    | 1 |
| 105  | GM36539  | Elbow                        | 1    | 1 |
| 106  | GM36540  | Bearing, ball                | 1    | 1 |
| 107  | GM36541  | Bearing, ball                | 2    | 2 |
| 108  | GM36542  | Seal, oil                    | 1    | 1 |
| 109  | GM31459  | Connector                    | 1    | 1 |
| 110  | GM14558  | Clamp                        | 1    | 1 |
| 111  | GM36543  | Washer                       | 1    | 1 |
| 112  | GM36544  | Shaft, water pump            | 1    | 1 |
| 113  | GM36545  | Impeller                     | 1    | 1 |
| 114  | GM36546  | Spacer                       | 1    | 1 |
| 115  | GM36547  | Packing                      | 1    | 1 |
| 116  | GM31685  | Seal, unit                   | 1    | 1 |
| 117  | GM36548  | Pulley, water pump           | 1    |   |
| 117  | GM57347  | Pulley, water pump           |      | 1 |
| 118  | GM36549  | Case, water pump             | 1    |   |
| 118  | GM57348  | Case, water pump             |      | 1 |
| 119  | GM14620  | Pipe, drain                  | 1    | 1 |
| 120  | GM36550  | Cover                        | 1    | 1 |
| 121  | GM14622  | Cock, drain                  | 1    |   |
| 121  | GM57191  | Cock, drain                  |      | 1 |
| 122  | GM36551  | Seal, oil                    | 1    | 1 |
| 123  | GM37122  | Pipe, water pump (not shown) |      | 1 |
| 2    | GM15981  | Bolt w/washer                | 4    | 4 |
| 3    | GM15174  | Washer, plain                | 4    | 4 |
| 4    | GM36552  | Clamp                        | 1    | 1 |
| 5    | GM35975  | V-belt, water pump           | 1    | 1 |
| 6    | GM36554  | Pulley assembly, tension     | 1    | 1 |
| 601  | GM36555  | Bracket, tension             | 1    | 1 |
| 602  | GM36556  | Plate, thrust                | 1    | 1 |
| 603  | GM36557  | Pulley, tension              | 1    | 1 |
| 604  | GM36558  | Bearing, ball                | 2    | 2 |
| 605  | GM15107  | Bolt                         | 1    | 1 |
| 606  | GM21715  | Washer                       | 1    |   |
| 606  | GM36363  | Washer                       |      | 1 |
| 607  | GM36559  | Ring, snap                   | 1    | 1 |
| 608  | GM36560  | Spacer                       | 1    | 1 |
| 7    | GM15110  | Bolt                         | 3    | 3 |
| 8    | GM15180  | Washer, spring               | 3    | 3 |
| 9    | GM36607  | Washer, plain                | 3    | 3 |
| 10   | GM36561  | Bolt, tension                | 1    | 1 |
| 11   | GM15171  | Nut, jam                     | 1    | 1 |
| 12   | GM36562  | Connector                    | 1    | 1 |
| 13   | GM36563  | Packing                      | 1    | 1 |
| 14   | GM15160  | Bolt w/washer                | 6    | 6 |

# Group 46.1: Thermostat and Covers

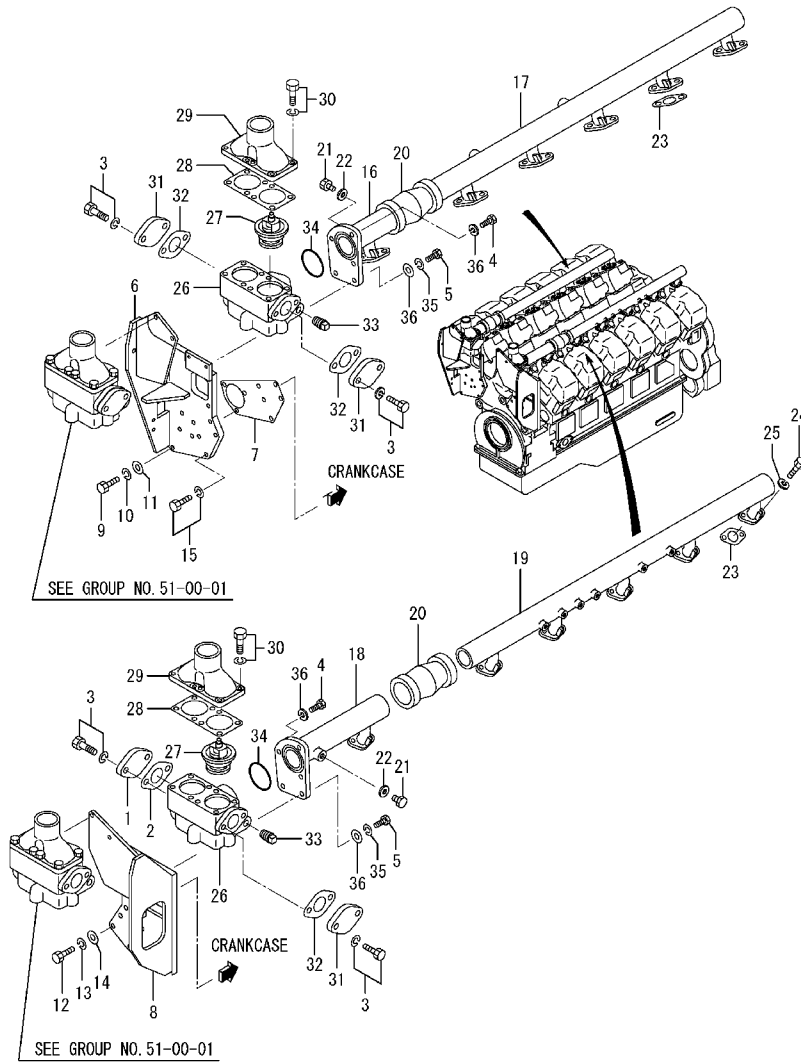


6282-46.1

| Item | Part No. | Description        | Qty. |      |
|------|----------|--------------------|------|------|
|      |          |                    | 1    | Var. |
| 1    | GM36564  | Pipe, water outlet | 1    |      |
| 2    | GM36565  | Pipe, water outlet | 1    |      |
| 3    | GM36566  | Pipe, water outlet | 1    |      |
| 4    | GM36567  | Pipe, water outlet | 1    |      |
| 5    | GM36568  | Coupling           | 2    |      |
| 6    | GM15238  | Plug, screw        | 2    |      |
| 7    | GM14531  | Washer, sealing    | 2    |      |
| 8    | GM36569  | Packing            | 12   |      |
| 9    | GM21147  | Bolt               | 24   |      |
| 10   | GM15179  | Washer, spring     | 24   |      |
| 11   | GM14606  | Case, thermostat   | 2    |      |
| 12   | GM13944  | Thermostat         | 4    |      |
| 13   | GM13945  | Gasket, thermostat | 2    |      |

| Item | Part No. | Description    | Qty. |      |
|------|----------|----------------|------|------|
|      |          |                | 1    | Var. |
| 14   | GM34234  | Cover, thermo  | 2    |      |
| 15   | GM15138  | Bolt w/washer  | 16   |      |
| 16   | GM36570  | Cover          | 2    |      |
| 17   | GM34235  | Packing        | 2    |      |
| 18   | GM15955  | Bolt           | 8    |      |
| 19   | GM15179  | Washer, spring | 8    |      |
| 20   | GM15247  | Plug, tapered  | 4    |      |
| 21   | GM15205  | O-ring         | 2    |      |
| 22   | GM21147  | Bolt           | 10   |      |
| 23   | GM15179  | Washer, spring | 10   |      |
| 24   | GM15164  | Nut            | 4    |      |
| 25   | GM36571  | Stay           | 1    |      |
| 26   | GM36572  | Stay           | 1    |      |

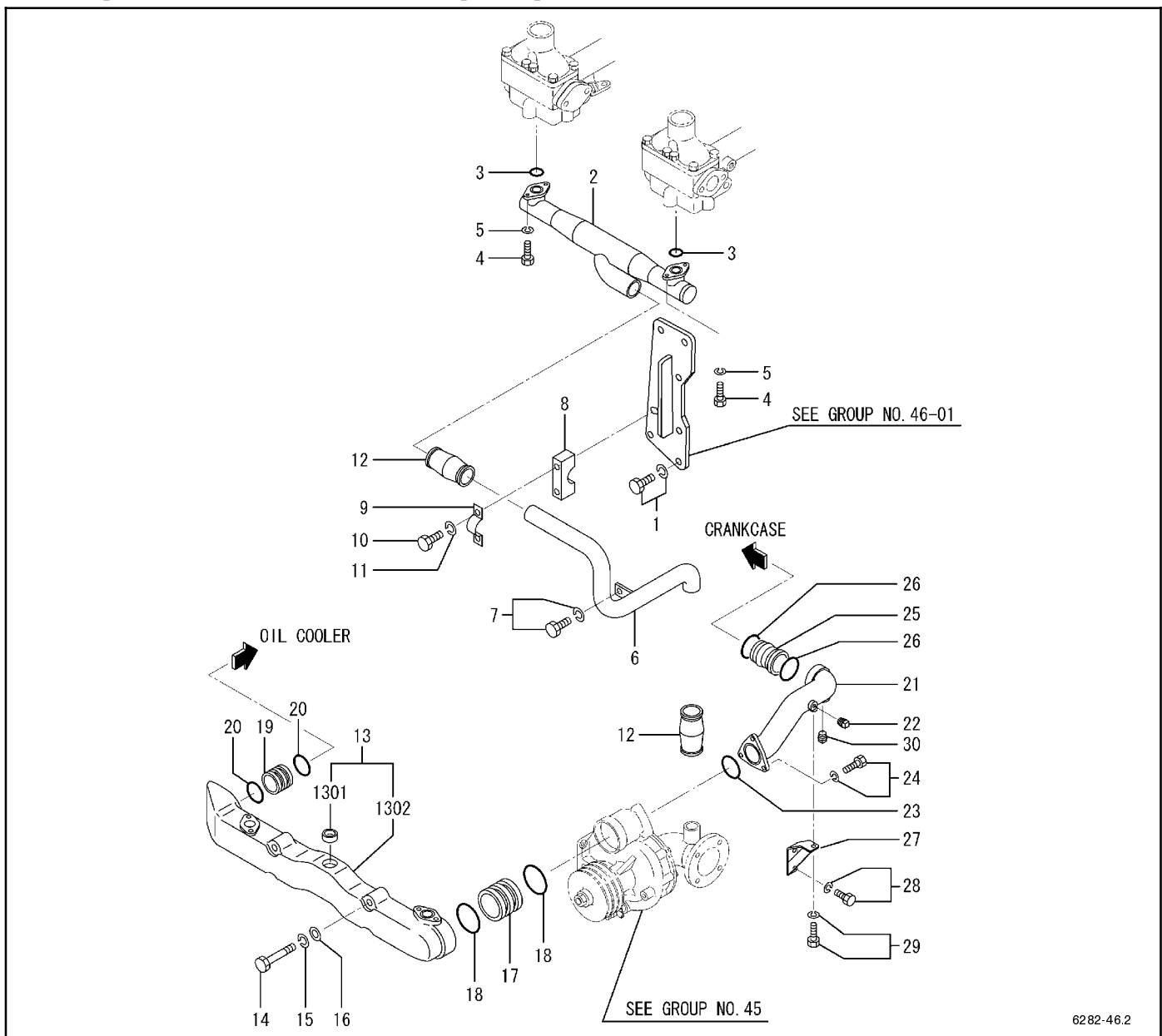
# Group 46.1: Thermostat and Covers



6282-46.1\_2

| Item | Part No. | Description        | Qty. | Var. | Item | Part No. | Description        | Qty. | Var. |
|------|----------|--------------------|------|------|------|----------|--------------------|------|------|
| 1    | GM36570  | Cover              | 2    |      | 19   | GM36567  | Pipe, water outlet | 1    |      |
| 2    | GM34235  | Packing            | 2    |      | 20   | GM36568  | Coupling           | 2    |      |
| 3    | GM15141  | Bolt               | 8    |      | 21   | GM15238  | Plug, screw        | 2    |      |
| 4    | GM21147  | Bolt               | 6    |      | 22   | GM14531  | Washer, sealing    | 2    |      |
| 5    | GM15956  | Bolt               | 4    |      | 23   | GM36569  | Packing            | 12   |      |
| 6    | GM57350  | Bracket, thermo    | 1    |      | 24   | GM21147  | Bolt               | 24   |      |
| 7    | GM57351  | Gasket             | 1    |      | 25   | GM15179  | Washer, spring     | 24   |      |
| 8    | GM57352  | Bracket, thermo    | 1    |      | 26   | GM14606  | Case, thermostat   | 2    |      |
| 9    | GM15110  | Bolt               | 8    |      | 27   | GM13944  | Thermostat         | 4    |      |
| 10   | GM36363  | Washer             | 8    |      | 28   | GM13945  | Gasket, thermostat | 2    |      |
| 11   | GM57353  | Spacer             | 1    |      | 29   | GM34234  | Cover, thermo      | 2    |      |
| 12   | GM15110  | Bolt               | 8    |      | 30   | GM15138  | Bolt w/washer      | 16   |      |
| 13   | GM36363  | Washer             | 8    |      | 31   | GM36570  | Cover              | 2    |      |
| 14   | GM57353  | Spacer             | 3    |      | 32   | GM34235  | Packing            | 2    |      |
| 15   | GM15140  | Bolt               | 2    |      | 33   | GM15247  | Plug, tapered      | 4    |      |
| 16   | GM36564  | Pipe, water outlet | 1    |      | 34   | GM15205  | O-ring             | 2    |      |
| 17   | GM36565  | Pipe, water outlet | 1    |      | 35   | GM15179  | Washer, spring     | 10   |      |
| 18   | GM36566  | Pipe, water outlet | 1    |      | 36   | GM31649  | Washer             | 5    |      |

# Group 46.2: Water Pump Pipes



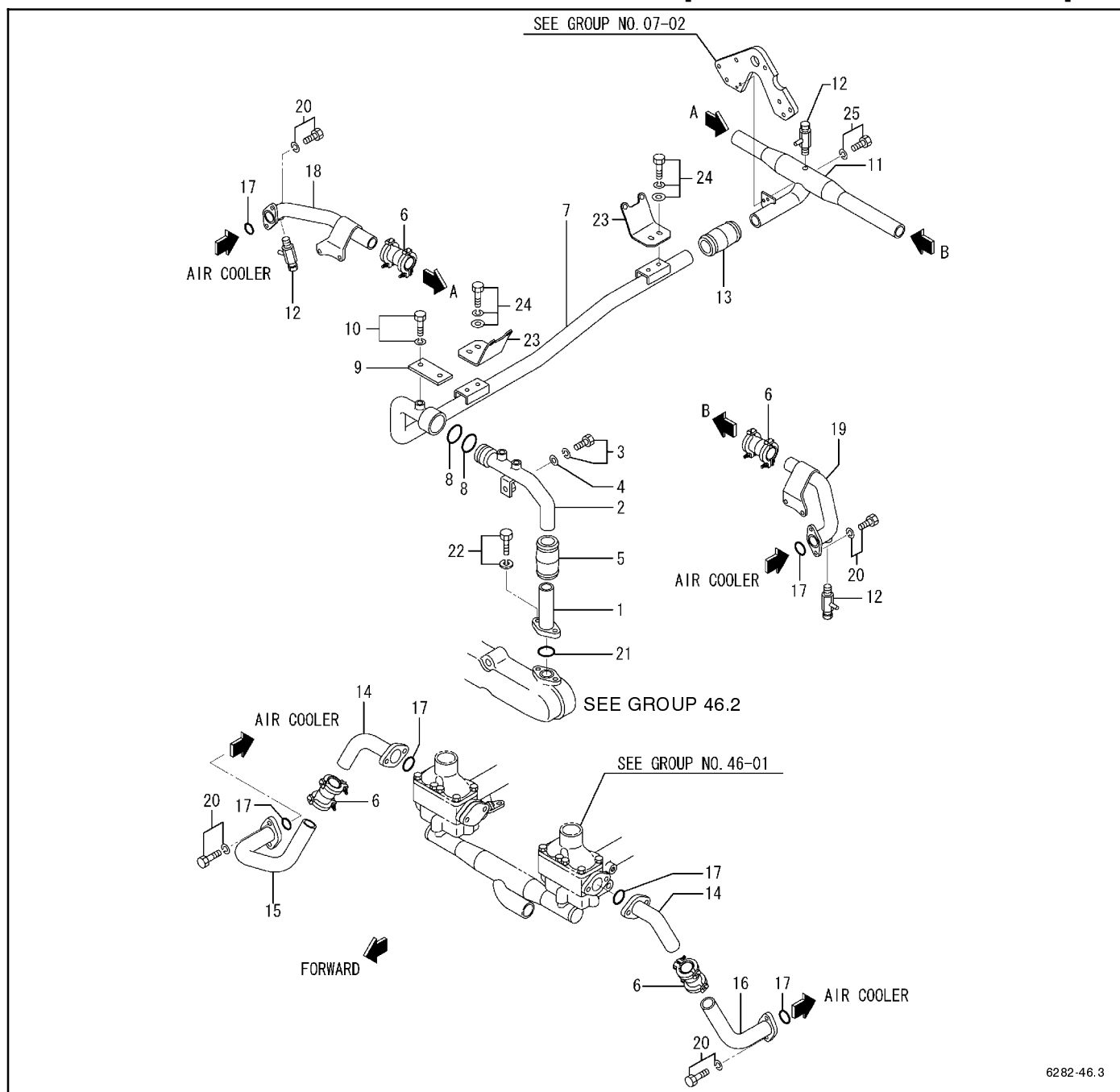
6282-46.2

| Item | Part No. | Description          | Qty. |   |
|------|----------|----------------------|------|---|
|      |          |                      | 1    | 2 |
| 1    | GM15983  | Bolt w/washer        | 4    |   |
| 2    | GM36573  | Pipe                 | 1    | 1 |
| 3    | GM15203  | O-ring               | 2    | 2 |
| 4    | GM15955  | Bolt                 | 4    | 4 |
| 5    | GM15179  | Washer, spring       | 4    | 4 |
| 6    | GM36574  | Pipe, bypass         | 1    | 1 |
| 7    | GM36453  | Bolt, w/washer       | 1    | 1 |
| 8    | GM36575  | Bracket              | 1    |   |
| 9    | GM36576  | Clamp                | 1    | 1 |
| 10   | GM22092  | Bolt                 | 2    |   |
| 10   | GM21147  | Bolt                 |      | 2 |
| 11   | GM15179  | Washer, spring       | 2    | 2 |
| 12   | GM36568  | Coupling             | 2    | 2 |
| 13   | GM36577  | Pipe assembly, water | 1    | 1 |
| 1301 | GM14491  | Cap, sealing         | 4    | 4 |
| 1302 | X        | Pipe, water          | 1    | 1 |
| 14   | GM36578  | Bolt                 | 4    | 4 |

| Item | Part No. | Description    | Qty. |   |
|------|----------|----------------|------|---|
|      |          |                | 1    | 2 |
| 15   | GM15180  | Washer, spring | 4    | 4 |
| 16   | GM15175  | Washer         | 4    | 4 |
| 17   | GM36579  | Joint          | 1    | 1 |
| 18   | GM36580  | O-ring         | 2    | 2 |
| 19   | GM36508  | Joint          | 1    | 1 |
| 20   | GM16005  | O-ring         | 2    | 2 |
| 21   | GM36581  | Pipe, water    | 1    | 1 |
| 22   | GM15246  | Plug, tapered  | 1    | 1 |
| 23   | GM36582  | O-ring         | 1    | 1 |
| 24   | GM15159  | Bolt w/washer  | 3    | 3 |
| 25   | GM36508  | Joint          | 1    | 1 |
| 26   | GM16005  | O-ring         | 2    | 2 |
| 27   | GM36583  | Stay           | 1    | 1 |
| 28   | GM36584  | Bolt, w/washer | 2    | 2 |
| 29   | GM15139  | Bolt w/washer  | 1    | 1 |
| 30   | GM15247  | Plug, tapered  | 1    | 1 |

X Part is not sold separately

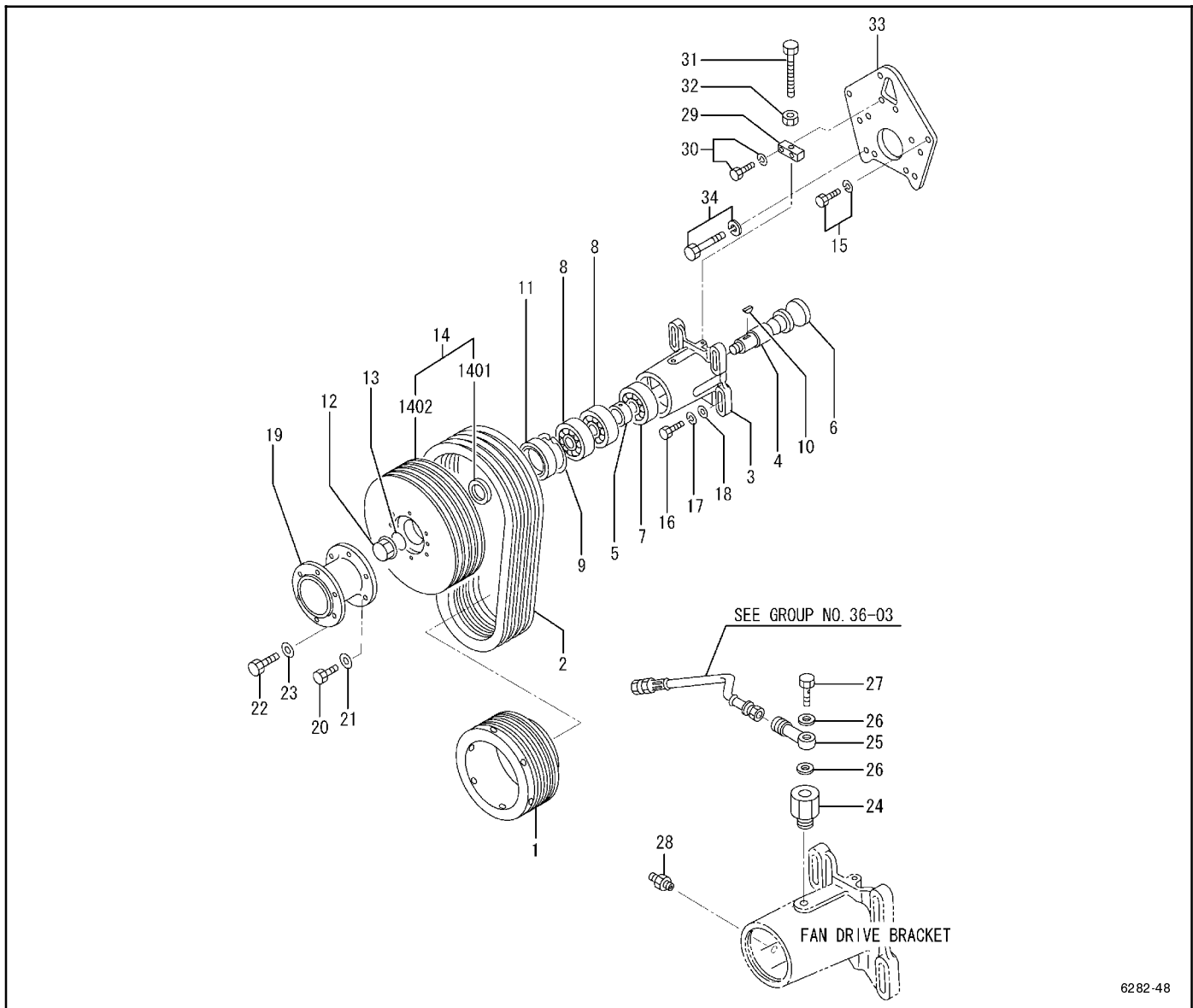
# Group 46.3: Air Cooler Pipes



6282-46.3

| Item | Part No. | Description   | Qty.<br>Var.<br>1 | Item | Part No. | Description    | Qty.<br>Var.<br>1 |
|------|----------|---------------|-------------------|------|----------|----------------|-------------------|
| 1    | GM36585  | Pipe, water   | 1                 | 14   | GM36591  | Pipe, water    | 2                 |
| 2    | GM36586  | Pipe, water   | 1                 | 15   | GM36592  | Pipe, water    | 1                 |
| 3    | GM15139  | Bolt w/washer | 1                 | 16   | GM36593  | Pipe, water    | 1                 |
| 4    | GM15174  | Washer, plain | 1                 | 17   | GM15203  | O-ring         | 6                 |
| 5    | GM14494  | Coupling      | 1                 | 18   | GM36594  | Pipe, water    | 1                 |
| 6    | GM14493  | Coupling      | 4                 | 19   | GM36595  | Pipe, water    | 1                 |
| 7    | GM36587  | Pipe, water   | 1                 | 20   | GM15159  | Bolt w/washer  | 8                 |
| 8    | GM36588  | O-ring        | 2                 | 21   | GM16005  | O-ring         | 1                 |
| 9    | GM36589  | Stay          | 1                 | 22   | GM36395  | Bolt, w/washer | 2                 |
| 10   | GM15140  | Bolt w/washer | 2                 | 23   | GM36596  | Plate          | 2                 |
| 11   | GM36590  | Pipe, water   | 1                 | 24   | GM15154  | Bolt w/washer  | 4                 |
| 12   | GM21660  | Valve, drain  | 3                 | 25   | GM15975  | Bolt w/washer  | 2                 |
| 13   | GM14494  | Coupling      | 1                 |      |          |                |                   |

# Group 48: Fan Drive



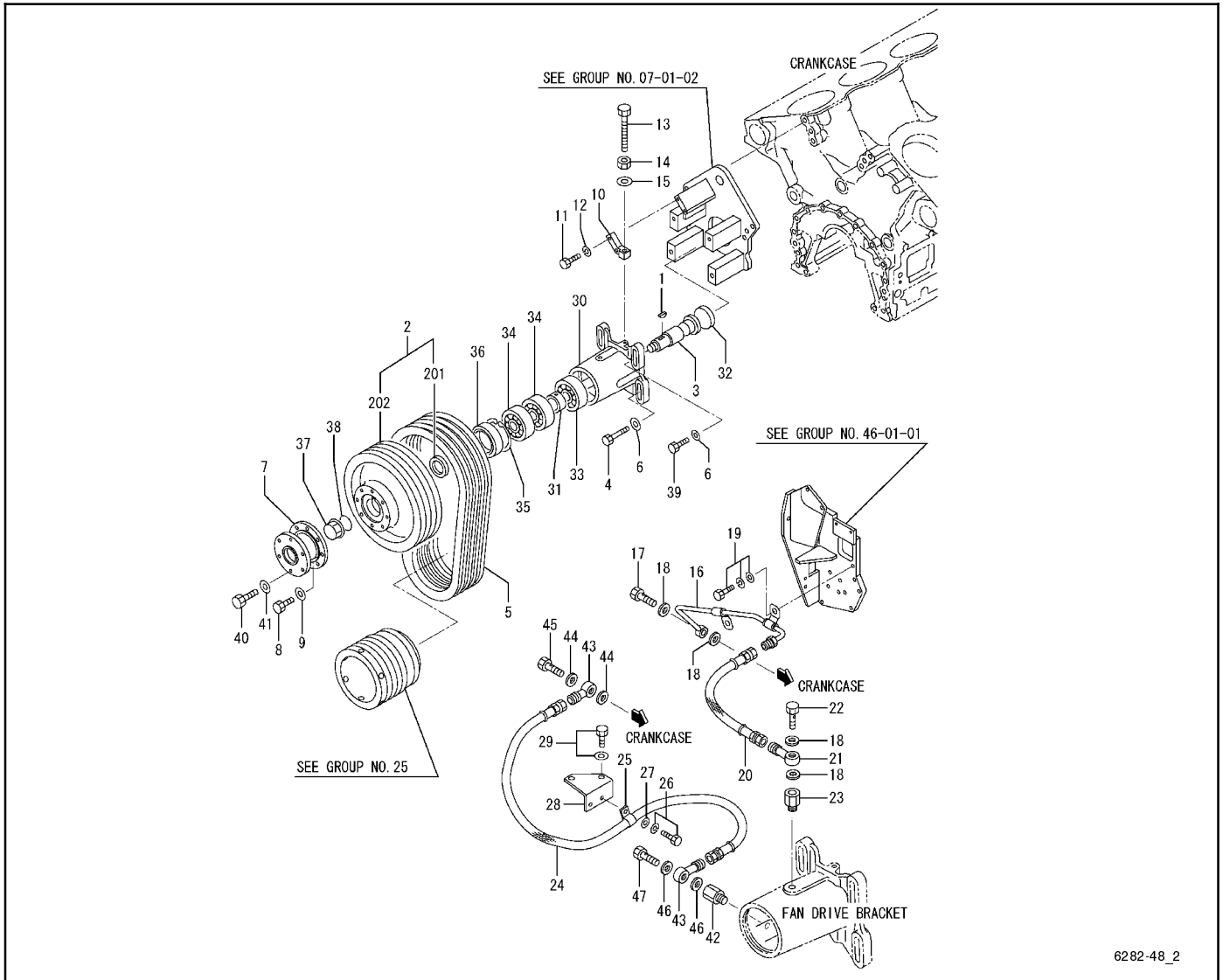
6282-48

| Item | Part No. | Description          | Qty. |      |
|------|----------|----------------------|------|------|
|      |          |                      | 1    | Var. |
| 1    | GM36597  | Pulley, fan drive    | 1    |      |
| 2    | GM36598  | V-belt, fan drive    | 1    |      |
| 3    | GM36599  | Bracket              | 1    |      |
| 4    | GM36600  | Shaft                | 1    |      |
| 5    | GM36601  | Spacer               | 1    |      |
| 6    | GM15567  | Cap, sealing         | 1    |      |
| 7    | GM16039  | Bearing, ball        | 1    |      |
| 8    | GM36602  | Bearing, ball        | 2    |      |
| 9    | GM36603  | Ring, snap           | 1    |      |
| 10   | GM15997  | Key, woodruff        | 1    |      |
| 11   | GM36604  | Seal, oil            | 1    |      |
| 12   | GM34244  | Nut, cap             | 1    |      |
| 13   | GM14516  | O-ring               | 1    |      |
| 14   | GM36605  | Pulley assembly, fan | 1    |      |
| 1401 | GM15568  | Sleeve               | 1    |      |
| 1402 | X        | Pulley, fan          | 1    |      |
| 15   | GM36445  | Bolt, w/washer       | 2    |      |
| 16   | GM36606  | Bolt                 | 2    |      |
| 17   | GM15180  | Washer, spring       | 2    |      |
| 18   | GM36607  | Washer, plain        | 4    |      |

| Item | Part No. | Description        | Qty. |      |
|------|----------|--------------------|------|------|
|      |          |                    | 1    | Var. |
| 19   | GM36608  | Spacer, fan        | 1    |      |
| 20   | GM36609  | Bolt               | 6    |      |
| 21   | GM34246  | Washer             | 6    |      |
| 22   | GM15112  | Bolt               | 6    |      |
| 23   | GM34246  | Washer             | 6    |      |
| 24   | GM36610  | Connector          | 1    |      |
| 25   | GM36611  | Joint              | 1    |      |
| 26   | GM14528  | Washer, sealing    | 2    |      |
| 27   | GM15233  | Bolt, eye          | 1    |      |
| 28   | GM36612  | Connector          | 1    |      |
| 29   | GM36613  | Bracket, adjusting | 1    |      |
| 30   | GM15981  | Bolt w/washer      | 2    |      |
| 31   | GM14624  | Bolt               | 1    |      |
| 32   | GM15165  | Nut                | 1    |      |
| 33   | GM36614  | Spacer             | 1    |      |
| 34   | GM36445  | Bolt, w/washer     | 2    |      |

X Part is not sold separately

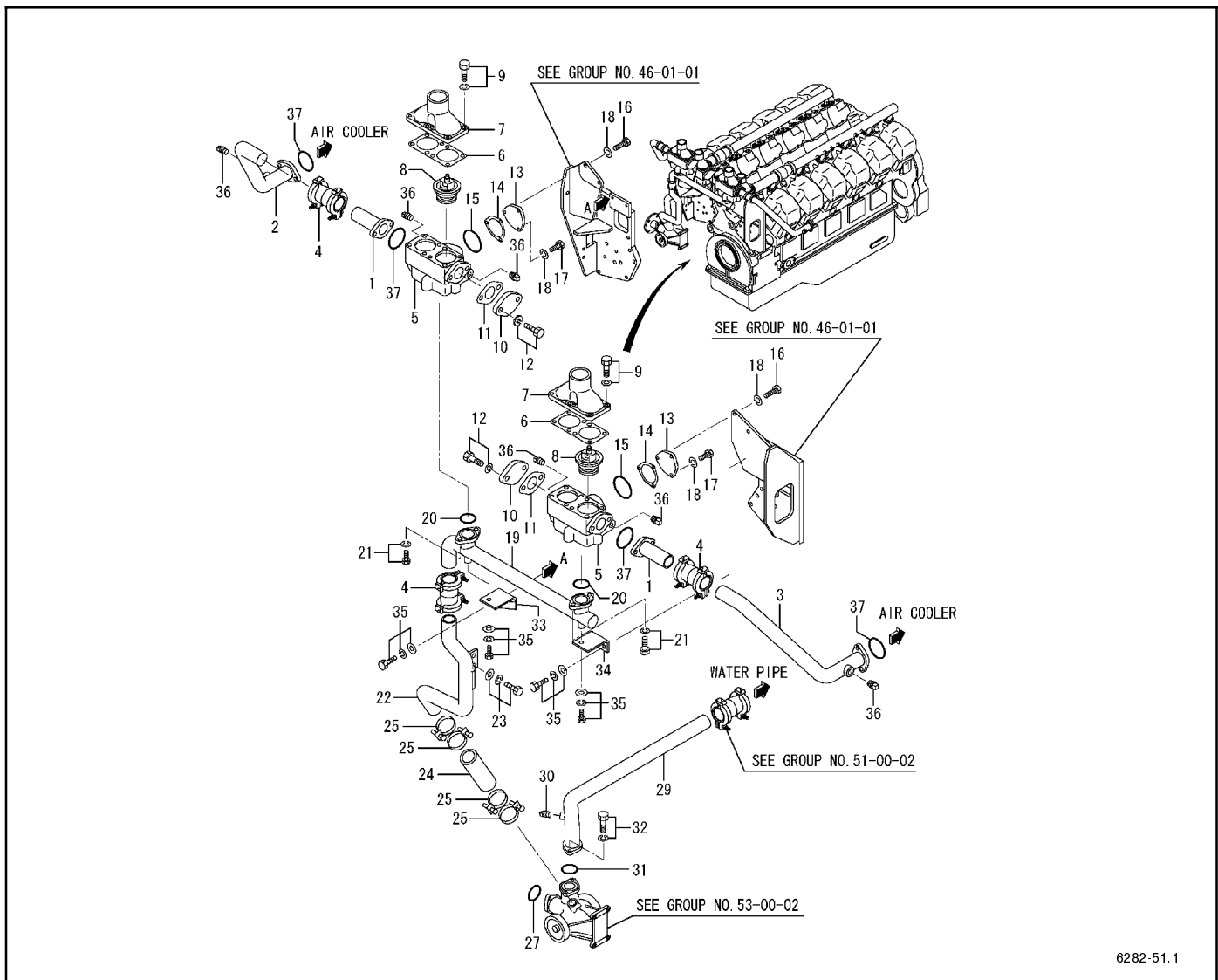
# Group 48: Fan Drive



6282-48\_2

| Item | Part No. | Description           | Qty.<br>Var. | Item | Part No. | Description          | Qty.<br>Var. |
|------|----------|-----------------------|--------------|------|----------|----------------------|--------------|
| 1    | GM57354  | Key, sunk             | 1            | 24   | GM36496  | Pipe, flexible       | 1            |
| 2    | GM57355  | Pulley, assembly, fan | 1            | 25   | GM36497  | Clip                 | 1            |
| 201  | GM15568  | Sleeve                | 1            | 26   | GM15139  | Bolt w/washer        | 1            |
| 202  | GM57356  | Pulley, fan           | 1            | 27   | GM15174  | Washer, plain        | 1            |
| 3    | GM57357  | Shaft, fan drive      | 1            | 28   | GM57363  | Stay, pipe oil drain | 1            |
| 4    | GM57358  | Bolt                  | 2            | 29   | GM15158  | Bolt                 | 2            |
| 5    | GM36598  | V-belt, fan drive     | 1            | 30   | GM36599  | Bracket              | 1            |
| 6    | GM34246  | Washer                | 4            | 31   | GM36601  | Spacer               | 1            |
| 7    | GM34245  | Spacer, fan           | 1            | 32   | GM15567  | Cap, sealing         | 1            |
| 8    | GM36609  | Bolt                  | 8            | 33   | GM16039  | Bearing, ball        | 1            |
| 9    | GM34246  | Washer                | 8            | 34   | GM36602  | Bearing, ball        | 2            |
| 10   | GM57359  | Bracket, adjusting    | 1            | 35   | GM36603  | Ring, snap           | 1            |
| 11   | GM15956  | Bolt                  | 2            | 36   | GM36604  | Seal, oil            | 1            |
| 12   | GM15179  | Washer, spring        | 2            | 37   | GM34244  | Nut, cap             | 1            |
| 13   | GM57360  | Bolt                  | 1            | 38   | GM14516  | O-ring               | 1            |
| 14   | GM34103  | Nut, jam              | 2            | 39   | GM36606  | Bolt                 | 2            |
| 15   | GM34246  | Washer                | 1            | 40   | GM15112  | Bolt                 | 8            |
| 16   | GM57361  | Pipe, oil fan drive   | 1            | 41   | GM34246  | Washer               | 8            |
| 17   | GM36484  | Bolt, eye             | 1            | 42   | GM57364  | Connector            | 1            |
| 18   | GM14528  | Washer, sealing       | 4            | 43   | GM36611  | Joint                | 2            |
| 19   | GM15153  | Bolt                  | 2            | 44   | GM14528  | Washer, sealing      | 2            |
| 20   | GM57362  | Pipe, flexible        | 1            | 45   | GM15233  | Bolt, eye            | 1            |
| 21   | GM36611  | Joint                 | 1            | 46   | GM14530  | Washer, sealing      | 2            |
| 22   | GM15233  | Bolt, eye             | 1            | 47   | GM15234  | Bolt, eye            | 1            |
| 23   | GM36610  | Connector             | 1            |      |          |                      |              |

# Group 51.1: Intercooler Thermostat

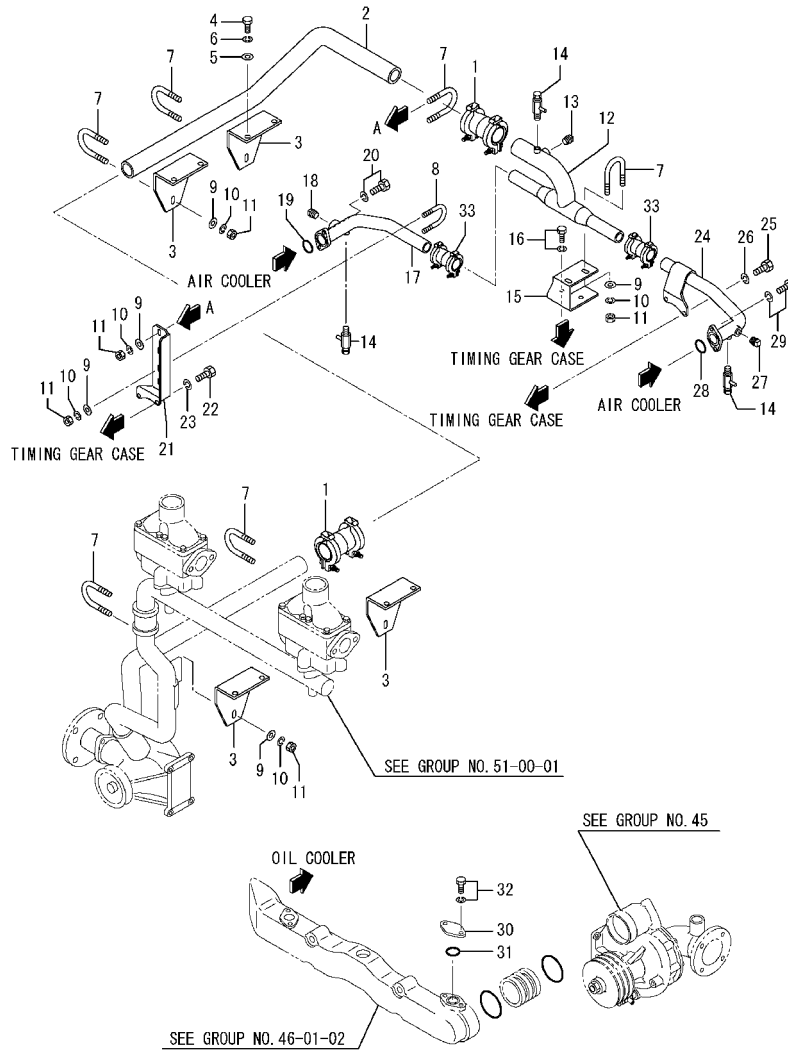


6282-51.1

| Item | Part No. | Description        | Qty.<br>Var. | Item | Part No. | Description      | Qty.<br>Var. |
|------|----------|--------------------|--------------|------|----------|------------------|--------------|
| 1    | TBD      | Pipe, water        | 2            | 19   | GM57893  | Pipe, bypass     | 1            |
| 2    | GM57889  | Pipe, water        | 1            | 20   | GM15203  | O-ring           | 2            |
| 3    | GM57890  | Pipe, water        | 1            | 21   | GM15141  | Bolt             | 4            |
| 4    | GM21604  | Coupling           | 3            | 22   | GM57894  | Pipe, bypass     | 1            |
| 5    | GM14606  | Case, thermostat   | 2            | 23   | GM15153  | Bolt             | 1            |
| 6    | GM13945  | Gasket, thermostat | 2            | 24   | GM57252  | Hose, rubber     | 1            |
| 7    | GM34234  | Cover, thermo      | 2            | 25   | GM57250  | Clamp            | 4            |
| 8    | GM57251  | Thermostat         | 4            | 27   | GM36582  | O-ring           | 1            |
| 9    | GM15138  | Bolt w/washer      | 16           | 29   | GM57895  | Pipe, water pump | 1            |
| 10   | GM36570  | Cover              | 2            | 30   | GM15247  | Plug, tapered    | 1            |
| 11   | GM34235  | Packing            | 2            | 31   | GM36582  | O-ring           | 1            |
| 12   | GM15141  | Bolt               | 4            | 32   | GM15151  | Bolt             | 2            |
| 13   | GM57891  | Cover              | 2            | 33   | GM57896  | Stay, thermo     | 1            |
| 14   | GM57892  | Packing            | 2            | 34   | GM57897  | Stay, thermo     | 1            |
| 15   | GM15205  | O-ring             | 2            | 35   | GM15154  | Bolt             | 6            |
| 16   | GM15956  | Bolt               | 4            | 36   | GM15247  | Plug, tapered    | 6            |
| 17   | GM15955  | Bolt               | 2            | 37   | GM15203  | O-ring           | 4            |
| 18   | GM15179  | Washer, spring     | 6            |      |          |                  |              |



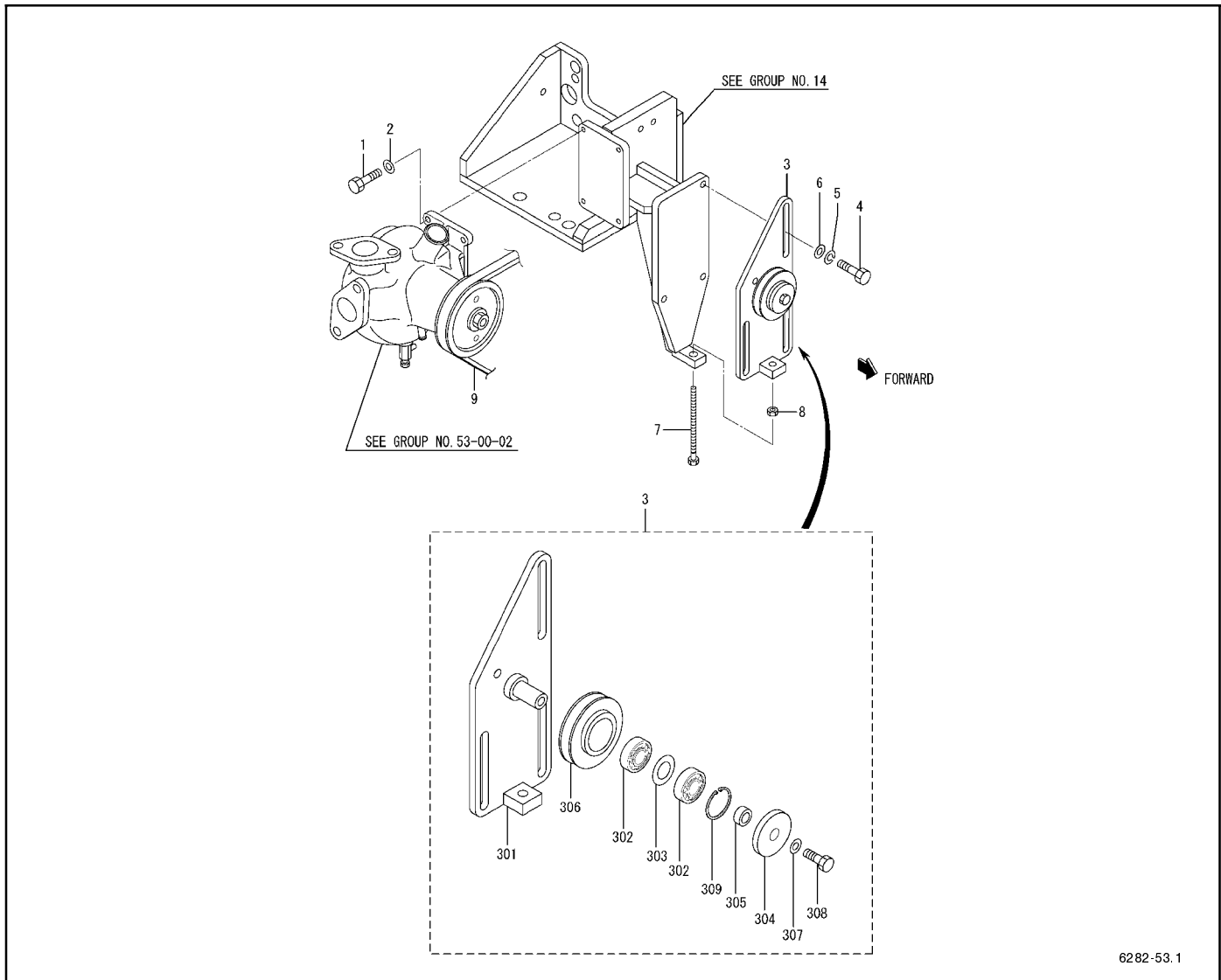
# Group 51.2: Intercooler Piping



6282-51.2

| Item | Part No. | Description       | Qty.<br>Var. | Item | Part No. | Description    | Qty.<br>Var. |
|------|----------|-------------------|--------------|------|----------|----------------|--------------|
| 1    | GM36568  | Coupling          | 2            | 17   | GM57905  | Pipe, water    | 1            |
| 2    | GM57898  | Pipe, water       | 1            | 18   | GM16033  | Plug           | 1            |
| 3    | GM57899  | Stay, pipe        | 4            | 19   | GM15203  | O-ring         | 1            |
| 4    | GM36621  | Bolt              | 8            | 20   | GM15159  | Bolt w/washer  | 2            |
| 5    | GM15174  | Washer, plain     | 8            | 21   | GM57906  | Stay, pipe     | 1            |
| 6    | GM15179  | Washer, spring    | 8            | 22   | GM15116  | Bolt           | 2            |
| 7    | GM57900  | U-bolt            | 6            | 23   | GM15180  | Washer, spring | 2            |
| 8    | GM57901  | U-bolt            | 1            | 24   | GM57907  | Pipe, water    | 1            |
| 9    | GM15174  | Washer, plain     | 14           | 25   | GM15116  | Bolt           | 2            |
| 10   | GM15179  | Washer, spring    | 14           | 26   | GM15180  | Washer, spring | 2            |
| 11   | GM57902  | Nut               | 14           | 27   | GM16033  | Plug           | 1            |
| 12   | GM57903  | Pipe, water       | 1            | 28   | GM15203  | O-ring         | 1            |
| 13   | GM16033  | Plug              | 1            | 29   | GM15159  | Bolt w/washer  | 2            |
| 14   | GM57237  | Cock, water drain | 3            | 30   | GM57908  | Cover          | 1            |
| 15   | GM57904  | Stay, pipe        | 1            | 31   | GM16005  | O-ring         | 1            |
| 16   | GM15150  | Bolt              | 2            | 32   | GM36395  | Boit, w/washer | 2            |
|      |          |                   |              | 33   | GM21604  | Coupling       | 2            |

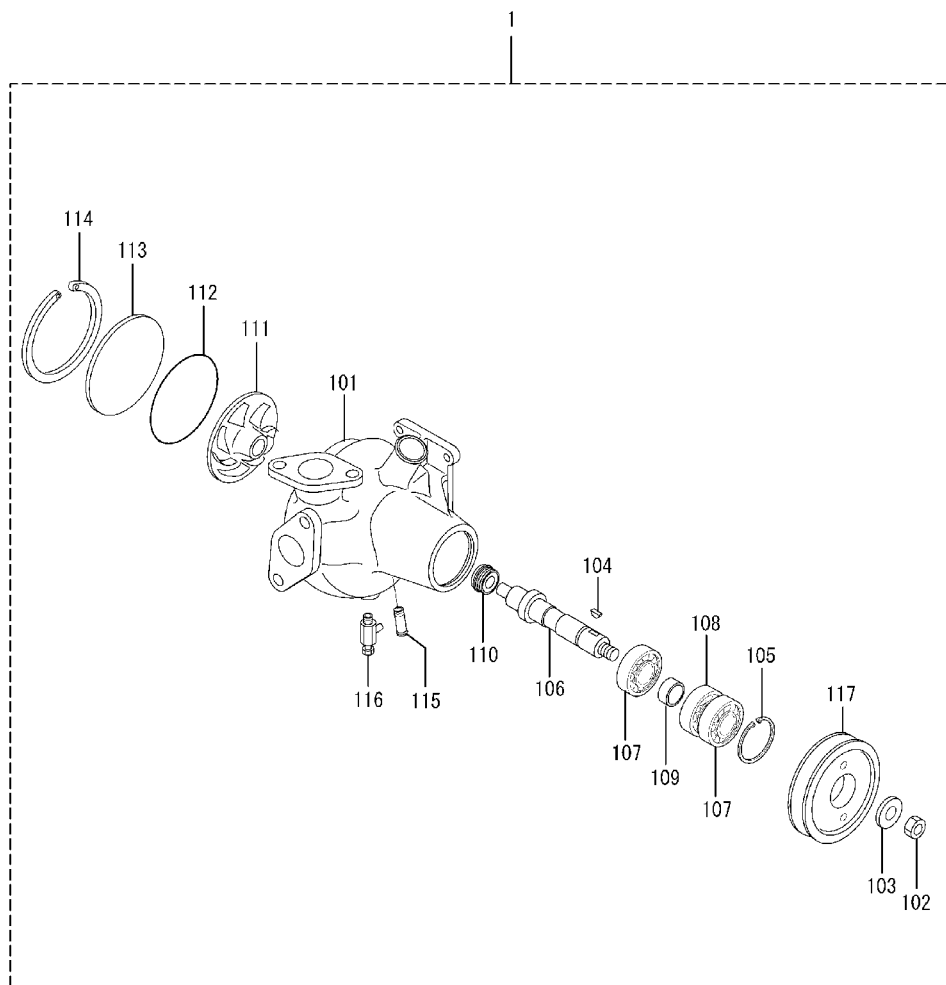
# Group 53.1: Intercooler Pump



6282-53.1

| Item | Part No. | Description             | Qty. |      | Item | Part No. | Description    | Qty. |      |
|------|----------|-------------------------|------|------|------|----------|----------------|------|------|
|      |          |                         | 1    | Var. |      |          |                | 1    | Var. |
| 1    | GM15956  | Bolt                    | 4    |      | 307  | GM36363  | Washer         | 1    |      |
| 2    | GM31310  | Washer                  | 4    |      | 308  | GM15107  | Bolt           | 1    |      |
| 3    | GM57909  | Tension pulley assembly | 1    |      | 309  | GM16018  | Ring, snap     | 1    |      |
| 301  | GM57910  | Bracket, tension        | 1    |      | 4    | GM15110  | Bolt           | 3    |      |
| 302  | GM15581  | Bearing                 | 2    |      | 5    | GM15180  | Washer, spring | 3    |      |
| 303  | GM15582  | Spacer                  | 1    |      | 6    | GM36607  | Washer, plain  | 3    |      |
| 304  | GM15583  | Plate, thrust           | 1    |      | 7    | GM57911  | Bolt, set      | 1    |      |
| 305  | GM15584  | Spacer                  | 1    |      | 8    | GM34103  | Nut, jam       | 2    |      |
| 306  | GM15585  | Pulley, tension         | 1    |      | 9    | GM55487  | V-belt         | 2    |      |

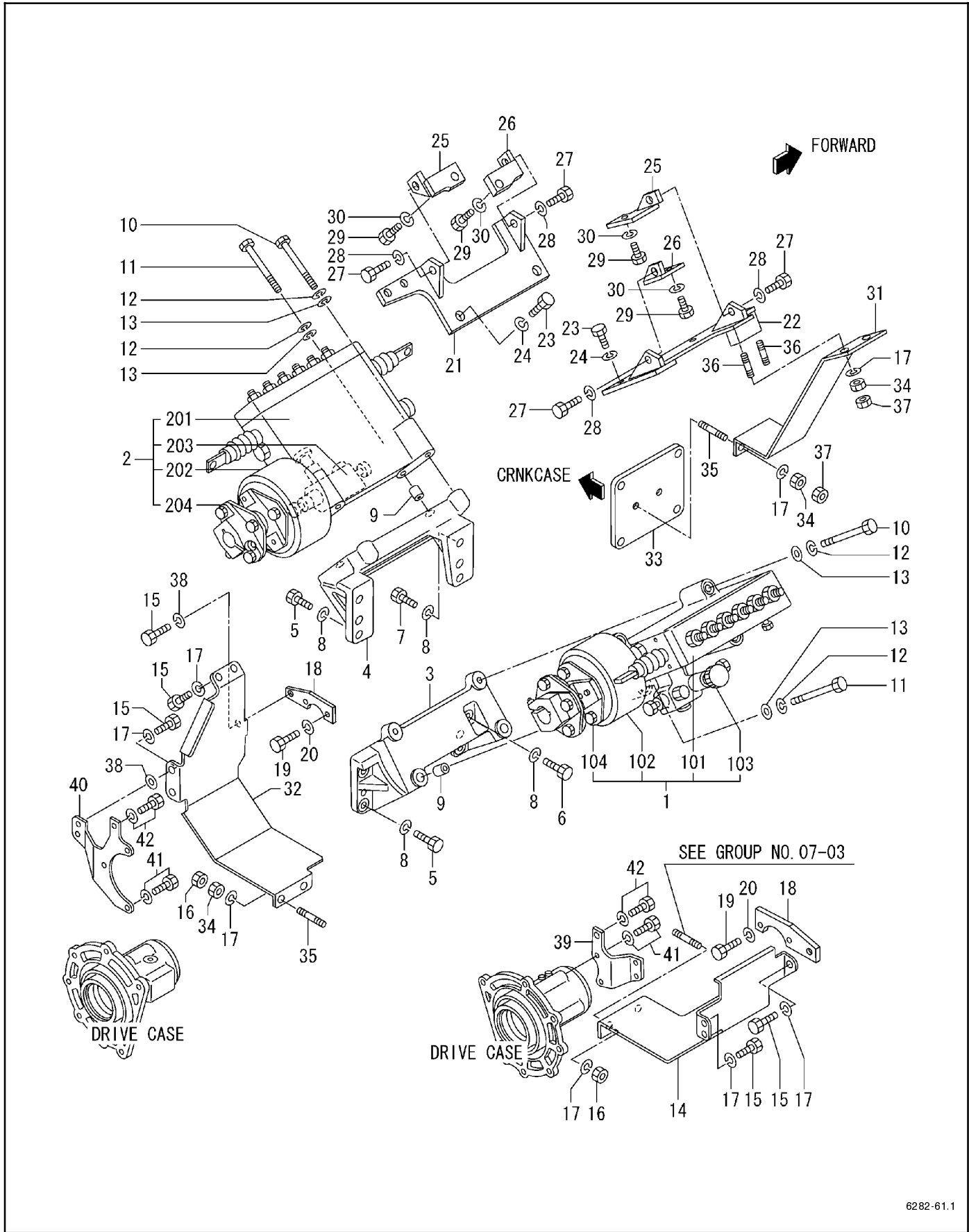
## Group 53.2: Intercooler Pump Assembly



6282-53.2

| Item | Part No. | Description          | Qty.<br>Var. | Item | Part No. | Description       | Qty.<br>Var. |
|------|----------|----------------------|--------------|------|----------|-------------------|--------------|
| 1    | GM57488  | Pump assembly, water | 1            | 109  | X        | Spacer            | 1            |
| 101  | GM57489  | Case                 | 2            | 110  | GM57496  | Seal, unit        | 1            |
| 102  | GM57490  | Nut                  | 1            | 111  | X        | Impeller          | 1            |
| 103  | GM57491  | Washer               | 1            | 112  | GM57497  | O-ring            | 1            |
| 104  | GM57492  | Key                  | 1            | 113  | GM57498  | Cover             | 1            |
| 105  | GM57493  | Ring, snap           | 1            | 114  | GM57499  | Ring, snap        | 1            |
| 106  | X        | Shaft                | 1            | 115  | GM37122  | Pipe              | 1            |
| 107  | X        | Bearing, ball        | 1            | 116  | GM57237  | Cock, water drain | 1            |
| 108  | X        | Bearing, ball        | 1            | 117  | X        | Pulley            | 1            |

# Group 61.1: Fuel Injection Pump



6282-61.1

## Group 61.1: Fuel Injection Pump

| Item | Part No. | Description              | Qty.      |
|------|----------|--------------------------|-----------|
|      |          |                          | Var.<br>1 |
| 1    | GM36615  | Pump assembly, injection | 1         |
| 101  | X        | Pump assembly, injection | 1         |
| 102  | GM36867  | Coupling                 | 1         |
| 103  | GM36617  | Pump, feed               | 1         |
| 104  | GM36618  | Coupling assembly        | 1         |
| 2    | GM36616  | Pump assembly, injection | 1         |
| 201  | X        | Pump assembly, injection | 1         |
| 202  | GM36867  | Coupling                 | 1         |
| 203  | GM36617  | Pump, feed               | 1         |
| 204  | GM36618  | Coupling assembly        | 1         |
| 3    | GM36619  | Bracket, injection pump  | 1         |
| 4    | GM36620  | Bracket, injection pump  | 1         |
| 5    | GM15129  | Bolt                     | 6         |
| 6    | GM36621  | Bolt                     | 1         |
| 7    | GM36622  | Bolt                     | 1         |
| 8    | GM15179  | Washer, spring           | 8         |
| 9    | GM36623  | Pin                      | 4         |
| 10   | GM36624  | Bolt                     | 4         |
| 11   | GM36625  | Bolt                     | 4         |
| 12   | GM15179  | Washer, spring           | 8         |
| 13   | GM15174  | Washer, plain            | 8         |
| 14   | GM36626  | Cover coupling           | 1         |
| 15   | GM36474  | Bolt                     | 8         |
| 16   | GM15164  | Nut                      | 4         |
| 17   | GM15179  | Washer, spring           | 16        |
| 18   | GM36627  | Stay                     | 2         |
| 19   | GM36628  | Bolt                     | 4         |
| 20   | GM15177  | Washer, spring           | 4         |
| 21   | GM36629  | Stay, injection pump     | 1         |
| 22   | GM36630  | Stay, injection pump     | 1         |
| 23   | GM36631  | Bolt                     | 4         |
| 24   | GM15181  | Washer, spring           | 4         |
| 25   | GM36632  | Stay                     | 2         |
| 26   | GM36633  | Stay                     | 2         |
| 27   | GM15109  | Bolt                     | 4         |
| 28   | GM15180  | Washer, spring           | 4         |
| 29   | GM36634  | Bolt                     | 4         |
| 30   | GM15179  | Washer, spring           | 4         |
| 31   | GM36635  | Plate, tamper            | 1         |
| 32   | GM36636  | Plate, tamper            | 1         |
| 33   | GM36637  | Cover, side              | 1         |
| 34   | GM36638  | Nut                      | 6         |
| 35   | GM36639  | Stud                     | 4         |
| 36   | GM36338  | Stud                     | 2         |
| 37   | GM15164  | Nut                      | 5         |
| 38   | GM15173  | Washer, plain            | 1         |
| 39   | GM36640  | Stay, cover              | 1         |
| 40   | GM36641  | Stay, cover              | 1         |
| 41   | GM15975  | Bolt w/washer            | 5         |
| 42   | GM15140  | Bolt w/washer            | 2         |

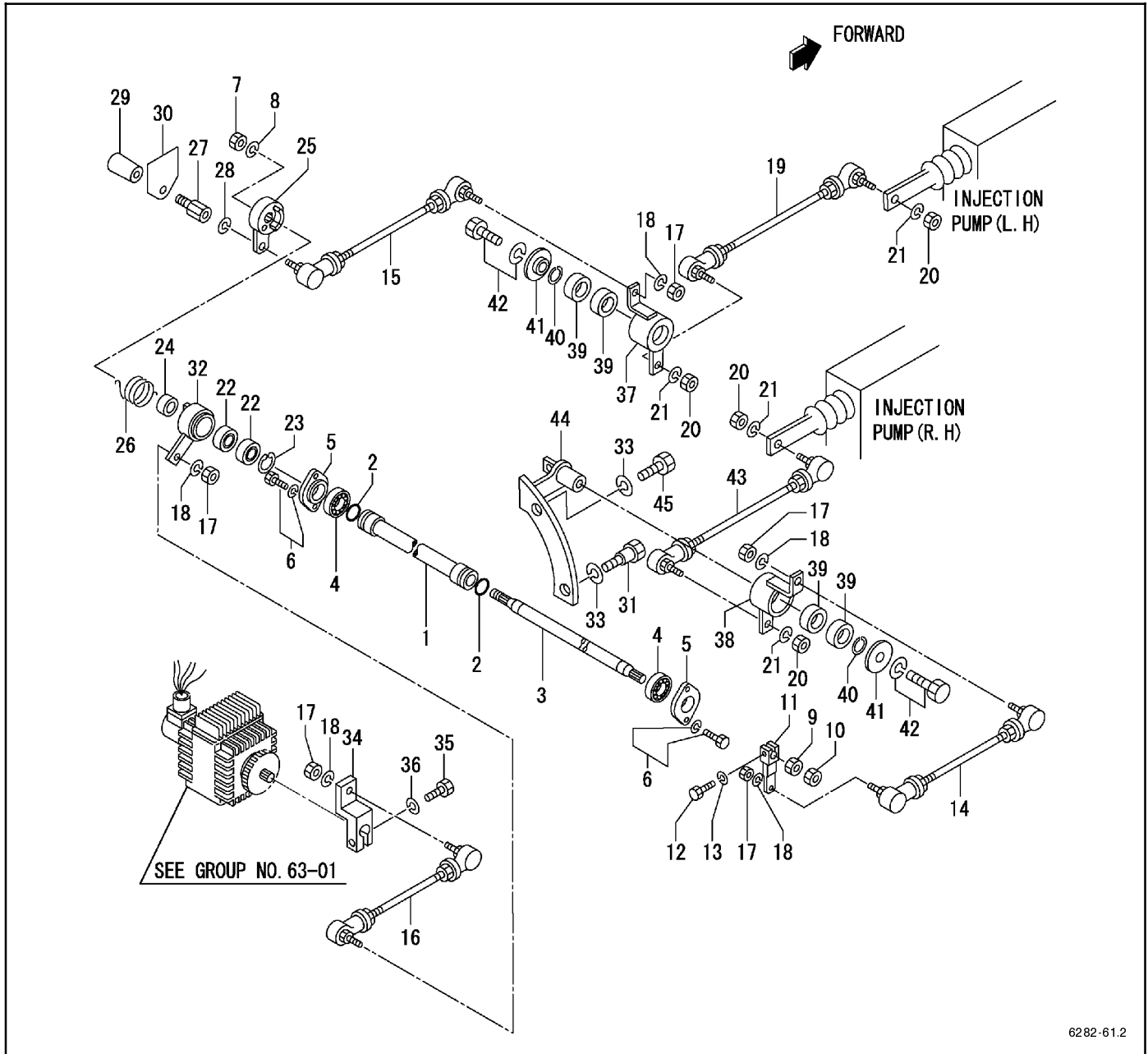
X Part is not sold separately



## Group 61.1: Fuel Injection Pump, continued

| Item | Part No. | Description              | Qty.      |
|------|----------|--------------------------|-----------|
|      |          |                          | Var.<br>2 |
| 1    | GM57365  | Pump assembly, injection | 1         |
| 101  | X        | Pump assembly, injection | 1         |
| 102  | GM36867  | Coupling                 | 1         |
| 103  | GM36617  | Pump, feed               | 1         |
| 104  | GM36618  | Coupling assembly        | 1         |
| 2    | GM57366  | Pump assembly, injection | 1         |
| 201  | X        | Pump assembly, injection | 1         |
| 202  | GM36867  | Coupling                 | 1         |
| 203  | GM36617  | Pump, feed               | 1         |
| 204  | GM36618  | Coupling assembly        | 1         |
| 3    | GM36619  | Bracket, injection pump  | 1         |
| 4    | GM36620  | Bracket, injection pump  | 1         |
| 5    | GM15129  | Bolt                     | 6         |
| 6    | GM36621  | Bolt                     | 1         |
| 7    | GM36622  | Bolt                     | 1         |
| 8    | GM15179  | Washer, spring           | 8         |
| 9    | GM36623  | Pin                      | 4         |
| 10   | GM36624  | Bolt                     | 4         |
| 11   | GM36625  | Bolt                     | 4         |
| 12   | GM15179  | Washer, spring           | 8         |
| 13   | GM15174  | Washer, plain            | 8         |
| 14   | GM36626  | Cover coupling           | 1         |
| 15   | GM36474  | Bolt                     | 8         |
| 16   | GM15164  | Nut                      | 4         |
| 17   | GM15179  | Washer, spring           | 16        |
| 18   | GM36627  | Stay                     | 2         |
| 19   | GM36628  | Bolt                     | 4         |
| 20   | GM15177  | Washer, spring           | 4         |
| 21   | GM36629  | Stay, injection pump     | 1         |
| 22   | GM36630  | Stay, injection pump     | 1         |
| 23   | GM36631  | Bolt                     | 4         |
| 24   | GM15181  | Washer, spring           | 4         |
| 25   | GM36632  | Stay                     | 2         |
| 26   | GM36633  | Stay                     | 2         |
| 27   | GM15109  | Bolt                     | 4         |
| 28   | GM15180  | Washer, spring           | 4         |
| 29   | GM36634  | Bolt                     | 4         |
| 30   | GM15179  | Washer, spring           | 4         |
| 31   | GM36635  | Plate, tamper            | 1         |
| 32   | GM36636  | Plate, tamper            | 1         |
| 33   | GM36637  | Cover, side              | 1         |
| 34   | GM36638  | Nut                      | 6         |
| 35   | GM36639  | Stud                     | 4         |
| 36   | GM36338  | Stud                     | 2         |
| 37   | GM15164  | Nut                      | 5         |

# Group 61.2: Control Shaft

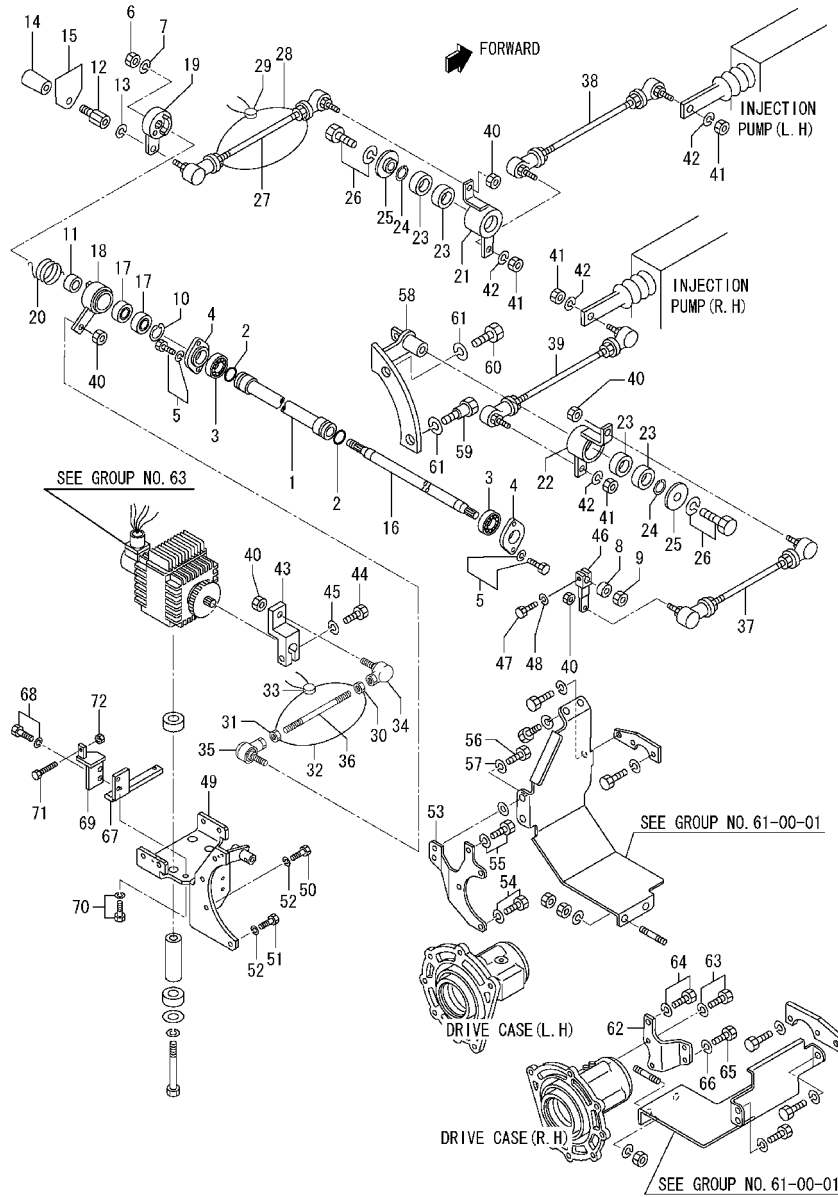




## Group 61.2: Control Shaft

| Item | Part No. | Description        | Qty.      |
|------|----------|--------------------|-----------|
|      |          |                    | Var.<br>1 |
| 1    | GM36642  | Pipe, case         | 1         |
| 2    | GM14508  | O-ring             | 2         |
| 3    | GM36643  | Shaft, control     | 1         |
| 4    | GM36644  | Bearing, ball      | 2         |
| 5    | GM14913  | Cover              | 2         |
| 6    | GM15137  | Bolt w/washer      | 4         |
| 7    | GM22119  | Nut, self-locking  | 1         |
| 8    | GM15179  | Washer, spring     | 1         |
| 9    | GM21907  | Spacer             | 1         |
| 10   | GM21908  | Nut, lock          | 1         |
| 11   | GM36645  | Lever, control     | 1         |
| 12   | GM36646  | Bolt, locking wire | 1         |
| 13   | GM15178  | Washer, spring     | 1         |
| 14   | GM36647  | Link, control      | 1         |
| 15   | GM36648  | Link, control      | 1         |
| 16   | GM36649  | Link, control      | 1         |
| 17   | GM15163  | Nut                | 5         |
| 18   | GM15178  | Washer, spring     | 5         |
| 19   | GM36650  | Link, control      | 1         |
| 20   | GM15162  | Nut                | 4         |
| 21   | GM15177  | Washer, spring     | 4         |
| 22   | GM31477  | Bearing, ball      | 2         |
| 23   | GM15220  | Ring, snap         | 1         |
| 24   | GM15088  | Spacer             | 1         |
| 25   | GM36651  | Lever              | 1         |
| 26   | GM36652  | Spring             | 1         |
| 27   | GM14617  | Connector          | 1         |
| 28   | GM15178  | Washer, spring     | 1         |
| 29   | GM14474  | Grip               | 1         |
| 30   | GM36653  | Plate, caution     | 1         |
| 31   | GM36654  | Bolt, reamer       | 1         |
| 32   | GM36655  | Lever              | 1         |
| 33   | GM15180  | Washer, spring     | 2         |
| 34   | GM36656  | Lever, actuator    | 1         |
| 35   | GM36646  | Bolt, locking wire | 1         |
| 36   | GM15178  | Washer, spring     | 1         |
| 37   | GM36657  | Lever              | 1         |
| 38   | GM36658  | Lever              | 1         |
| 39   | GM36659  | Bearing, ball      | 4         |
| 40   | GM16017  | Ring, snap         | 2         |
| 41   | GM14608  | Plate, end         | 2         |
| 42   | GM15144  | Bolt w/washer      | 2         |
| 43   | GM36660  | Link, control      | 1         |
| 44   | GM36661  | Stay               | 1         |
| 45   | GM36944  | Bolt               | 1         |

# Group 61.2: Control Shaft, continued

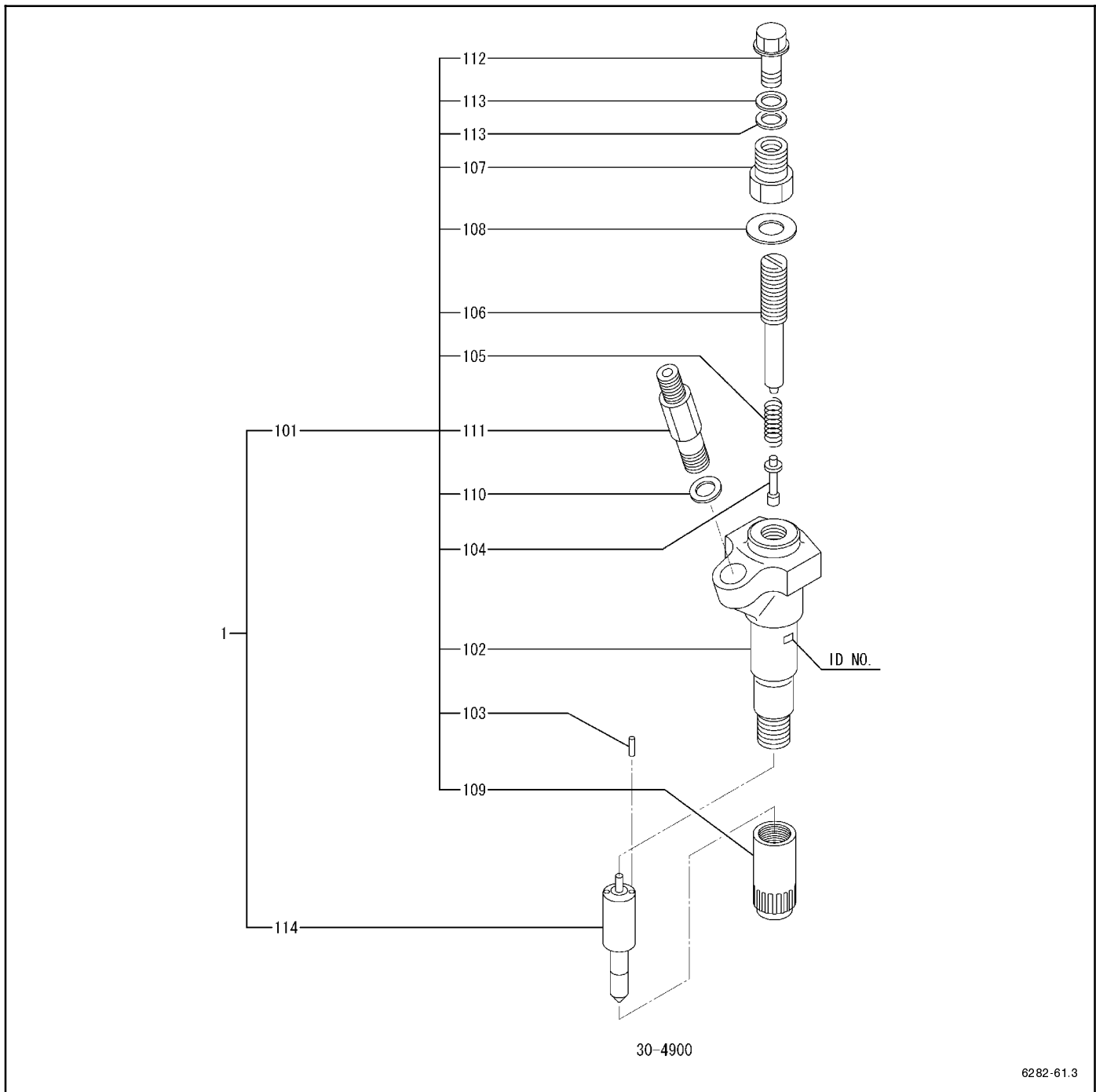


6282-61.2\_2

## Group 61.2: Control Shaft, continued

| Item | Part No. | Description        | Qty.      |
|------|----------|--------------------|-----------|
|      |          |                    | Var.<br>2 |
| 1    | GM36642  | Pipe, case         | 1         |
| 2    | GM34256  | O-ring             | 2         |
| 3    | GM36644  | Bearing, ball      | 2         |
| 4    | GM14913  | Cover              | 2         |
| 5    | GM15137  | Bolt w/washer      | 4         |
| 6    | GM22119  | Nut, self-locking  | 1         |
| 7    | GM15179  | Washer, spring     | 1         |
| 8    | GM21907  | Spacer             | 1         |
| 9    | GM21908  | Nut, lock          | 1         |
| 10   | GM15220  | Ring, snap         | 1         |
| 11   | GM15088  | Spacer             | 1         |
| 12   | GM14617  | Connector          | 1         |
| 13   | GM15178  | Washer, spring     | 1         |
| 14   | GM14474  | Grip               | 1         |
| 15   | GM15860  | Plate, caution     | 1         |
| 16   | GM36643  | Shaft, control     | 1         |
| 17   | GM57289  | Bearing, ball      | 2         |
| 18   | GM36655  | Lever              | 1         |
| 19   | GM36651  | Lever              | 1         |
| 20   | GM36652  | Spring             | 1         |
| 21   | GM36657  | Lever              | 1         |
| 22   | GM36658  | Lever              | 1         |
| 23   | GM57373  | Bearing, ball      | 4         |
| 24   | GM16017  | Ring, snap         | 2         |
| 25   | GM14608  | Plate, end         | 2         |
| 26   | GM15144  | Bolt               | 2         |
| 27   | GM57374  | Link, control      | 1         |
| 28   | GM14463  | Wire, seal         | 1         |
| 29   | GM15001  | Seal               | 1         |
| 30   | GM31473  | Nut, lock          | 1         |
| 31   | GM34252  | Nut, lock          | 1         |
| 32   | GM14463  | Wire, seal         | 1         |
| 33   | GM15001  | Seal               | 1         |
| 34   | GM21676  | Joint, ball        | 1         |
| 35   | GM21677  | Joint, ball        | 1         |
| 36   | GM21626  | Bolt               | 1         |
| 37   | GM36647  | Link, control      | 1         |
| 38   | GM36650  | Link, control      | 1         |
| 39   | GM36660  | Link, control      | 1         |
| 40   | GM31420  | Nut, self locking  | 5         |
| 41   | GM15162  | Nut                | 4         |
| 42   | GM15177  | Washer, spring     | 4         |
| 43   | GM36656  | Lever, actuator    | 1         |
| 44   | GM36646  | Bolt, locking wire | 1         |
| 45   | GM15178  | Washer, spring     | 1         |
| 46   | GM36645  | Lever, control     | 1         |
| 47   | GM36646  | Bolt, locking wire | 1         |
| 48   | GM15178  | Washer, spring     | 1         |
| 49   | GM36943  | Bracket            | 1         |
| 50   | GM36654  | Bolt, reamer       | 1         |
| 51   | GM36944  | Bolt               | 3         |
| 52   | GM15180  | Washer, spring     | 4         |
| 53   | GM57375  | Stay, cover        | 1         |
| 54   | GM15975  | Bolt w/washer      | 3         |
| 55   | GM15140  | Bolt               | 1         |
| 56   | GM36474  | Bolt               | 2         |
| 57   | GM15179  | Washer, spring     | 2         |
| 58   | GM36661  | Stay               | 1         |
| 59   | GM36654  | Bolt, reamer       | 1         |
| 60   | GM36944  | Bolt               | 1         |
| 61   | GM15180  | Washer, spring     | 2         |
| 62   | GM36640  | Stay, cover        | 1         |
| 63   | GM15975  | Bolt w/washer      | 2         |
| 64   | GM15140  | Bolt               | 1         |
| 65   | GM36474  | Bolt               | 2         |
| 66   | GM15179  | Washer, spring     | 2         |
| 67   | GM57376  | Bracket, stopper   | 1         |
| 68   | GM15141  | Bolt               | 2         |
| 69   | GM36946  | Bracket, stopper   | 1         |
| 70   | GM15141  | Bolt               | 2         |
| 71   | GM36947  | Bolt               | 1         |
| 72   | GM15163  | Nut                | 1         |

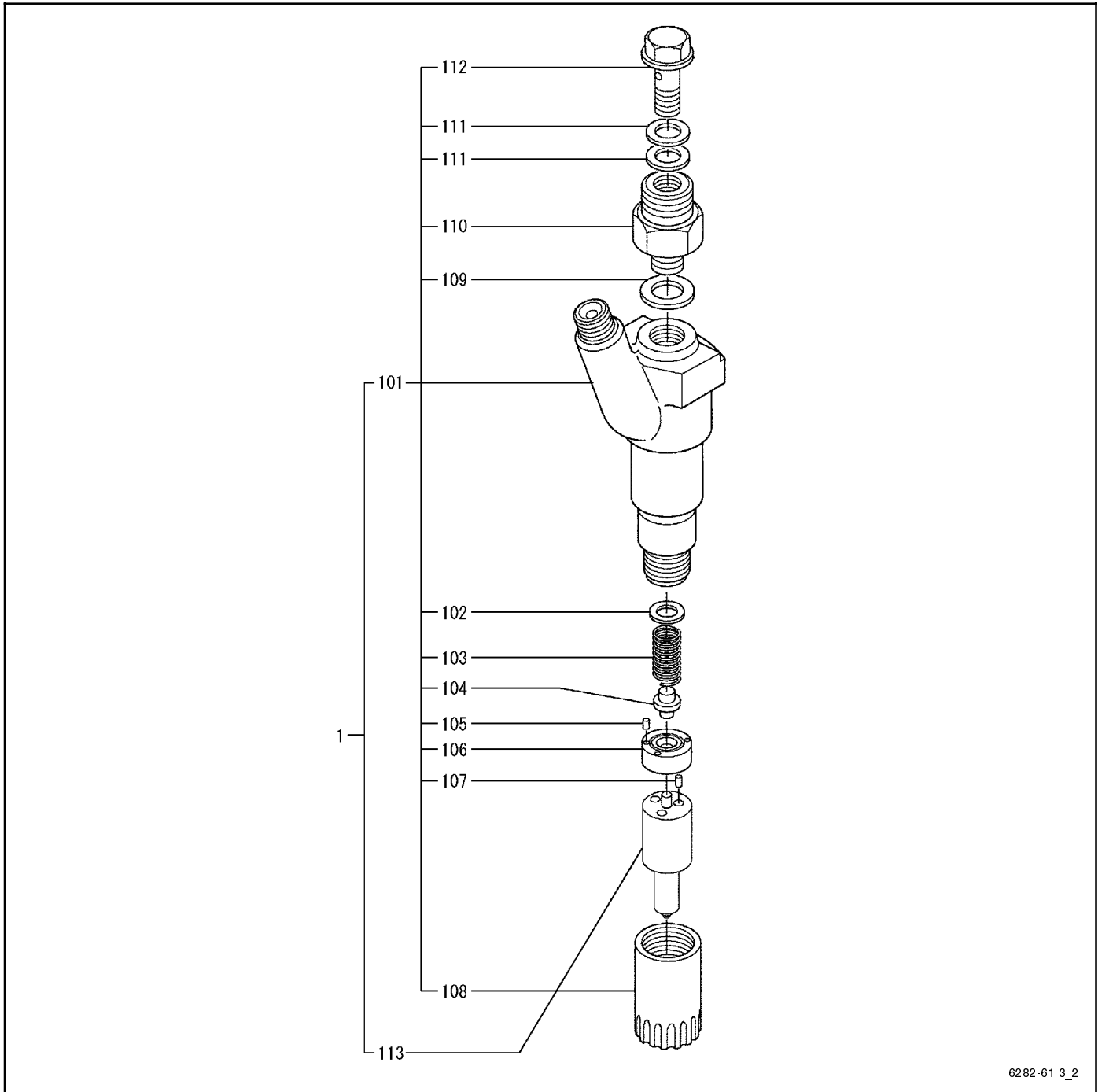
# Group 61.3: Injector Nozzle Assembly



| Item | Part No. | Description             | Qty. |      | Item | Part No. | Description          | Qty. |      |
|------|----------|-------------------------|------|------|------|----------|----------------------|------|------|
|      |          |                         | 1    | Var. |      |          |                      | 1    | Var. |
| 1    | GM36662  | Nozzle assembly         | 12   |      | 108  | GM36669  | Gasket               | 12   |      |
| 101  | GM36663  | Holder assembly, nozzle | 12   |      | 109  | GM36670  | Nut, retaining       | 12   |      |
| 102  | X        | Body                    | 12   |      | 110  | GM36671  | Gasket               | 12   |      |
| 103  | GM36664  | Pin, pressure           | 24   |      | 111  | GM36672  | Connector, inlet     | 12   |      |
| 104  | GM36665  | Rod, push               | 12   |      | 112  | GM36673  | Bolt, eye            | 12   |      |
| 105  | GM36666  | Spring, nozzle          | 12   |      | 113  | GM36674  | Gasket               | 24   |      |
| 106  | GM36667  | Screw, adjusting        | 12   |      | 114  | GM35977  | Tip assembly, nozzle | 12   |      |
| 107  | GM36668  | Nut, cap                | 12   |      |      |          |                      |      |      |

X Part is not sold separately

# Group 61.3: Injector Nozzle Assembly

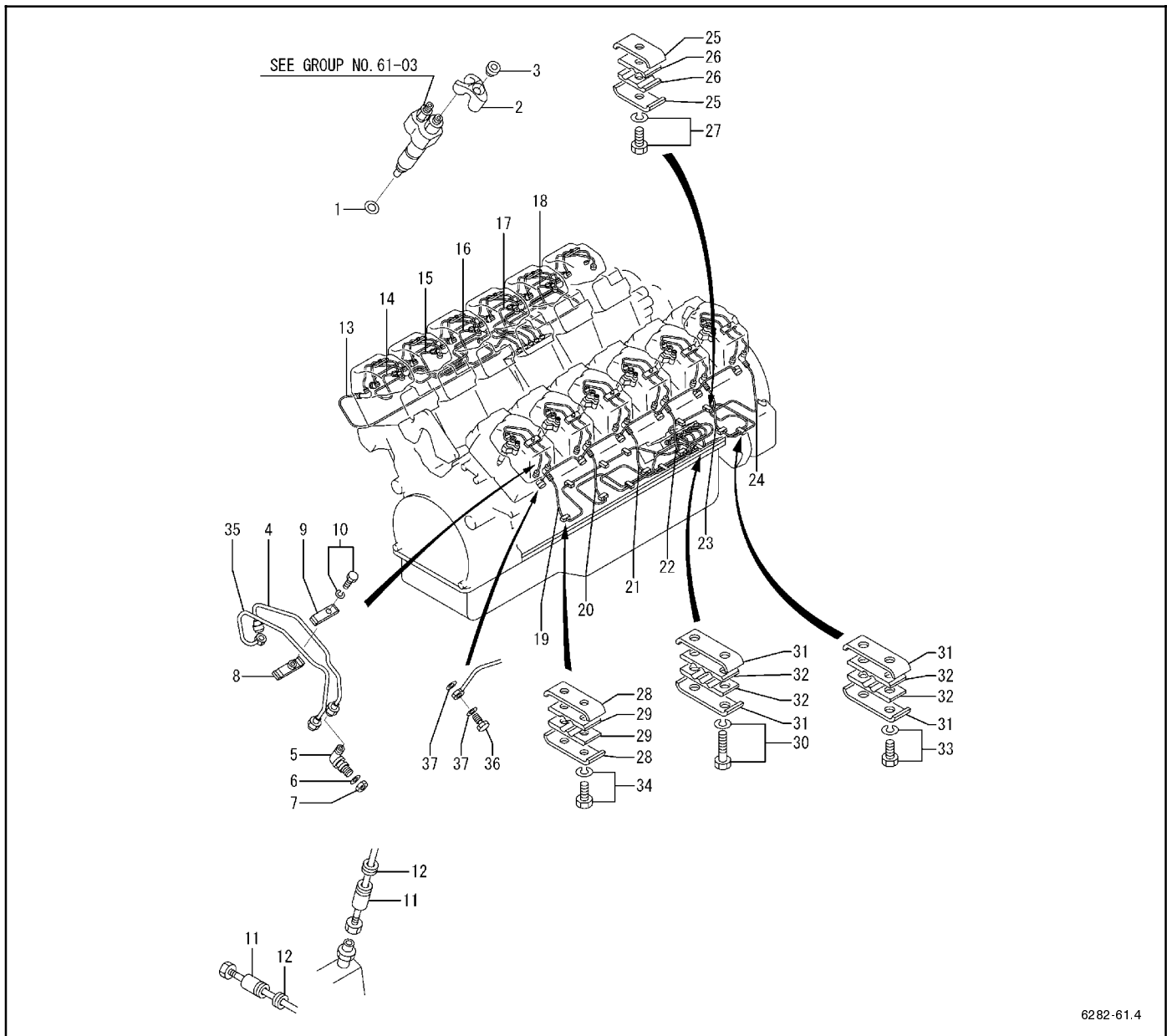


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| Item | Part No. | Description             | Qty. | Var. | Item | Part No. | Description          | Qty. | Var. |
|------|----------|-------------------------|------|------|------|----------|----------------------|------|------|
| 1    | GM57398  | Nozzle assembly         | 12   |      | 104  | GM57409  | Rod, push            | 12   |      |
| 101  | GM57399  | Holder assembly, nozzle | 12   |      | 105  | GM57410  | Pin                  | 24   |      |
| 102  | GM57400  | Shim, T=0.40            | AR   |      | 106  | GM57411  | Spacer               | 12   |      |
| 102  | GM57401  | Shim, T=0.50            | AR   |      | 107  | GM36664  | Pin, pressure        | 24   |      |
| 102  | GM57402  | Shim, T=0.52            | AR   |      | 108  | GM57412  | Nut, retaining       | 12   |      |
| 102  | GM57403  | Shim, T=0.54            | AR   |      | 109  | GM57413  | Gasket               | 12   |      |
| 102  | GM57404  | Shim, T=0.56            | AR   |      | 110  | GM57414  | Connector            | 12   |      |
| 102  | GM57405  | Shim, T=0.58            | AR   |      | 111  | GM36674  | Gasket               | 24   |      |
| 102  | GM57406  | Shim, T=0.60            | AR   |      | 112  | GM36673  | Boit, eye            | 12   |      |
| 102  | GM57407  | Shim, T=0.70            | AR   |      | 113  | GM57415  | Tip assembly, nozzle | 12   |      |
| 103  | GM57408  | Spring, nozzle          | 12   |      |      |          |                      |      |      |

X Part is not sold separately  
AR As Required

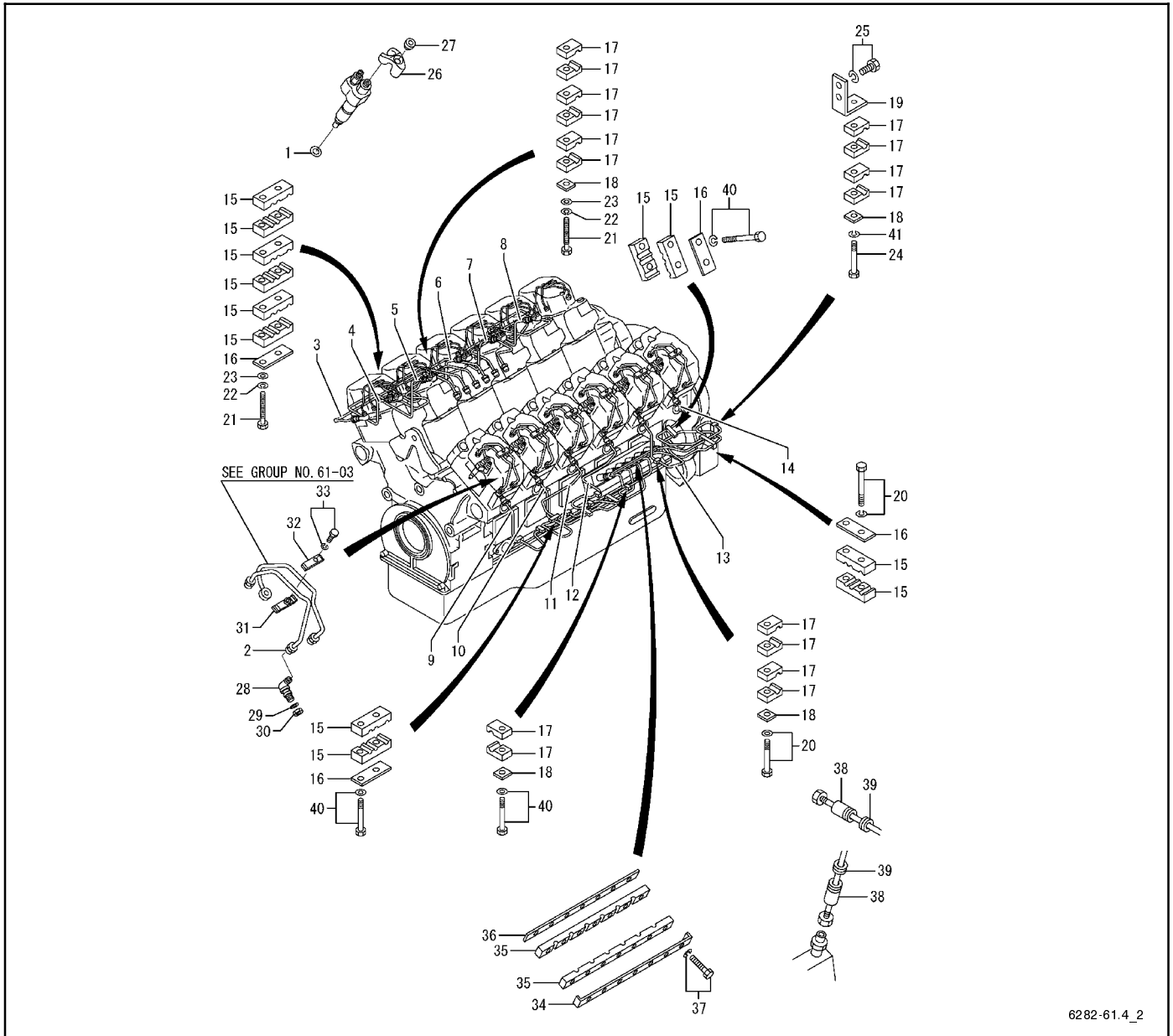
# Group 61.4: Fuel Injection Pipes



6282-61.4

| Item | Part No. | Description            | Qty. | Item | Part No. | Description             | Qty. |
|------|----------|------------------------|------|------|----------|-------------------------|------|
|      |          |                        | Var. |      |          |                         | Var. |
| 1    | GM35818  | Gasket, nozzle         | 12   | 20   | GM36693  | Pipe, injection, no. 8  | 1    |
| 2    | GM36676  | Gland, nozzle          | 12   | 21   | GM36694  | Pipe, injection, no. 9  | 1    |
| 3    | GM36677  | Washer                 | 12   | 22   | GM36695  | Pipe, injection, no. 10 | 1    |
| 4    | GM36678  | Pipe, injection        | 12   | 23   | GM36696  | Pipe, injection, no. 11 | 1    |
| 5    | GM36679  | L-joint                | 12   | 24   | GM36697  | Pipe, injection, no. 12 | 1    |
| 6    | GM36680  | O-ring                 | 12   | 25   | GM36698  | Clamp                   | 20   |
| 7    | GM36681  | Nut                    | 12   | 26   | GM36699  | Seat, pipe              | 20   |
| 8    | GM36682  | Clamp                  | 12   | 27   | GM15138  | Bolt w/washer           | 10   |
| 9    | GM36683  | Clamp                  | 12   | 28   | GM36700  | Clamp                   | 20   |
| 10   | GM15976  | Bolt w/washer          | 12   | 29   | GM36701  | Seat, pipe              | 20   |
| 11   | GM36684  | Cover                  | 24   | 30   | GM15976  | Bolt w/washer           | 20   |
| 12   | GM36685  | Holder                 | 24   | 31   | GM36702  | Clamp                   | 34   |
| 13   | GM36686  | Pipe, injection, no. 1 | 1    | 32   | GM36703  | Seat, pipe              | 34   |
| 14   | GM36687  | Pipe, injection, no. 2 | 1    | 33   | GM36704  | Bolt, w/washer          | 16   |
| 15   | GM36688  | Pipe, injection, no. 3 | 1    | 34   | GM15976  | Bolt w/washer           | 2    |
| 16   | GM36689  | Pipe, injection, no. 4 | 1    | 35   | GM36705  | Pipe, fuel              | 12   |
| 17   | GM36690  | Pipe, injection, no. 5 | 1    | 36   | GM36484  | Bolt, eye               | 12   |
| 18   | GM36691  | Pipe, injection, no. 6 | 1    | 37   | GM14528  | Washer, sealing         | 24   |
| 19   | GM36692  | Pipe, injection, no. 7 | 1    |      |          |                         |      |

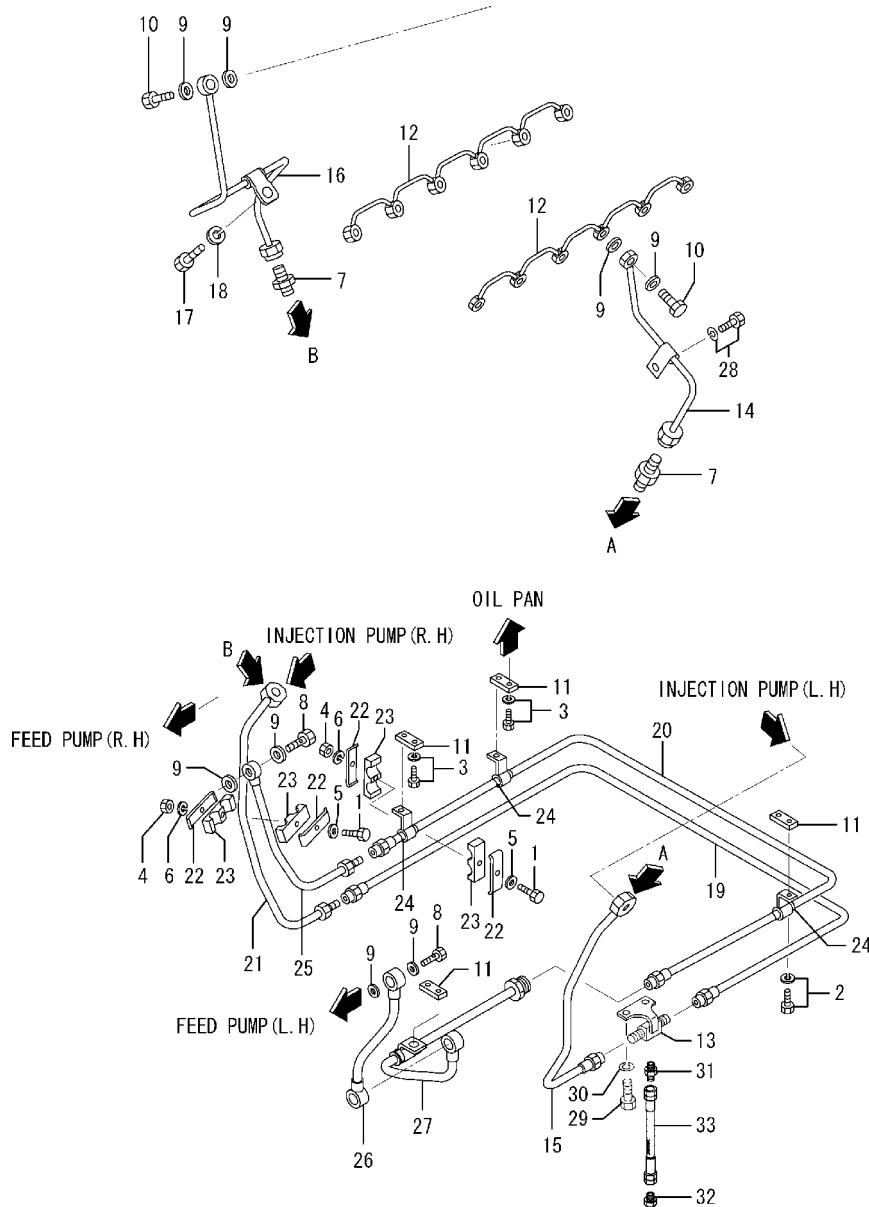
# Group 61.4: Fuel Injection Pipes



6282-61.4\_2

| Item | Part No. | Description            | Qty. | Var. | Item | Part No. | Description    | Qty. | Var. |
|------|----------|------------------------|------|------|------|----------|----------------|------|------|
| 1    | GM57377  | Gasket                 | 12   |      | 22   | GM15179  | Washer, spring | 7    |      |
| 2    | GM57378  | Pipe, injection        | 12   |      | 23   | GM15174  | Washer, plain  | 7    |      |
| 3    | GM57379  | Pipe, injection no. 1  | 1    |      | 24   | GM22092  | Bolt           | 1    |      |
| 4    | GM57380  | Pipe, injection no. 2  | 1    |      | 25   | GM15141  | Bolt           | 2    |      |
| 5    | GM57381  | Pipe, injection no. 3  | 1    |      | 26   | GM36676  | Gland, nozzle  | 12   |      |
| 6    | GM57382  | Pipe, injection no. 4  | 1    |      | 27   | GM36677  | Washer         | 12   |      |
| 7    | GM57383  | Pipe, injection no. 5  | 1    |      | 28   | X        | L-joint        | 12   |      |
| 8    | GM57384  | Pipe, injection no. 6  | 1    |      | 29   | GM36680  | O-ring         | 12   |      |
| 9    | GM57385  | Pipe, injection no. 7  | 1    |      | 30   | GM36681  | Nut            | 12   |      |
| 10   | GM57386  | Pipe, injection no. 8  | 1    |      | 31   | GM36682  | Clamp          | 12   |      |
| 11   | GM57387  | Pipe, injection no. 9  | 1    |      | 32   | GM36683  | Clamp          | 12   |      |
| 12   | GM57388  | Pipe, injection no. 10 | 1    |      | 33   | GM15976  | Bolt w/washer  | 12   |      |
| 13   | GM57389  | Pipe, injection no. 11 | 1    |      | 34   | GM57395  | Clamp          | 2    |      |
| 14   | GM57390  | Pipe, injection no. 12 | 1    |      | 35   | GM57396  | Seat, pipe     | 4    |      |
| 15   | GM31428  | Seat, pipe             | 64   |      | 36   | GM57397  | Clamp          | 2    |      |
| 16   | GM21740  | Plate                  | 19   |      | 37   | GM15977  | Bolt w/washer  | 14   |      |
| 17   | GM57391  | Seat, pipe             | 32   |      | 38   | GM36684  | Cover          | 24   |      |
| 18   | GM57392  | Plate, injection pipe  | 10   |      | 39   | GM36685  | Holder         | 24   |      |
| 19   | GM57393  | Stay, clamp            | 1    |      | 40   | GM15145  | Bolt           | 16   |      |
| 20   | GM57394  | Bolt, w/washer         | 16   |      | 41   | GM15179  | Washer, spring | 1    |      |
| 21   | GM14538  | Bolt                   | 7    |      |      |          |                |      |      |

# Group 61.5: Fuel Leak and Feed Piping

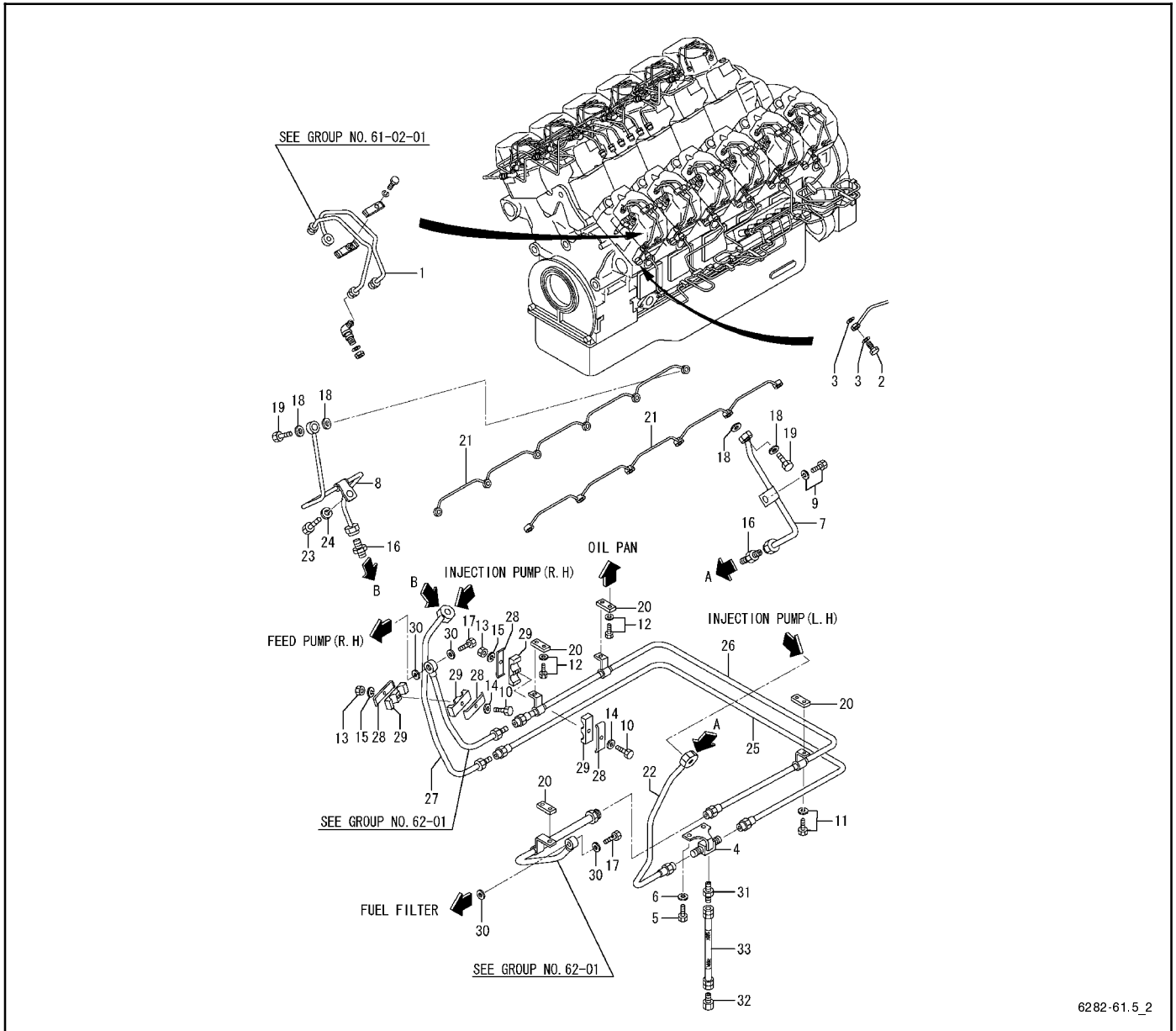


6282-61.5

| Item | Part No. | Description     | Qty.<br>Var. | Item | Part No. | Description     | Qty.<br>Var. |
|------|----------|-----------------|--------------|------|----------|-----------------|--------------|
| 1    | GM15956  | Bolt            | 6            | 18   | GM15179  | Washer, spring  | 1            |
| 2    | GM15975  | Bolt w/washer   | 4            | 19   | GM36715  | Pipe, fuel leak | 1            |
| 3    | GM36706  | Bolt, w/washer  | 4            | 20   | GM36716  | Pipe, fuel feed | 1            |
| 4    | GM15164  | Nut             | 6            | 21   | GM36717  | Pipe, fuel leak | 1            |
| 5    | GM15174  | Washer, plain   | 6            | 22   | GM15599  | Clamp           | 12           |
| 6    | GM15179  | Washer, spring  | 6            | 23   | GM15600  | Seat            | 12           |
| 7    | GM15230  | Connector       | 2            | 24   | GM36718  | Clip            | 3            |
| 8    | GM15234  | Bolt, eye       | 2            | 25   | GM36719  | Pipe, fuel feed | 1            |
| 9    | GM14528  | Washer, sealing | 8            | 26   | GM36720  | Pipe, fuel feed | 1            |
| 10   | GM36707  | Bolt, eye       | 2            | 27   | GM36721  | Pipe, fuel feed | 1            |
| 11   | GM36708  | Stay            | 4            | 28   | GM15140  | Bolt w/washer   | 1            |
| 12   | GM36709  | Pipe, fuel      | 2            | 29   | GM36722  | Bolt            | 2            |
| 13   | GM36710  | Connector       | 1            | 30   | GM15179  | Washer, spring  | 2            |
| 14   | GM36711  | Pipe, fuel leak | 1            | 31   | GM31459  | Connector       | 1            |
| 15   | GM36712  | Pipe, fuel leak | 1            | 32   | GM14995  | Connector       | 1            |
| 16   | GM36713  | Pipe, fuel leak | 1            | 33   | GM14996  | Hose            | 1            |
| 17   | GM36714  | Bolt            | 1            |      |          |                 |              |



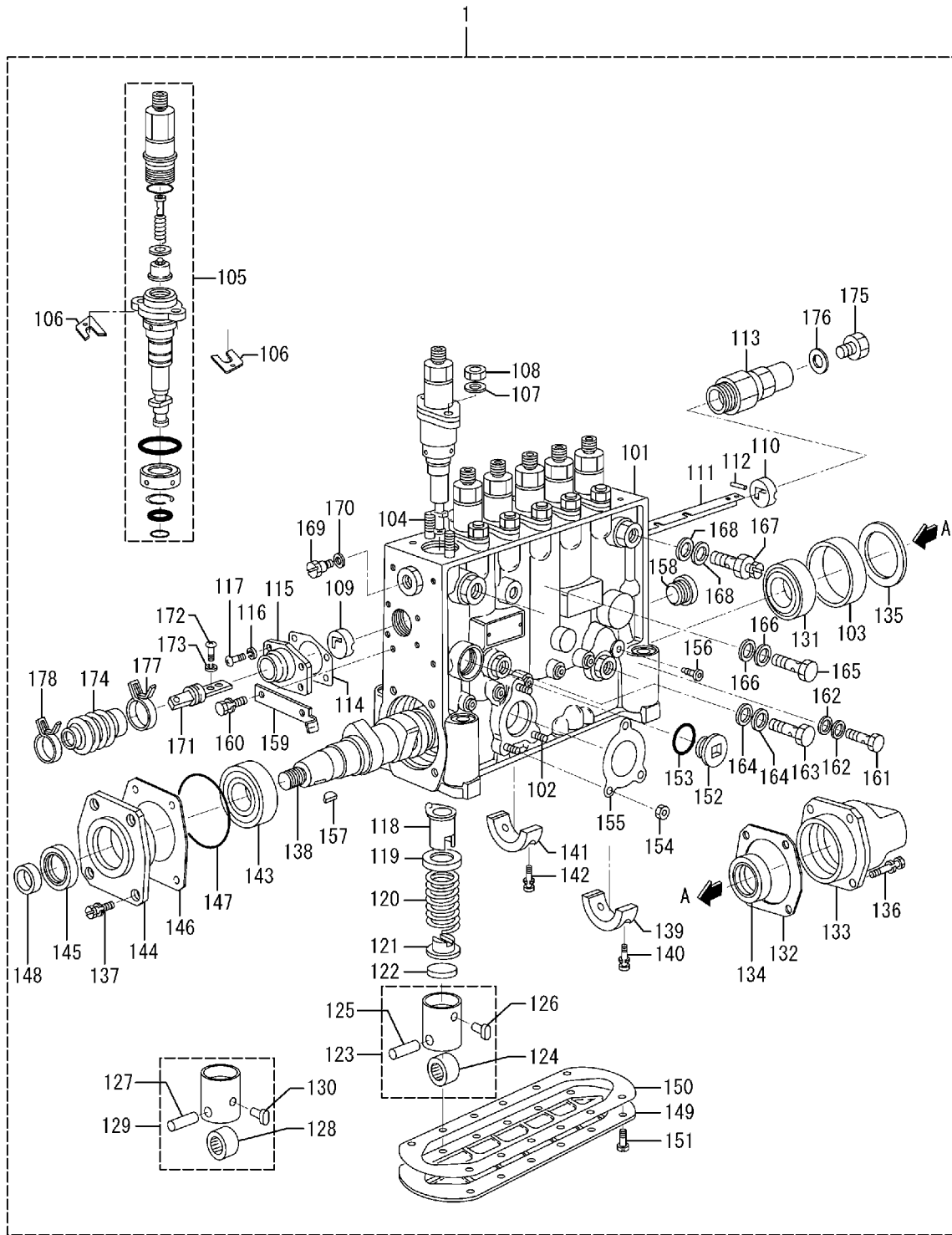
# Group 61.5: Fuel Leak and Feed Piping



6282-61.5\_2

| Item | Part No. | Description            | Qty. | Var. | Item | Part No. | Description                | Qty. | Var. |
|------|----------|------------------------|------|------|------|----------|----------------------------|------|------|
| 1    | GM36705  | Pipe, fuel             | 12   |      | 18   | GM57417  | Washer, sealing            | 8    |      |
| 2    | GM36484  | Bolt, eye              | 12   |      | 19   | GM36707  | Boit, eye                  | 2    |      |
| 3    | GM14528  | Washer, sealing        | 24   |      | 20   | GM36708  | Stay                       | 4    |      |
| 4    | GM36710  | Connector              | 1    |      | 21   | GM36709  | Pipe, fuel                 | 2    |      |
| 5    | GM36722  | Bolt                   | 2    |      | 22   | GM57418  | Pipe, fuel leak, left hand | 1    |      |
| 6    | GM15179  | Washer, spring         | 2    |      | 23   | GM36714  | Bolt                       | 1    |      |
| 7    | GM57416  | Pipe, leak, right hand | 1    |      | 24   | GM15179  | Washer, spring             | 1    |      |
| 8    | GM36713  | Pipe, fuel leak        | 1    |      | 25   | GM57419  | Pipe, leak, right hand     | 1    |      |
| 9    | GM15140  | Bolt                   | 1    |      | 26   | GM36716  | Pipe, fuel feed            | 1    |      |
| 10   | GM15956  | Bolt                   | 6    |      | 27   | GM36717  | Pipe, fuel leak            | 1    |      |
| 11   | GM15975  | Bolt w/washer          | 4    |      | 28   | GM15599  | Clamp                      | 12   |      |
| 12   | GM36706  | Bolt, w/washer         | 4    |      | 29   | GM15600  | Seat                       | 12   |      |
| 13   | GM15164  | Nut                    | 6    |      | 30   | GM14530  | Washer, sealing            | 4    |      |
| 14   | GM15174  | Washer, plain          | 6    |      | 31   | GM31459  | Connector                  | 2    |      |
| 15   | GM15179  | Washer, spring         | 6    |      | 32   | GM14995  | Connector                  | 1    |      |
| 16   | GM15230  | Connector              | 2    |      | 33   | GM14996  | Hose                       | 1    |      |
| 17   | GM15234  | Bolt, eye              | 2    |      |      |          |                            |      |      |

# Group 61.6: Injection Pump, Right Side



6282-61.6

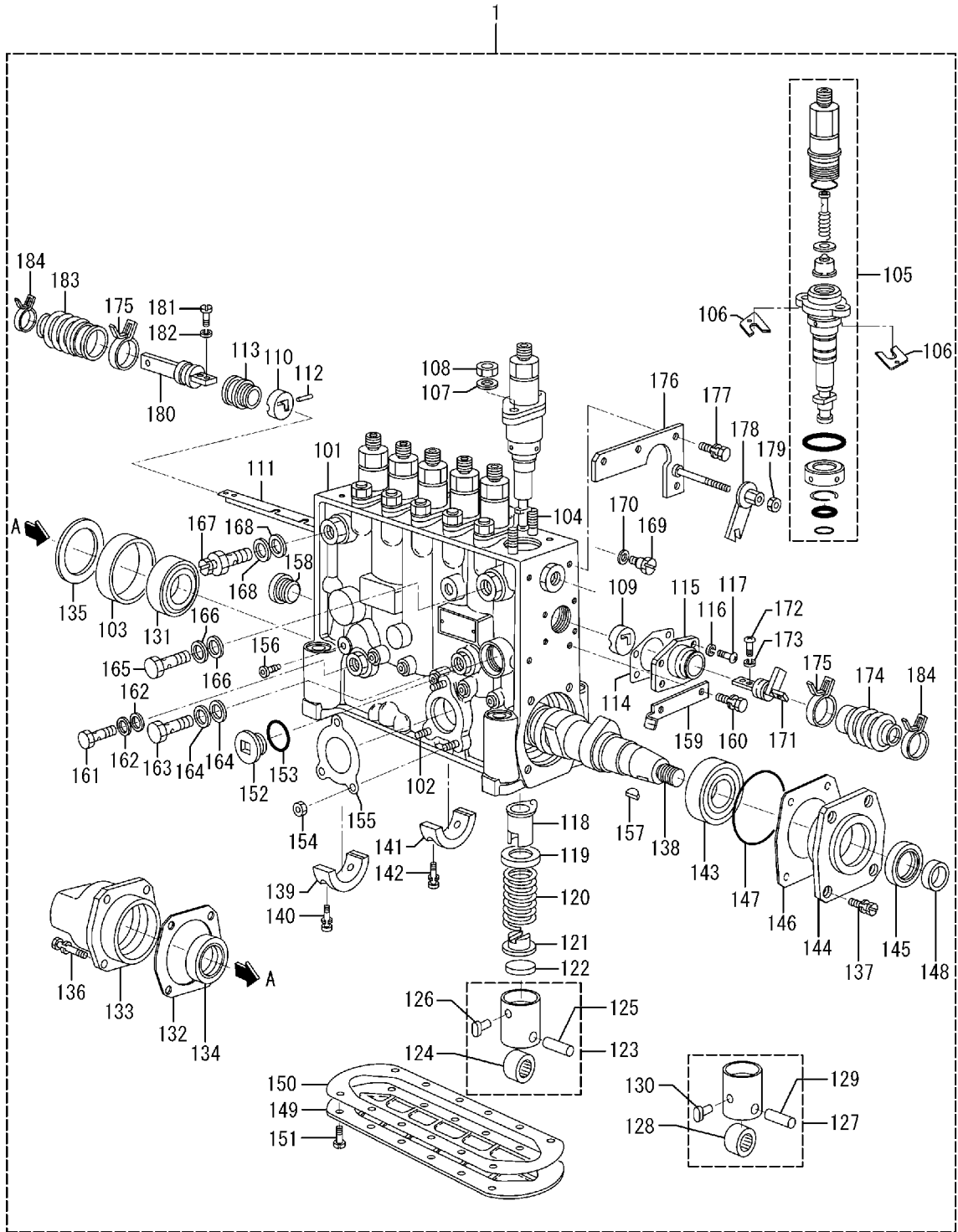
## Group 61.6: Injection Pump, Right Side

| Item | Part No. | Description              | Qty. Var. |    | Item | Part No. | Description     | Qty. Var. |    |
|------|----------|--------------------------|-----------|----|------|----------|-----------------|-----------|----|
|      |          |                          | 1         | 2  |      |          |                 | 1         | 2  |
| 1    | X        | Pump assembly, injection | 1         | 1  | 115  | GM36833  | Adapter         | 1         | 1  |
| 101  | GM36723  | Housing, pump            | 1         | 1  | 116  | GM36761  | Washer, spring  | 4         | 4  |
| 102  | GM36796  | Stud                     | 3         | 3  | 117  | GM36762  | Screw           | 4         | 4  |
| 103  | GM36797  | Ring                     | 1         | 1  | 118  | GM36834  | Sleeve, control | 6         | 6  |
| 104  | GM36798  | Stud                     | 12        | 12 | 119  | GM36835  | Seat, spring    | 6         | 6  |
| 105  | GM36724  | Block, plunger           | 6         |    | 120  | GM36763  | Spring, plunger | 6         | 6  |
| 105  | GM57367  | Block, plunger           |           | 6  | 121  | GM36764  | Seat, spring    | 6         | 6  |
| 106  | GM36725  | Shim, 0.500 mm           | AR        | AR | 122  | GM36836  | Seat            | 6         | 6  |
| 106  | GM36726  | Shim, 0.525 mm           | AR        | AR | 123  | GM36837  | Tappet assembly | 4         | 4  |
| 106  | GM36799  | Shim, 0.550 mm           | AR        | AR | 124  | GM36765  | Roller          | 4         | 4  |
| 106  | GM36800  | Shim, 0.575 mm           | AR        | AR | 125  | GM36766  | Pin             | 4         | 4  |
| 106  | GM36801  | Shim, 0.600 mm           | AR        | AR | 126  | GM36838  | Guide           | 4         | 4  |
| 106  | GM36802  | Shim, 0.625 mm           | AR        | AR | 127  | GM36839  | Tappet assembly | 2         | 2  |
| 106  | GM36803  | Shim, 0.65 mm            | AR        | AR | 128  | GM36765  | Roller          | 2         | 2  |
| 106  | GM36727  | Shim, 0.675 mm           | AR        | AR | 129  | GM36766  | Pin             | 2         | 2  |
| 106  | GM36804  | Shim, 0.7 mm             | AR        | AR | 130  | GM36838  | Guide           | 2         | 2  |
| 106  | GM36805  | Shim, 0.725 mm           | AR        | AR | 131  | GM36840  | Bearing, ball   | 1         | 1  |
| 106  | GM36728  | Shim, 0.75 mm            | AR        | AR | 132  | GM36767  | Gasket          | 1         | 1  |
| 106  | GM36806  | Shim, 0.775 mm           | AR        | AR | 133  | GM36841  | Cover           | 1         | 1  |
| 106  | GM36729  | Shim, 0.8 mm             | AR        | AR | 134  | GM36842  | Seal, oil       | 1         | 1  |
| 106  | GM36730  | Shim, 0.825 mm           | AR        | AR | 135  | GM36843  | Shim            | 1         | 1  |
| 106  | GM36807  | Shim, 0.85 mm            | AR        | AR | 136  | GM36768  | Bolt            | 4         | 4  |
| 106  | GM36808  | Shim, 0.875 mm           | AR        | AR | 137  | GM36844  | Bolt            | 4         | 4  |
| 106  | GM36731  | Shim, 0.9 mm             | AR        | AR | 138  | GM36769  | Camshaft        | 1         | 1  |
| 106  | GM36732  | Shim, 0.925 mm           | AR        | AR | 139  | GM36845  | Bearing, center | 1         | 1  |
| 106  | GM36809  | Shim, 0.95 mm            | AR        | AR | 140  | GM36846  | Bolt            | 2         | 2  |
| 106  | GM36810  | Shim, 0.975 mm           | AR        | AR | 141  | GM36770  | Bearing, center | 2         | 2  |
| 106  | GM36733  | Shim, 1 mm               | AR        | AR | 142  | GM36846  | Bolt            | 4         | 4  |
| 106  | GM36734  | Shim, 1.025 mm           | AR        | AR | 143  | GM36771  | Bearing, ball   | 1         | 1  |
| 106  | GM36735  | Shim, 1.05 mm            | AR        | AR | 144  | GM36772  | Cover           | 1         | 1  |
| 106  | GM36811  | Shim, 1.075 mm           | AR        | AR | 145  | GM36847  | Seal, oil       | 1         | 1  |
| 106  | GM36812  | Shim, 1.1 mm             | AR        | AR | 146  | GM36773  | Shim, 0.10 mm   | AR        | AR |
| 106  | GM36813  | Shim, 1.125 mm           | AR        | AR | 146  | GM36774  | Shim, 0.12 mm   | AR        | AR |
| 106  | GM36814  | Shim, 1.15 mm            | AR        | AR | 146  | GM36775  | Shim, 0.14 mm   | AR        | AR |
| 106  | GM36736  | Shim, 1.175 mm           | AR        | AR | 146  | GM36776  | Shim, 0.16 mm   | AR        | AR |
| 106  | GM36737  | Shim, 1.2 mm             | AR        | AR | 146  | GM36777  | Shim, 0.18 mm   | AR        | AR |
| 106  | GM36738  | Shim, 1.225 mm           | AR        | AR | 146  | GM36778  | Shim, 0.30 mm   | AR        | AR |
| 106  | GM36739  | Shim, 1.25 mm            | AR        | AR | 146  | GM36848  | Shim, 0.50 mm   | AR        | AR |
| 106  | GM36815  | Shim, 1.275 mm           | AR        | AR | 147  | GM36779  | O-ring          | 1         | 1  |
| 106  | GM36816  | Shim, 1.3 mm             | AR        | AR | 148  | GM36849  | Sleeve          | 1         | 1  |
| 106  | GM36817  | Shim, 1.325 mm           | AR        | AR | 149  | GM36850  | Cover           | 1         |    |
| 106  | GM36740  | Shim, 1.35 mm            | AR        | AR | 149  | X        | Cover           |           | 1  |
| 106  | GM36818  | Shim, 1.375 mm           | AR        | AR | 150  | GM36851  | Gasket          | 1         | 1  |
| 106  | GM36741  | Shim, 1.4 mm             | AR        | AR | 151  | GM36780  | Screw           | 12        | 12 |
| 106  | GM36742  | Shim, 1.425 mm           | AR        | AR | 152  | GM36852  | Plug            | 1         | 1  |
| 106  | GM36743  | Shim, 1.45 mm            | AR        | AR | 153  | GM36781  | Gasket          | 1         | 1  |
| 106  | GM36744  | Shim, 1.475 mm           | AR        | AR | 154  | GM36853  | Nut             | 3         | 3  |
| 106  | GM36745  | Shim, 1.5 mm             | AR        | AR | 155  | GM36854  | Gasket          | 1         | 1  |
| 106  | GM36746  | Shim, 1.525 mm           | AR        | AR | 156  | GM36855  | Plug            | 6         | 6  |
| 106  | GM36819  | Shim, 1.55 mm            | AR        | AR | 157  | GM36782  | Key, woodruff   | 1         | 1  |
| 106  | GM36820  | Shim, 1.575 mm           | AR        | AR | 158  | GM36783  | Plug            | 1         | 1  |
| 106  | GM36747  | Shim, 1.6 mm             | AR        | AR | 159  | GM36784  | Pointer         | 1         | 1  |
| 106  | GM36821  | Shim, 1.625 mm           | AR        | AR | 160  | GM36785  | Bolt            | 2         | 2  |
| 106  | GM36748  | Shim, 1.65 mm            | AR        | AR | 161  | GM36786  | Bolt, eye       | 1         | 1  |
| 106  | GM36749  | Shim, 1.675 mm           | AR        | AR | 162  | GM36858  | Gasket          | 2         | 2  |
| 106  | GM36822  | Shim, 1.7 mm             | AR        | AR | 163  | GM36857  | Bolt, eye       | 1         | 1  |
| 106  | GM36823  | Shim, 1.725 mm           | AR        | AR | 164  | GM36787  | Gasket          | 2         | 2  |
| 106  | GM36750  | Shim, 1.75 mm            | AR        | AR | 165  | GM15513  | Bolt, eye       | 1         | 1  |
| 106  | GM36824  | Shim, 1.775 mm           | AR        | AR | 166  | GM36858  | Gasket          | 2         | 2  |
| 106  | GM36751  | Shim, 1.8 mm             | AR        | AR | 167  | GM36788  | Valve, overflow | 1         |    |
| 106  | GM36752  | Shim, 1.825 mm           | AR        | AR | 167  | GM57368  | Valve, overflow |           | 1  |
| 106  | GM36825  | Shim, 1.85 mm            | AR        | AR | 168  | GM36858  | Gasket          | 2         | 2  |
| 106  | GM36753  | Shim, 1.875 mm           | AR        | AR | 169  | GM36859  | Bolt            | 1         | 1  |
| 106  | GM36754  | Shim, 1.9 mm             | AR        | AR | 170  | GM36789  | Gasket          | 1         | 1  |
| 106  | GM36826  | Shim, 1.925 mm           | AR        | AR | 171  | GM36790  | Connector       | 2         | 2  |
| 106  | GM36755  | Shim, 1.95 mm            | AR        | AR | 172  | GM36791  | Screw           | 2         | 2  |
| 106  | GM36827  | Shim, 1.975 mm           | AR        | AR | 173  | GM36761  | Washer, spring  | 1         |    |
| 107  | GM36756  | Washer                   | 12        | 12 | 173  | GM57369  | Washer, spring  |           | 1  |
| 108  | GM36828  | Nut                      | 12        | 12 | 174  | GM36792  | Cover           | 1         | 1  |
| 109  | GM36757  | Bushing                  | 1         | 1  | 175  | GM36793  | Bolt            | 1         | 1  |
| 110  | GM36829  | Bushing                  | 1         | 1  | 176  | GM36794  | Gasket          | 1         | 1  |
| 111  | GM36758  | Rack, control            | 1         | 1  | 177  | GM36861  | Clip            | 1         | 1  |
| 112  | GM36831  | Pin                      | 1         | 1  | 178  | GM36866  | Clip            | 1         | 1  |
| 113  | GM36759  | Connector                | 1         | 1  |      |          |                 |           |    |
| 114  | GM36760  | Gasket                   | 1         | 1  |      |          |                 |           |    |

X Part is not sold separately

AR As Required

# Group 61.7: Injection Pump, Left Side



6282-61.7

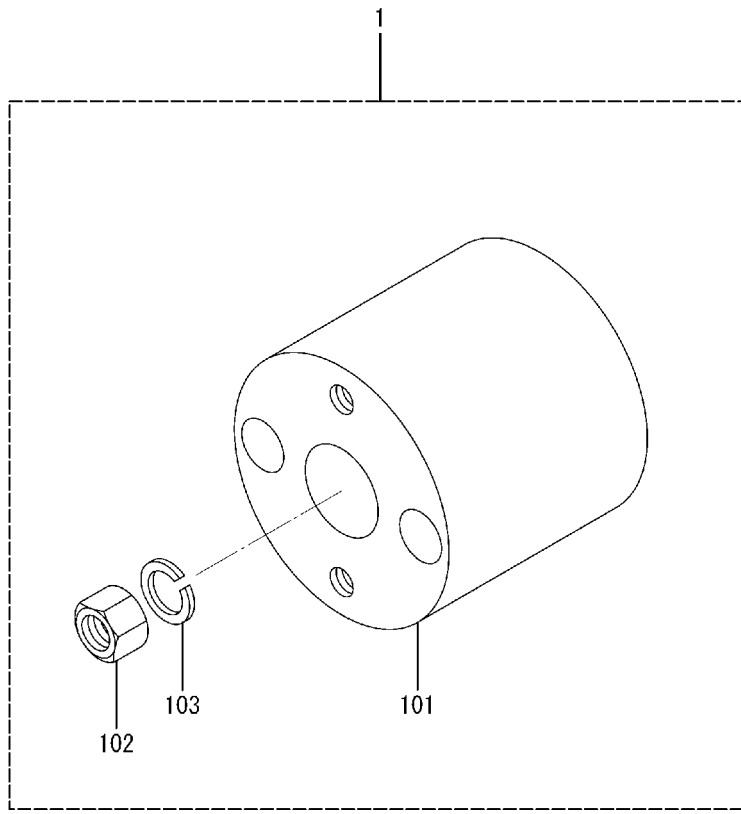
## Group 61.7: Injection Pump, Left Side

| Item | Part No. | Description              | Qty. Var. |    | Item | Part No. | Description     | Qty. Var. |    |
|------|----------|--------------------------|-----------|----|------|----------|-----------------|-----------|----|
|      |          |                          | 1         | 2  |      |          |                 | 1         | 2  |
| 1    | X        | Pump assembly, injection | 1         | 1  | 118  | GM36834  | Sleeve, control | 6         | 6  |
| 101  | GM36795  | Housing, pump            | 1         | 1  | 119  | GM36835  | Seat, spring    | 6         | 6  |
| 102  | GM36796  | Stud                     | 3         | 3  | 120  | GM36763  | Spring, plunger | 6         | 6  |
| 103  | GM36797  | Ring                     | 1         | 1  | 121  | GM36764  | Seat, spring    | 6         | 6  |
| 104  | GM36798  | Stud                     | 12        | 12 | 122  | GM36836  | Seat            | 6         | 6  |
| 105  | GM36724  | Block, plunger           | 6         |    | 123  | GM36837  | Tappet assembly | 4         | 4  |
| 105  | GM57367  | Block, plunger           |           | 6  | 124  | GM36765  | Roller          | 4         | 4  |
| 106  | GM36725  | Shim, 0.500 mm           | AR        | AR | 125  | GM36766  | Pin             | 4         | 4  |
| 106  | GM36726  | Shim, 0.525 mm           | AR        | AR | 126  | GM36838  | Guide           | 4         | 4  |
| 106  | GM36799  | Shim, 0.550 mm           | AR        | AR | 127  | GM36839  | Tappet assembly | 2         | 2  |
| 106  | GM36800  | Shim, 0.575 mm           | AR        | AR | 128  | GM36765  | Roller          | 2         | 2  |
| 106  | GM36801  | Shim, 0.600 mm           | AR        | AR | 129  | GM36766  | Pin             | 2         | 2  |
| 106  | GM36802  | Shim, 0.625 mm           | AR        | AR | 130  | GM36838  | Guide           | 2         | 2  |
| 106  | GM36803  | Shim, 0.65 mm            | AR        | AR | 131  | GM36840  | Bearing, ball   | 1         | 1  |
| 106  | GM36727  | Shim, 0.675 mm           | AR        | AR | 132  | GM36767  | Gasket          | 1         | 1  |
| 106  | GM36804  | Shim, 0.7 mm             | AR        | AR | 133  | GM36841  | Cover           | 1         | 1  |
| 106  | GM36805  | Shim, 0.725 mm           | AR        | AR | 134  | GM36842  | Seal, oil       | 1         | 1  |
| 106  | GM36728  | Shim, 0.75 mm            | AR        | AR | 135  | GM36843  | Shim            | 1         | 1  |
| 106  | GM36806  | Shim, 0.775 mm           | AR        | AR | 136  | GM36768  | Bolt            | 4         | 4  |
| 106  | GM36729  | Shim, 0.8 mm             | AR        | AR | 137  | GM36844  | Bolt            | 4         | 4  |
| 106  | GM36730  | Shim, 0.825 mm           | AR        | AR | 138  | GM36769  | Camshaft        | 1         | 1  |
| 106  | GM36807  | Shim, 0.85 mm            | AR        | AR | 139  | GM36845  | Bearing, center | 1         | 1  |
| 106  | GM36808  | Shim, 0.875 mm           | AR        | AR | 140  | GM36846  | Bolt            | 2         | 2  |
| 106  | GM36731  | Shim, 0.9 mm             | AR        | AR | 141  | GM36770  | Bearing, center | 2         | 2  |
| 106  | GM36732  | Shim, 0.925 mm           | AR        | AR | 142  | GM36846  | Bolt            | 4         | 4  |
| 106  | GM36809  | Shim, 0.95 mm            | AR        | AR | 143  | GM36771  | Bearing, ball   | 1         | 1  |
| 106  | GM36810  | Shim, 0.975 mm           | AR        | AR | 144  | GM36772  | Cover           | 1         | 1  |
| 106  | GM36733  | Shim, 1 mm               | AR        | AR | 145  | GM36847  | Seal, oil       | 1         | 1  |
| 106  | GM36734  | Shim, 1.025 mm           | AR        | AR | 146  | GM36773  | Shim, 0.10 mm   | AR        | AR |
| 106  | GM36735  | Shim, 1.05 mm            | AR        | AR | 146  | GM36774  | Shim, 0.12 mm   | AR        | AR |
| 106  | GM36811  | Shim, 1.075 mm           | AR        | AR | 146  | GM36775  | Shim, 0.14 mm   | AR        | AR |
| 106  | GM36812  | Shim, 1.1 mm             | AR        | AR | 146  | GM36776  | Shim, 0.16 mm   | AR        | AR |
| 106  | GM36813  | Shim, 1.125 mm           | AR        | AR | 146  | GM36777  | Shim, 0.18 mm   | AR        | AR |
| 106  | GM36814  | Shim, 1.15 mm            | AR        | AR | 146  | GM36778  | Shim, 0.30 mm   | AR        | AR |
| 106  | GM36736  | Shim, 1.175 mm           | AR        | AR | 146  | GM36848  | Shim, 0.50 mm   | AR        | AR |
| 106  | GM36737  | Shim, 1.2 mm             | AR        | AR | 147  | GM36779  | O-ring          | 1         | 1  |
| 106  | GM36738  | Shim, 1.225 mm           | AR        | AR | 148  | GM36849  | Sleeve          | 1         | 1  |
| 106  | GM36739  | Shim, 1.25 mm            | AR        | AR | 149  | GM36850  | Cover           | 1         | 1  |
| 106  | GM36815  | Shim, 1.275 mm           | AR        | AR | 150  | GM36851  | Gasket          | 1         | 1  |
| 106  | GM36816  | Shim, 1.3 mm             | AR        | AR | 151  | GM36780  | Screw           | 12        | 12 |
| 106  | GM36817  | Shim, 1.325 mm           | AR        | AR | 152  | GM36852  | Plug            | 1         | 1  |
| 106  | GM36740  | Shim, 1.35 mm            | AR        | AR | 153  | GM36781  | Gasket          | 1         | 1  |
| 106  | GM36818  | Shim, 1.375 mm           | AR        | AR | 154  | GM36853  | Nut             | 3         | 3  |
| 106  | GM36741  | Shim, 1.4 mm             | AR        | AR | 155  | GM36854  | Gasket          | 1         | 1  |
| 106  | GM36742  | Shim, 1.425 mm           | AR        | AR | 156  | GM36855  | Plug            | 6         | 6  |
| 106  | GM36743  | Shim, 1.45 mm            | AR        | AR | 157  | GM36782  | Key, woodruff   | 1         | 1  |
| 106  | GM36744  | Shim, 1.475 mm           | AR        | AR | 158  | GM36783  | Plug            | 1         | 1  |
| 106  | GM36745  | Shim, 1.5 mm             | AR        | AR | 159  | GM36856  | Pointer         | 1         | 1  |
| 106  | GM36746  | Shim, 1.525 mm           | AR        | AR | 160  | GM36785  | Bolt            | 2         | 2  |
| 106  | GM36819  | Shim, 1.55 mm            | AR        | AR | 161  | GM36786  | Bolt, eye       | 1         | 1  |
| 106  | GM36820  | Shim, 1.575 mm           | AR        | AR | 162  | GM36858  | Gasket          | 2         | 2  |
| 106  | GM36747  | Shim, 1.6 mm             | AR        | AR | 163  | GM36857  | Bolt, eye       | 1         | 1  |
| 106  | GM36821  | Shim, 1.625 mm           | AR        | AR | 164  | GM36787  | Gasket          | 2         | 2  |
| 106  | GM36748  | Shim, 1.65 mm            | AR        | AR | 165  | GM15513  | Bolt, eye       | 1         | 1  |
| 106  | GM36749  | Shim, 1.675 mm           | AR        | AR | 166  | GM36858  | Gasket          | 2         | 2  |
| 106  | GM36822  | Shim, 1.7 mm             | AR        | AR | 167  | GM36788  | Valve, overflow | 1         |    |
| 106  | GM36823  | Shim, 1.725 mm           | AR        | AR | 167  | GM57368  | Valve, overflow |           | 1  |
| 106  | GM36750  | Shim, 1.75 mm            | AR        | AR | 168  | GM36858  | Gasket          | 2         | 2  |
| 106  | GM36824  | Shim, 1.775 mm           | AR        | AR | 169  | GM36859  | Bolt            | 1         | 1  |
| 106  | GM36751  | Shim, 1.8 mm             | AR        | AR | 170  | GM36789  | Gasket          | 1         | 1  |
| 106  | GM36752  | Shim, 1.825 mm           | AR        | AR | 171  | GM36860  | Connector       | 1         | 1  |
| 106  | GM36825  | Shim, 1.85 mm            | AR        | AR | 172  | GM36791  | Screw           | 2         | 2  |
| 106  | GM36753  | Shim, 1.875 mm           | AR        | AR | 173  | GM36761  | Washer, spring  | 2         |    |
| 106  | GM36754  | Shim, 1.9 mm             | AR        | AR | 173  | GM57369  | Washer, spring  |           | 2  |
| 106  | GM36826  | Shim, 1.925 mm           | AR        | AR | 174  | GM36792  | Cover           | 1         | 1  |
| 106  | GM36755  | Shim, 1.95 mm            | AR        | AR | 175  | GM36861  | Clip            | 2         | 2  |
| 106  | GM36827  | Shim, 1.975 mm           | AR        | AR | 176  | GM36862  | Bracket         | 1         |    |
| 107  | GM36756  | Washer                   | 12        | 12 | 176  | GM57370  | Bracket         |           | 1  |
| 108  | GM36828  | Nut                      | 12        | 12 | 177  | GM36846  | Bolt            | 3         | 3  |
| 109  | GM36757  | Bushing                  | 1         | 1  | 178  | GM36863  | Plate           | 1         | 1  |
| 110  | GM36829  | Bushing                  | 1         | 1  | 179  | GM36864  | Nut             | 1         |    |
| 111  | GM36830  | Rack, control            | 1         | 1  | 179  | GM57371  | Nut             |           | 1  |
| 112  | GM36831  | Pin                      | 1         | 1  | 180  | GM36865  | Connector       | 1         | 1  |
| 113  | GM36832  | Bushing                  | 1         | 1  | 181  | GM36791  | Screw           | 2         | 2  |
| 114  | GM36760  | Gasket                   | 1         | 1  | 182  | GM36761  | Washer, spring  | 2         |    |
| 115  | GM36833  | Adapter                  | 1         | 1  | 182  | GM57369  | Washer, spring  |           | 2  |
| 116  | GM36761  | Washer, spring           | 4         | 4  | 183  | GM36792  | Cover           | 1         | 1  |
| 117  | GM36762  | Screw                    | 4         | 4  | 184  | GM36866  | Clip            | 2         | 2  |

X Part is not sold separately

AR As Required

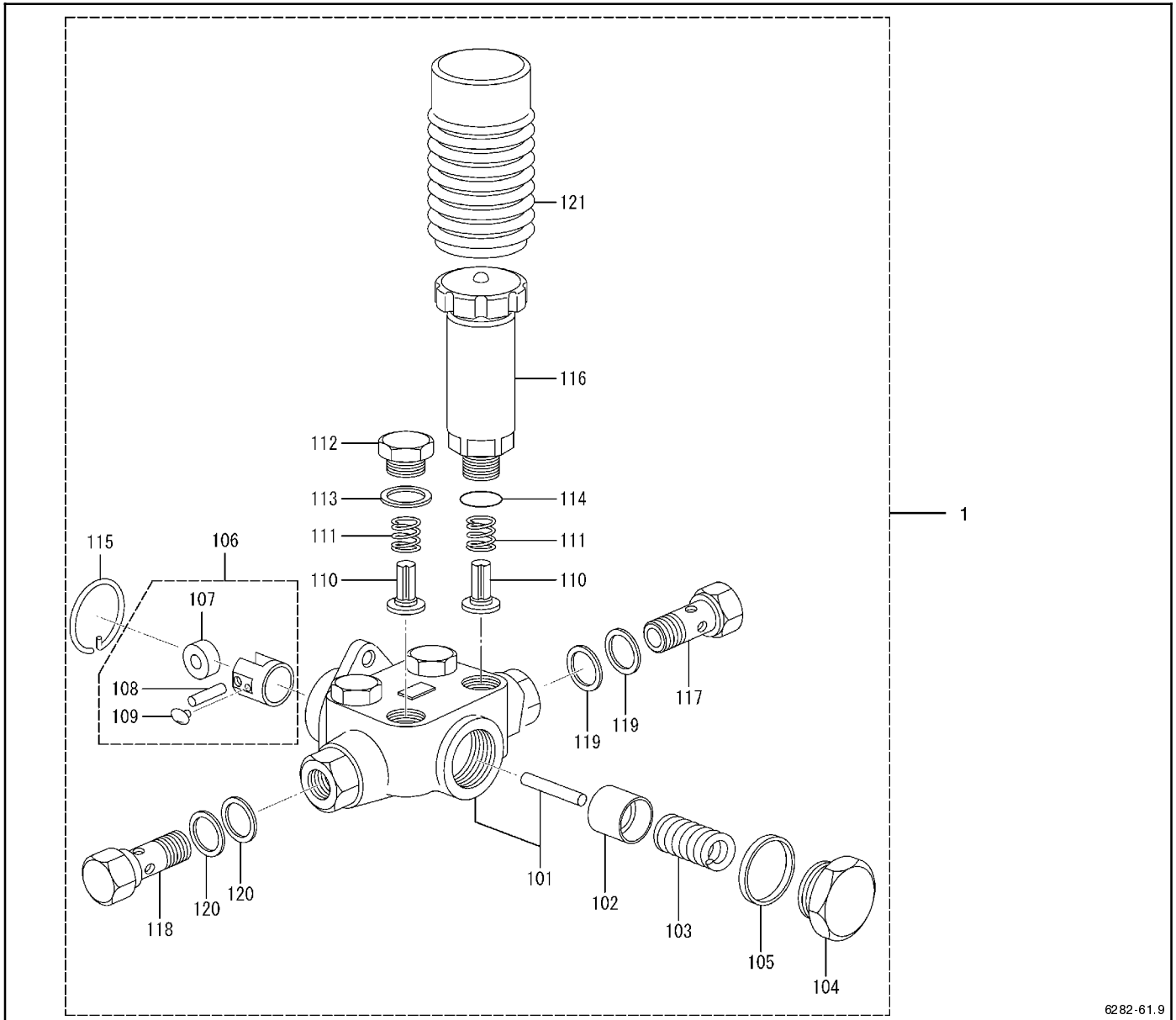
# Group 61.8: Coupling



6282-61.8

| Item | Part No. | Description     | Qty. |
|------|----------|-----------------|------|
|      |          |                 | Var. |
| 1    | GM36867  | Coupling        | 2    |
| 101  | GM36868  | Plate, coupling | 2    |
| 102  | GM36869  | Nut             | 2    |
| 103  | GM36870  | Washer, spring  | 2    |

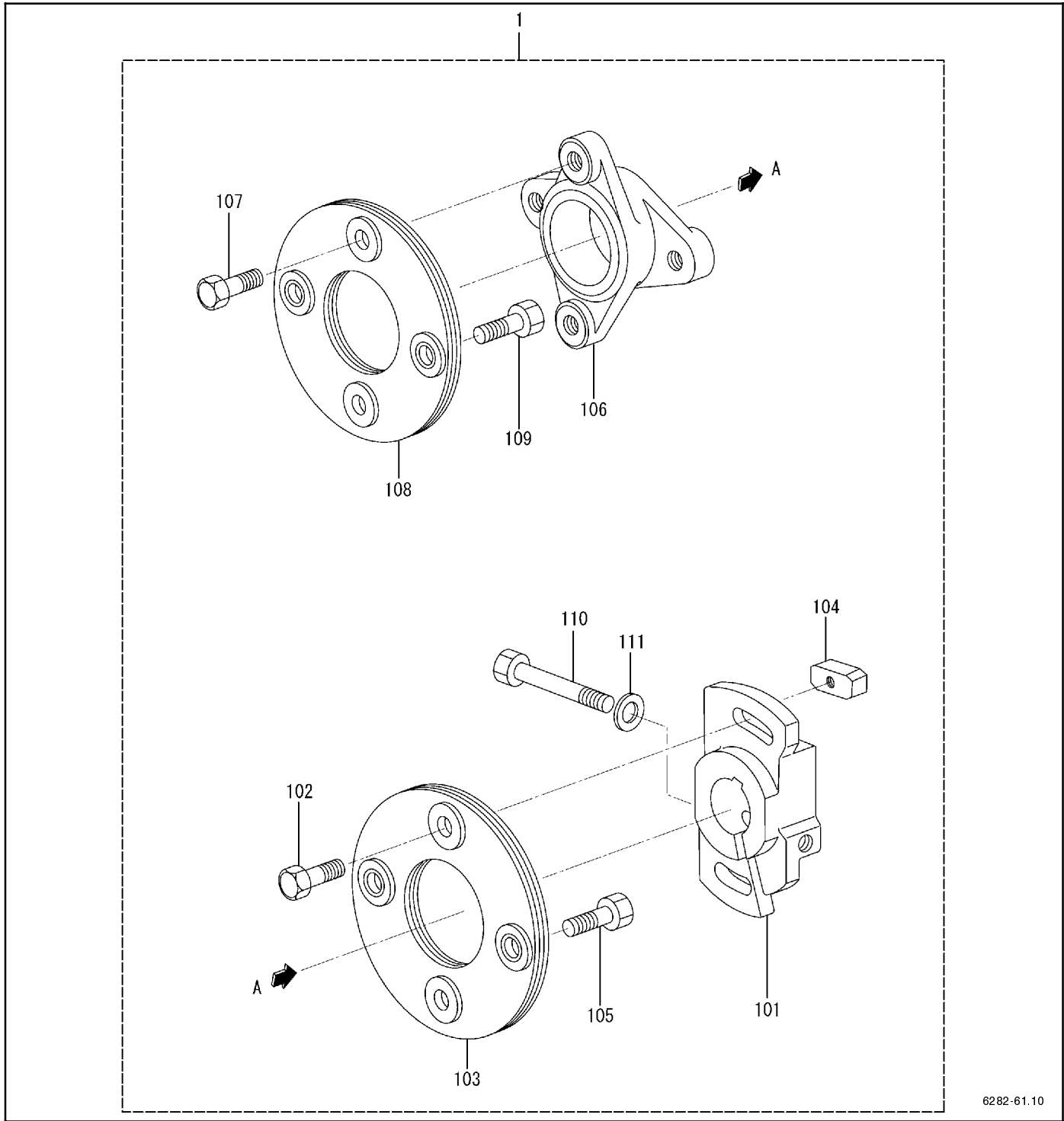
# Group 61.9: Feed Pump



6282-61.9

| Item | Part No. | Description     | Qty. |   | Item | Part No. | Description     | Qty. |   |
|------|----------|-----------------|------|---|------|----------|-----------------|------|---|
|      |          |                 | 1    | 2 |      |          |                 | 1    | 2 |
| 1    | GM36617  | Pump, feed      | 2    | 2 | 113  | GM36881  | Gasket          | 6    | 6 |
| 101  | GM36871  | Housing         | 2    | 2 | 114  | GM36882  | O-ring          | 2    | 2 |
| 102  | GM15533  | Piston          | 2    | 2 | 115  | GM36883  | Ring, snap      | 2    | 2 |
| 103  | GM36872  | Spring, piston  | 2    | 2 | 116  | GM36884  | Pump, priming   | 2    | 2 |
| 104  | GM36873  | Plug            | 2    | 2 | 117  | GM36885  | Bolt, eye       | 2    | 2 |
| 105  | GM36874  | Gasket          | 2    | 2 | 118  | GM36885  | Bolt, eye       | 2    | 2 |
| 106  | GM36875  | Tappet assembly | 2    | 2 | 119  | GM14530  | Washer, sealing | 4    | 4 |
| 107  | GM36876  | Roller          | 2    | 2 | 119  | GM36858  | Gasket          | 4    | 4 |
| 108  | GM36877  | Pin             | 2    | 2 | 120  | GM14530  | Washer, sealing | 4    | 4 |
| 109  | GM36878  | Guide           | 4    | 4 | 120  | GM36858  | Gasket          | 4    | 4 |
| 110  | GM36879  | Valve           | 8    | 8 | 121  | GM36886  | Cover           | 2    | 2 |
| 111  | GM15541  | Spring          | 8    | 8 |      |          |                 |      |   |
| 112  | GM36880  | Plug            | 6    | 6 |      |          |                 |      |   |

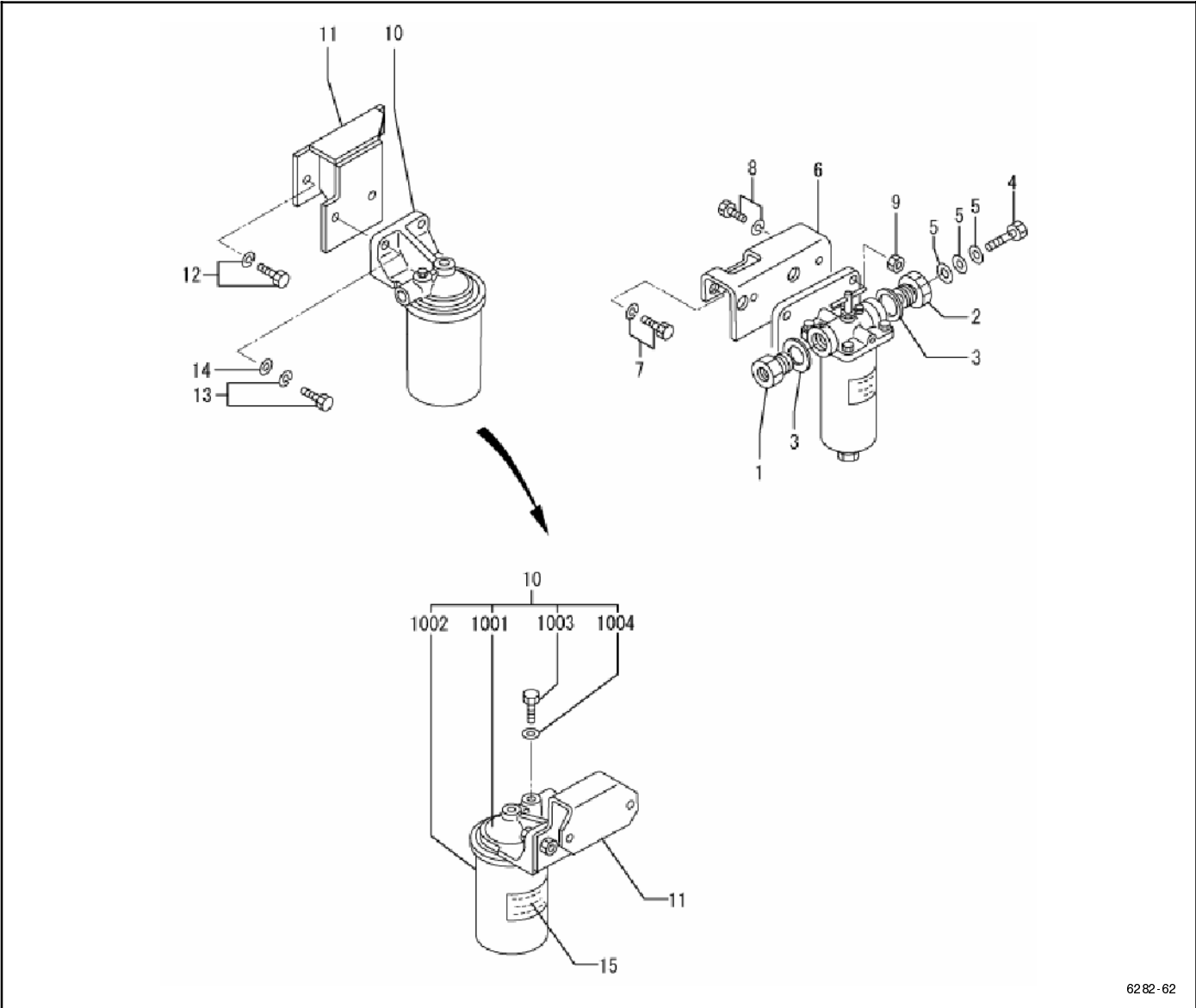
# Group 61.10: Coupling Assembly



| Item | Part No. | Description       | Qty.<br>Var. | Item | Part No. | Description     | Qty.<br>Var. |
|------|----------|-------------------|--------------|------|----------|-----------------|--------------|
| 1    | GM36618  | Coupling assembly | 2            | 106  | GM36891  | Coupling, cross | 2            |
| 101  | GM36887  | Coupling          | 2            | 107  | GM36893  | Bolt            | 4            |
| 102  | GM36888  | Bolt              | 4            | 108  | GM36892  | Plate           | 2            |
| 103  | GM36889  | Plate             | 2            | 109  | GM36893  | Bolt            | 4            |
| 104  | GM36890  | Nut               | 4            | 110  | GM36894  | Bolt            | 2            |
| 105  | GM36893  | Bolt              | 4            | 111  | GM36895  | Washer          | 2            |



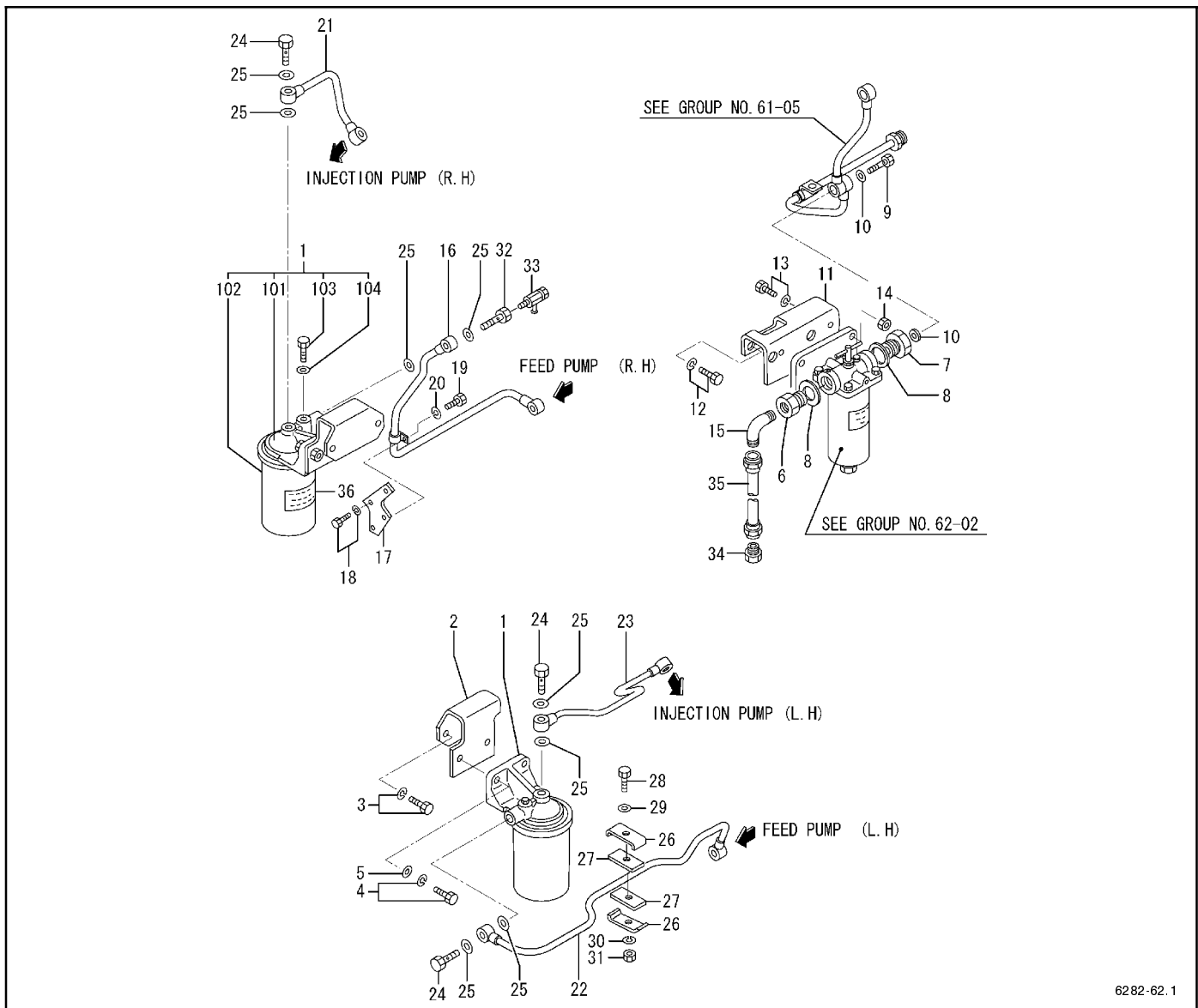
# Group 62: Fuel Filter



6282-62

| Item | Part No. | Description           | Qty. | Var. | Item | Part No. | Description          | Qty. | Var. |
|------|----------|-----------------------|------|------|------|----------|----------------------|------|------|
| 1    | GM36899  | Connector             | 1    |      | 1001 | GM36897  | Bracket assembly     | 2    |      |
| 2    | GM36900  | Connector             | 1    |      | 1002 | GM13947  | Filter, fuel         | 2    |      |
| 3    | GM21627  | Washer, sealing       | 2    |      | 1003 | GM14609  | Plug, air            | 2    |      |
| 4    | GM36901  | Bolt, eye             | 1    |      | 1004 | GM14527  | Washer               | 2    |      |
| 5    | GM14530  | Washer, sealing       | 3    |      | 11   | GM36898  | Bracket, fuel filter | 2    |      |
| 6    | TBD      | Bracket, fuel filter  | 1    |      | 12   | GM15158  | Bolt w/washer        | 4    |      |
| 7    | GM36706  | Bolt w/washer         | 2    |      | 13   | GM15142  | Bolt w/washer        | 4    |      |
| 8    | GM15152  | Bolt w/washer         | 2    |      | 14   | GM15174  | Washer, plain        | 4    |      |
| 9    | GM15165  | Nut                   | 2    |      | 15   | GM21662  | Label                | 2    |      |
| 10   | TBD      | Filter assembly, fuel | 2    |      |      |          |                      |      |      |

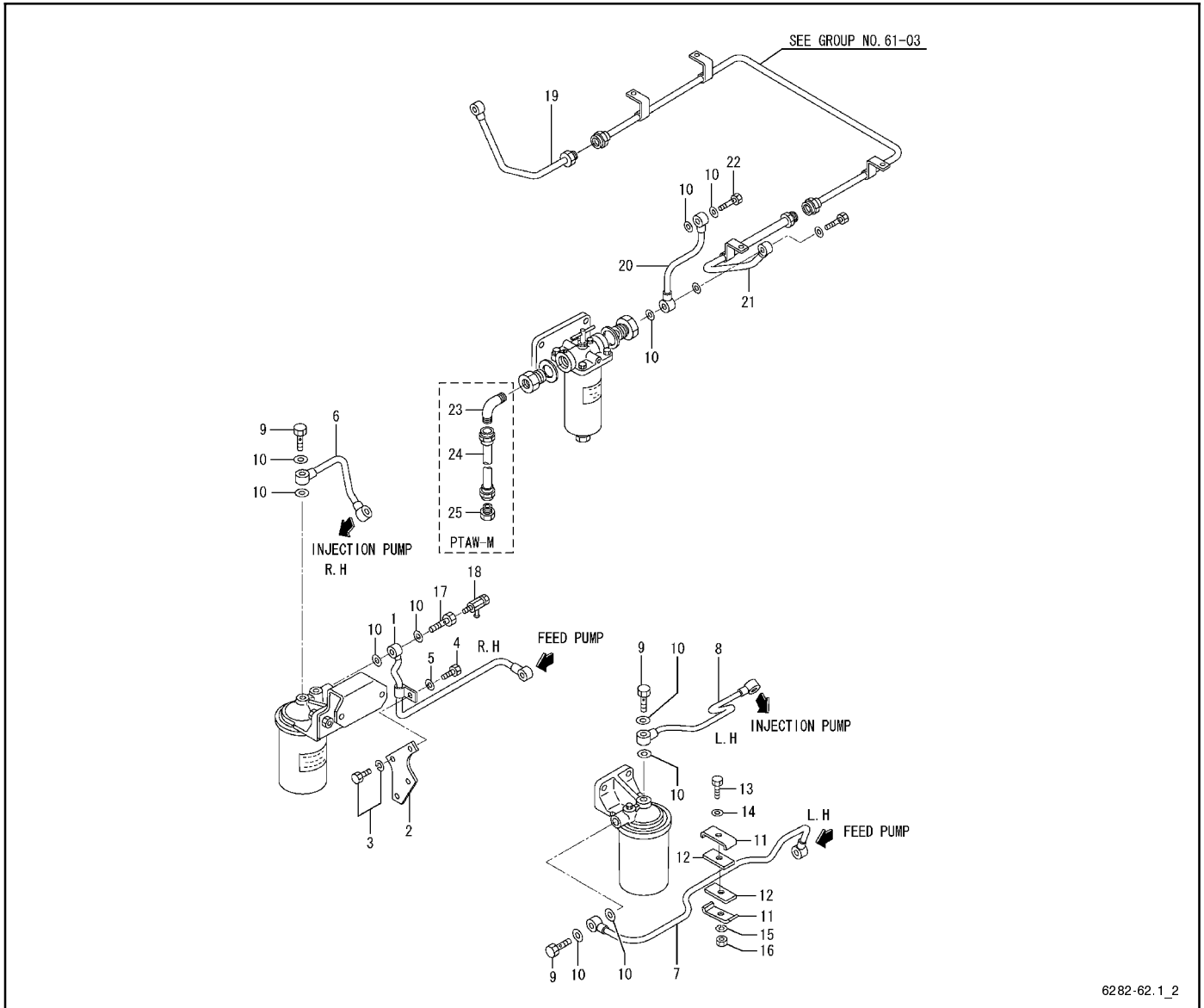
# Group 62.1: Fuel Filter Piping



6282-62.1

| Item | Part No. | Description           | Qty.<br>Var. | Item | Part No. | Description           | Qty.<br>Var. |
|------|----------|-----------------------|--------------|------|----------|-----------------------|--------------|
| 1    | GM36896  | Filter assembly, fuel | 2            | 17   | GM36904  | Plate, injection pump | 1            |
| 101  | GM36897  | Bracket assembly      | 2            | 18   | GM36905  | Bolt w/washer         | 3            |
| 102  | GM13951  | Fuel filter           | 2            | 19   | GM36474  | Bolt                  | 1            |
| 103  | GM14609  | Plug, air             | 2            | 20   | GM15179  | Washer, spring        | 1            |
| 104  | GM14527  | Washer                | 2            | 21   | GM36906  | Pipe, fuel            | 1            |
| 2    | GM36898  | Bracket, fuel filter  | 2            | 22   | GM36907  | Pipe, fuel            | 1            |
| 3    | GM15158  | Bolt w/washer         | 4            | 23   | GM36908  | Pipe, fuel            | 1            |
| 4    | GM15142  | Bolt w/washer         | 4            | 24   | GM15234  | Bolt, eye             | 3            |
| 5    | GM15174  | Washer, plain         | 4            | 25   | GM14530  | Washer, sealing       | 8            |
| 6    | GM36899  | Connector             | 1            | 26   | GM15599  | Clamp                 | 2            |
| 7    | GM36900  | Connector             | 1            | 27   | GM15600  | Seat                  | 2            |
| 8    | GM21627  | Washer, sealing       | 2            | 28   | GM15956  | Bolt                  | 1            |
| 9    | GM36901  | Bolt, eye             | 1            | 29   | GM15174  | Washer, plain         | 1            |
| 10   | GM14530  | Washer, sealing       | 2            | 30   | GM15179  | Washer, spring        | 1            |
| 11   | GM36902  | Bracket, filter       | 1            | 31   | GM36909  | Nut, jam              | 1            |
| 12   | GM36706  | Bolt w/washer         | 2            | 32   | GM36910  | Bolt, eye             | 1            |
| 13   | GM15152  | Bolt w/washer         | 2            | 33   | GM15552  | Air vent              | 1            |
| 14   | GM15165  | Nut                   | 2            | 34   | GM36911  | Connector             | 1            |
| 15   | GM36343  | Elbow                 | 1            | 35   | GM22029  | Pipe                  | 1            |
| 16   | GM36903  | Pipe, fuel            | 1            | 36   | GM21662  | Label, caution        | 2            |

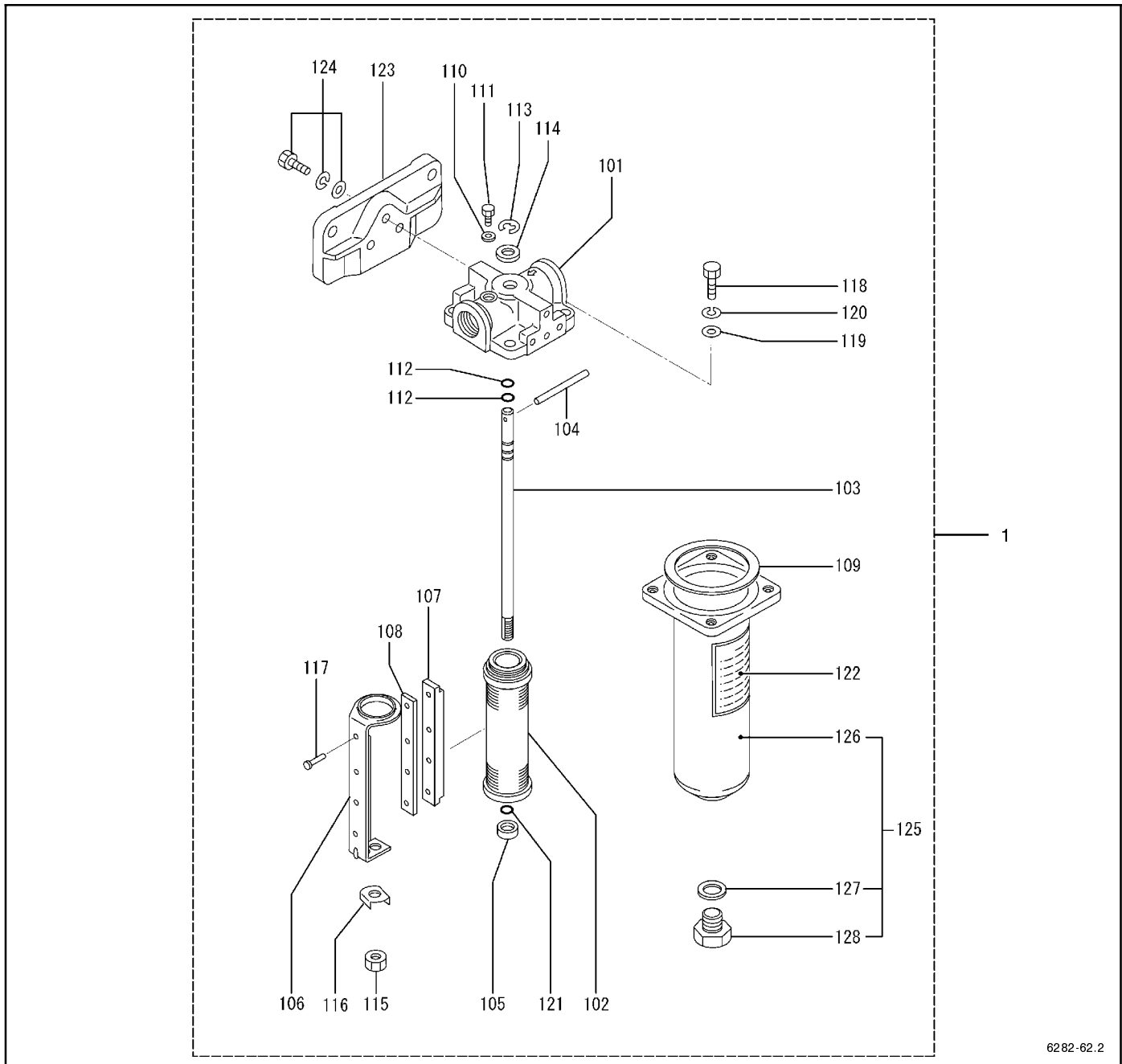
# Group 62.1: Fuel Filter Piping



6282-62.1\_2

| Item | Part No. | Description           | Qty.<br>Var.<br>2 | Item | Part No. | Description     | Qty.<br>Var.<br>2 |
|------|----------|-----------------------|-------------------|------|----------|-----------------|-------------------|
| 1    | GM36903  | Pipe, fuel            | 1                 | 14   | GM15174  | Washer, plain   | 1                 |
| 2    | GM36904  | Plate, injection pump | 1                 | 15   | GM15179  | Washer, spring  | 1                 |
| 3    | GM36905  | Bolt, w/washer        | 3                 | 16   | GM36909  | Nut, jam        | 1                 |
| 4    | GM36474  | Bolt                  | 1                 | 17   | GM36910  | Bolt, eye       | 1                 |
| 5    | GM15179  | Washer, spring        | 1                 | 18   | GM15552  | Air vent        | 1                 |
| 6    | GM36906  | Pipe, fuel            | 1                 | 19   | GM36719  | Pipe, fuel feed | 1                 |
| 7    | GM36907  | Pipe, fuel            | 1                 | 20   | GM36720  | Pipe, fuel feed | 1                 |
| 8    | GM36908  | Pipe, fuel            | 1                 | 21   | GM36721  | Pipe, fuel feed | 1                 |
| 9    | GM15234  | Bolt, eye             | 3                 | 22   | GM36901  | Bolt, eye       | 1                 |
| 10   | GM14530  | Washer, sealing       | 11                | 23   | GM36343  | Elbow           | 1                 |
| 11   | GM15599  | Clamp                 | 2                 | 24   | GM22029  | Pipe            | 1                 |
| 12   | GM15600  | Seat                  | 2                 | 25   | GM36911  | Connector       | 1                 |
| 13   | GM15956  | Bolt                  | 1                 |      |          |                 |                   |

# Group 62.2: Fuel Filter (Wire Element Type)

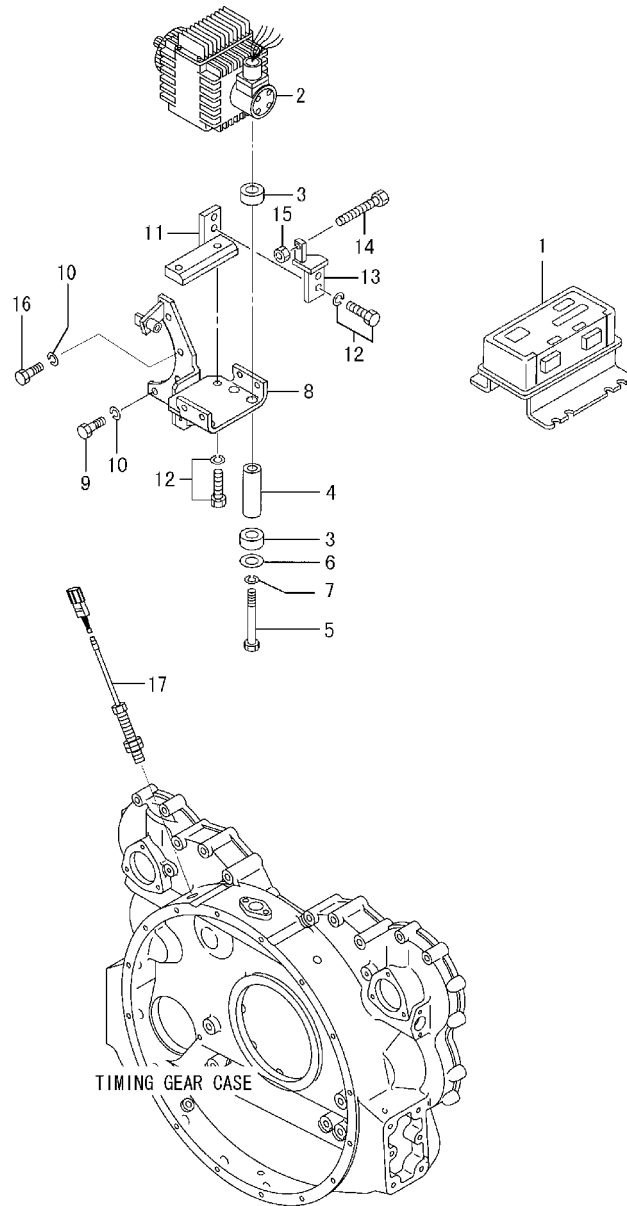


6282-62.2

| Item | Part No. | Description           | Qty. |
|------|----------|-----------------------|------|
|      |          |                       | Var. |
| 1    | GM36912  | Filter assembly, fuel | 1    |
| 101  | GM36913  | Cover                 | 1    |
| 102  | GM36914  | Element               | 1    |
| 103  | GM36915  | Rod                   | 1    |
| 104  | GM36916  | Handle                | 1    |
| 105  | GM36917  | Collar                | 1    |
| 106  | GM36918  | Plate                 | 1    |
| 107  | GM36919  | Scraper               | 1    |
| 108  | GM36920  | Retainer              | 1    |
| 109  | GM35980  | Packing               | 1    |
| 110  | GM35978  | Gasket                | 1    |
| 111  | GM36923  | Bolt                  | 1    |
| 112  | GM35979  | O-ring                | 2    |
| 113  | GM36925  | Ring, snap            | 1    |
| 114  | GM36926  | Washer, plain         | 1    |

| Item | Part No. | Description     | Qty. |
|------|----------|-----------------|------|
|      |          |                 | Var. |
| 115  | GM36927  | Nut             | 1    |
| 116  | GM36928  | Washer          | 1    |
| 117  | GM36929  | Rivet           | 4    |
| 118  | GM36930  | Bolt            | 4    |
| 119  | GM36931  | Washer, plain   | 4    |
| 120  | GM36932  | Washer, spring  | 4    |
| 121  | GM36933  | O-ring          | 1    |
| 122  | GM36934  | Plate, caution  | 1    |
| 123  | GM36935  | Bracket         | 1    |
| 124  | GM36936  | Bolt            | 3    |
| 125  | GM36937  | Bottle assembly | 1    |
| 126  | GM36938  | Case, lower     | 1    |
| 127  | GM36939  | Seal, fastener  | 1    |
| 128  | GM36940  | Plug, drain     | 1    |

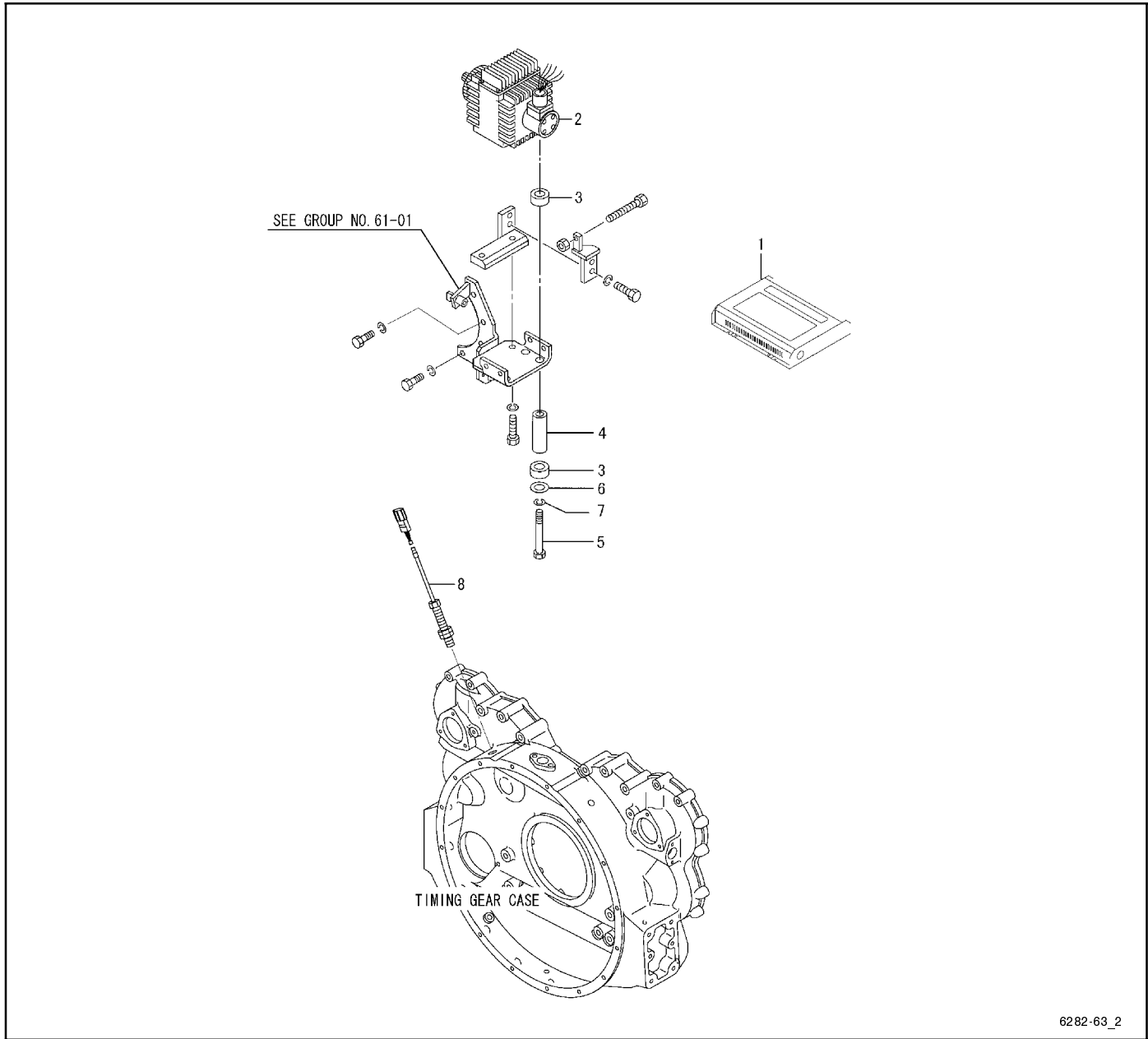
# Group 63.1: Governor



6282-63\_1

| Item | Part No. | Description      | Qty. |
|------|----------|------------------|------|
| 1    | GM36941  | Controller       | 1    |
| 2    | GM21678  | Actuator, proact | 1    |
| 3    | GM31466  | Mount            | 8    |
| 4    | GM21674  | Spacer           | 4    |
| 5    | GM36942  | Bolt             | 4    |
| 6    | GM22087  | Washer           | 4    |
| 7    | GM15178  | Washer, spring   | 4    |
| 8    | GM36943  | Bracket          | 1    |
| 9    | GM36944  | Bolt             | 3    |
| 10   | GM15180  | Washer, spring   | 4    |
| 11   | GM36945  | Bracket, stopper | 1    |
| 12   | GM15141  | Bolt w/washer    | 4    |
| 13   | GM36946  | Bracket, stopper | 1    |
| 14   | GM36947  | Bolt w/washer    | 1    |
| 15   | GM15163  | Nut              | 1    |
| 16   | GM36654  | Bolt, reamer     | 1    |
| 17   | GM31302  | Pickup, magnetic | 1    |

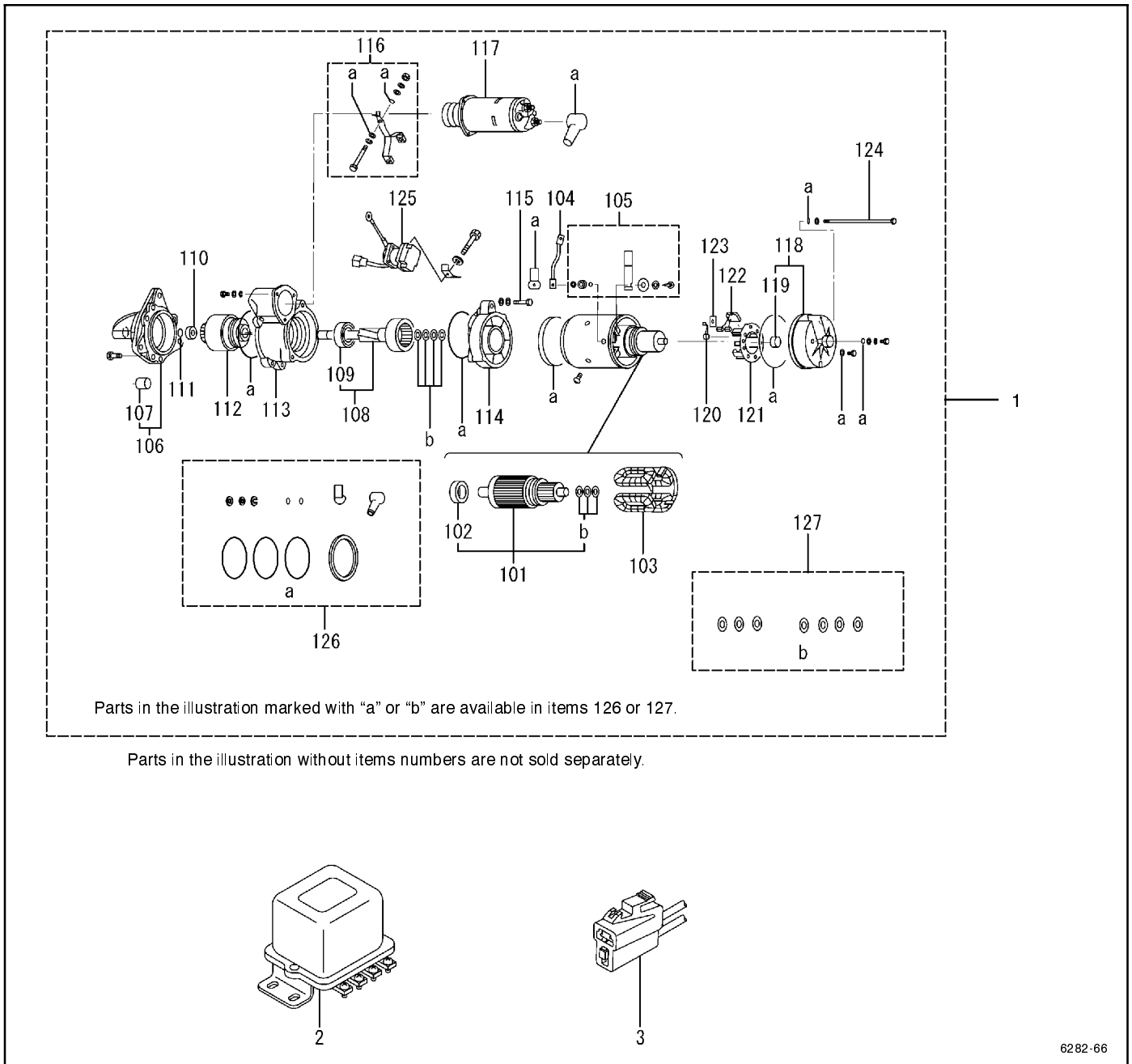
# Group 63.1: Governor



6282-63\_2

| Item | Part No. | Description      | Qty. |
|------|----------|------------------|------|
|      |          |                  | Var. |
| 1    | GM62222  | Controller       | 1    |
| 2    | GM31464  | Actuator, proact | 1    |
| 3    | GM31466  | Mount            | 8    |
| 4    | GM21674  | Spacer           | 4    |
| 5    | GM36942  | Bolt             | 4    |
| 6    | GM22087  | Washer           | 4    |
| 7    | GM15178  | Washer, spring   | 4    |
| 8    | GM31302  | Pickup, magnetic | 1    |

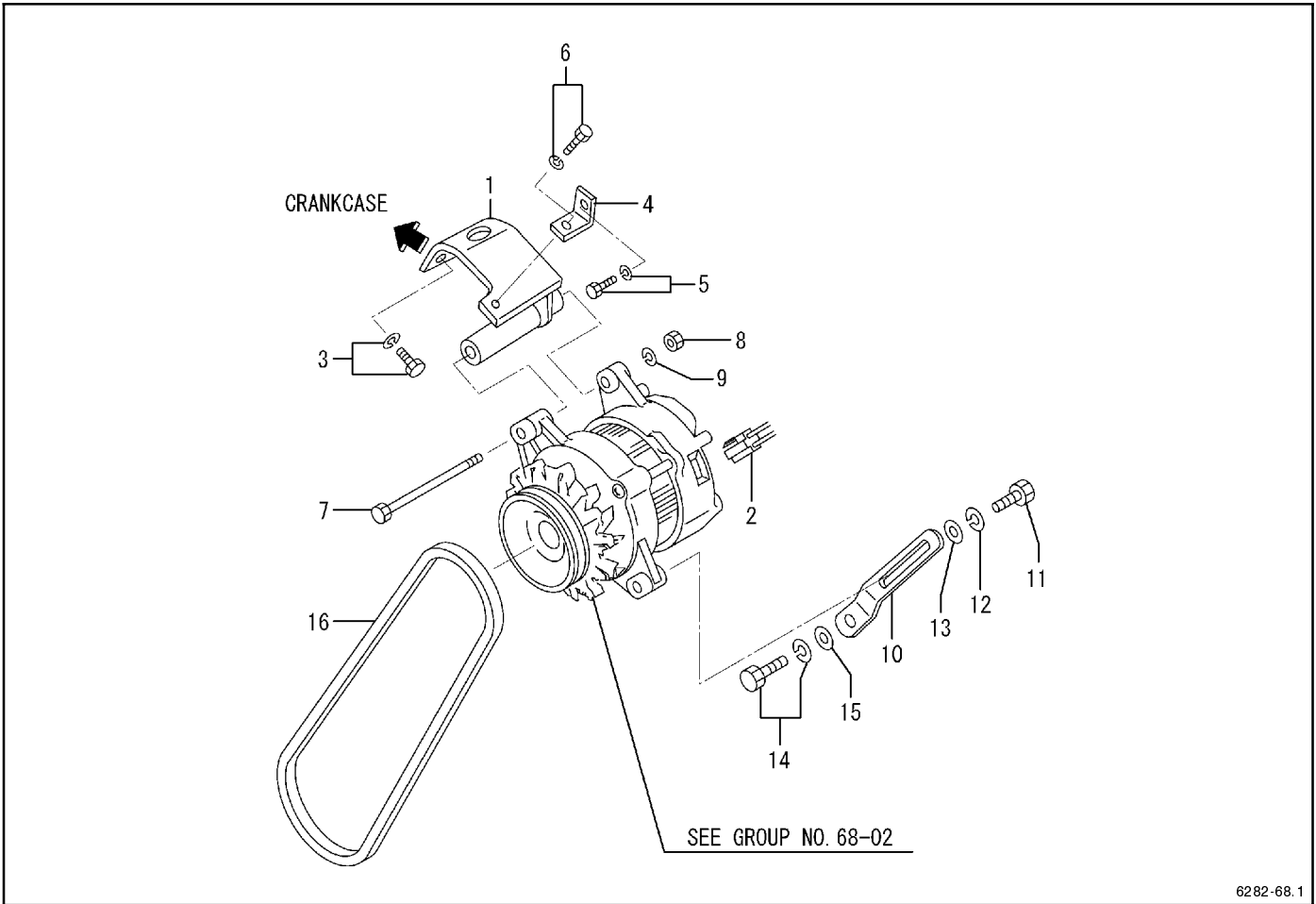
# Group 66: Starter



6282-66

| Item | Part No. | Description       | Qty. | Var. | Item | Part No. | Description     | Qty. | Var. |
|------|----------|-------------------|------|------|------|----------|-----------------|------|------|
| 1    | GM36948  | Starter assembly  | 2    |      | 115  | GM36953  | Bolt            | 6    |      |
| 101  | GM36949  | Armature assembly | 2    |      | 116  | GM21643  | Yoke assembly   | 2    |      |
| 102  | GM21641  | Bearing, ball     | 2    |      | 117  | GM21601  | Switch assembly | 2    |      |
| 103  | GM21591  | Coil, field       | 2    |      | 118  | GM36954  | Bracket         | 2    |      |
| 104  | GM36950  | Wire              | 2    |      | 119  | GM36955  | Metal           | 2    |      |
| 105  | GM31488  | Terminal          | 2    |      | 120  | GM21647  | Spring, brush   | 8    |      |
| 106  | GM31491  | Bracket, front    | 2    |      | 121  | GM21595  | Holder, brush   | 2    |      |
| 107  | GM22085  | Metal             | 2    |      | 122  | GM21646  | Brush           | 8    |      |
| 108  | GM36951  | Shaft assembly    | 2    |      | 123  | GM21652  | Plate           | 8    |      |
| 109  | GM21639  | Bearing, ball     | 2    |      | 124  | GM21589  | Bolt            | 4    |      |
| 110  | GM21642  | Stopper, pinion   | 2    |      | 125  | GM34345  | Relay, safety   | 2    |      |
| 111  | GM21648  | Ring, clip        | 2    |      | 126  | GM31490  | Washer assembly | 2    |      |
| 112  | GM36952  | Clutch assembly   | 2    |      | 127  | GM36956  | Seal assembly   | 2    |      |
| 113  | GM21645  | Housing           | 2    |      | 2    | GM36957  | Relay, safety   | 1    |      |
| 114  | GM21644  | Bracket           | 2    |      | 3    | GM31496  | Connector       | 3    |      |

# Group 68.1: Alternator Mounting

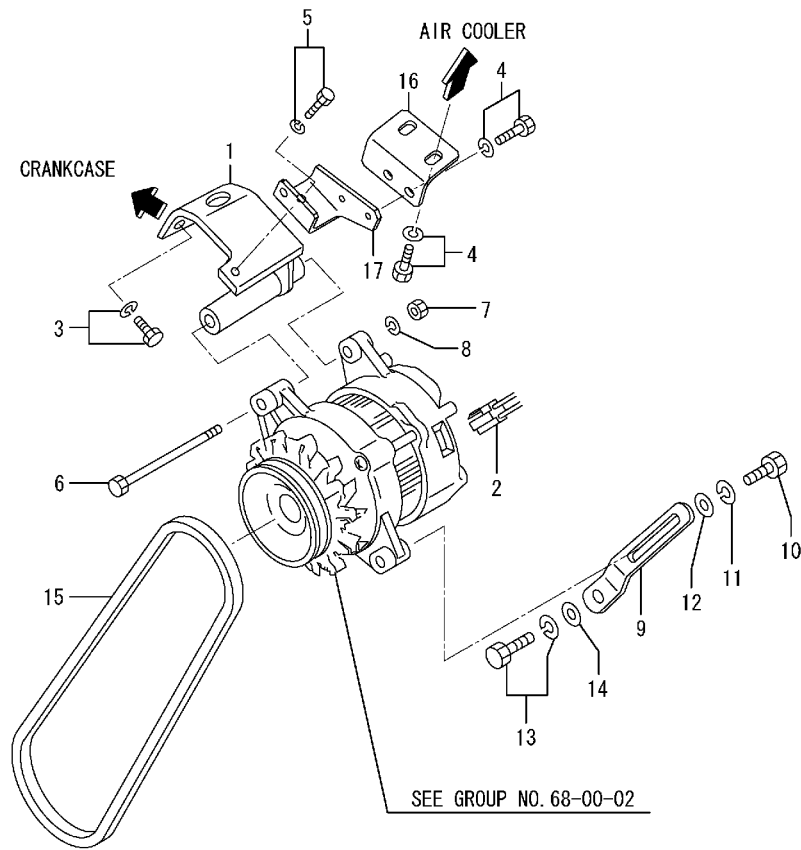


6282-68.1

| Item | Part No. | Description         | Qty. |
|------|----------|---------------------|------|
|      |          |                     | Var. |
| 1    | GM36958  | Bracket, alternator | 1    |
| 2    | GM31496  | Connector           | 1    |
| 3    | GM15159  | Bolt w/washer       | 2    |
| 4    | GM36959  | Stay                | 1    |
| 5    | GM15159  | Bolt w/washer       | 1    |
| 6    | GM15140  | Bolt                | 1    |
| 7    | GM22096  | Bolt                | 1    |
| 8    | GM15165  | Nut                 | 1    |
| 9    | GM15180  | Washer, spring      | 1    |
| 10   | GM36960  | Plate, adjusting    | 1    |
| 11   | GM36961  | Bolt                | 1    |
| 12   | GM15181  | Washer, spring      | 1    |
| 13   | GM15992  | Washer              | 1    |
| 14   | GM15150  | Bolt                | 1    |
| 15   | GM15175  | Washer              | 1    |
| 16   | GM36962  | V-belt, alternator  | 1    |



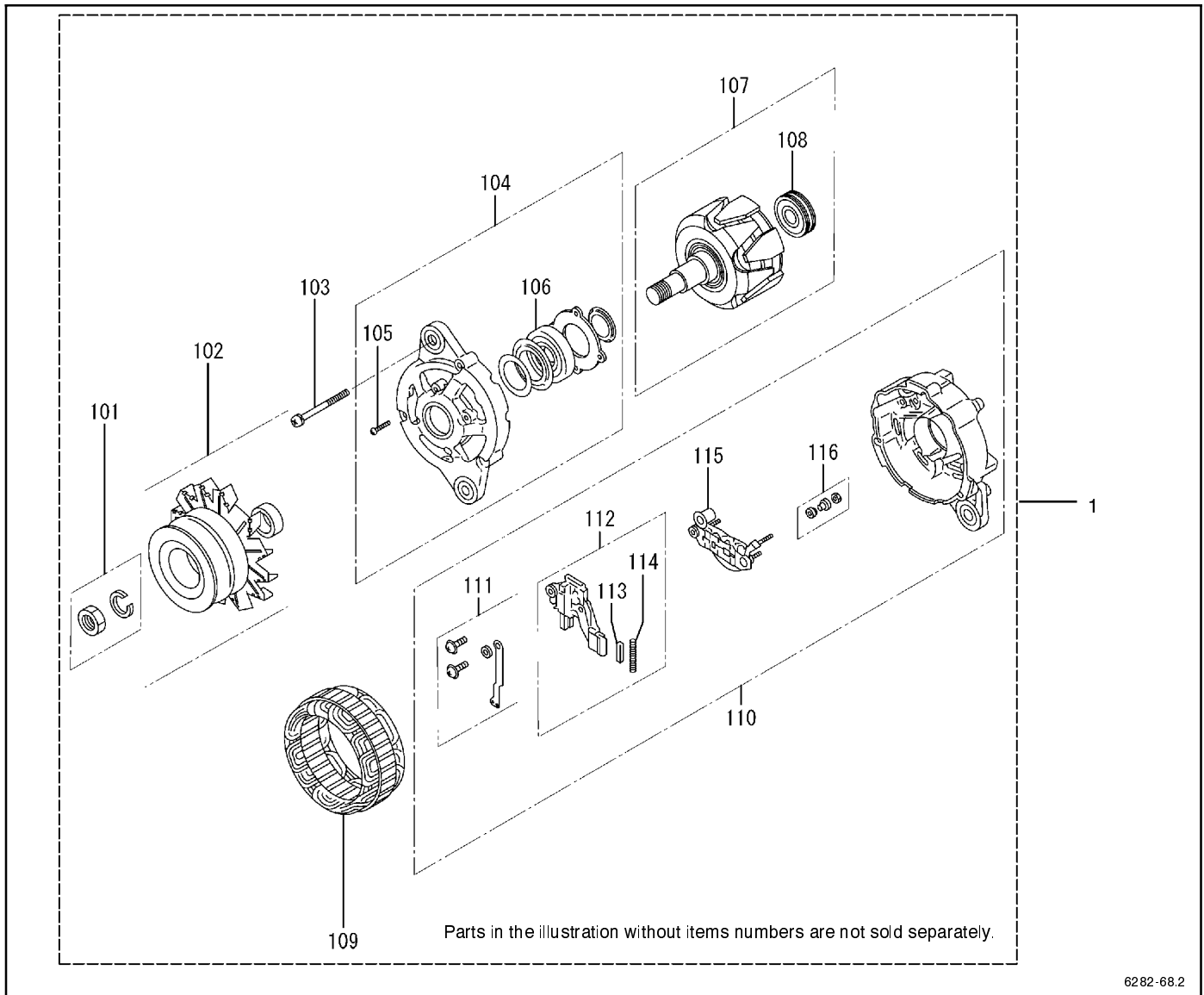
# Group 68.1: Alternator Mounting, continued



6282-68.1\_2

| Item | Part No. | Description         | Qty.      |
|------|----------|---------------------|-----------|
|      |          |                     | Var.<br>2 |
| 1    | GM36958  | Bracket, alternator | 1         |
| 2    | GM31496  | Connector           | 1         |
| 3    | GM15159  | Bolt w/washer       | 2         |
| 4    | GM15159  | Bolt w/washer       | 4         |
| 5    | GM15140  | Bolt                | 1         |
| 6    | GM22096  | Bolt                | 1         |
| 7    | GM15165  | Nut                 | 1         |
| 8    | GM15180  | Washer, spring      | 1         |
| 9    | GM36960  | Plate, adjusting    | 1         |
| 10   | GM36961  | Bolt                | 1         |
| 11   | GM15181  | Washer, spring      | 1         |
| 12   | GM15992  | Washer              | 1         |
| 13   | GM15150  | Bolt                | 1         |
| 14   | GM15175  | Washer              | 1         |
| 15   | GM36962  | V-belt, alternator  | 1         |
| 16   | GM57428  | Stay, alternator    | 1         |
| 17   | GM57429  | Stay, alternator    | 1         |

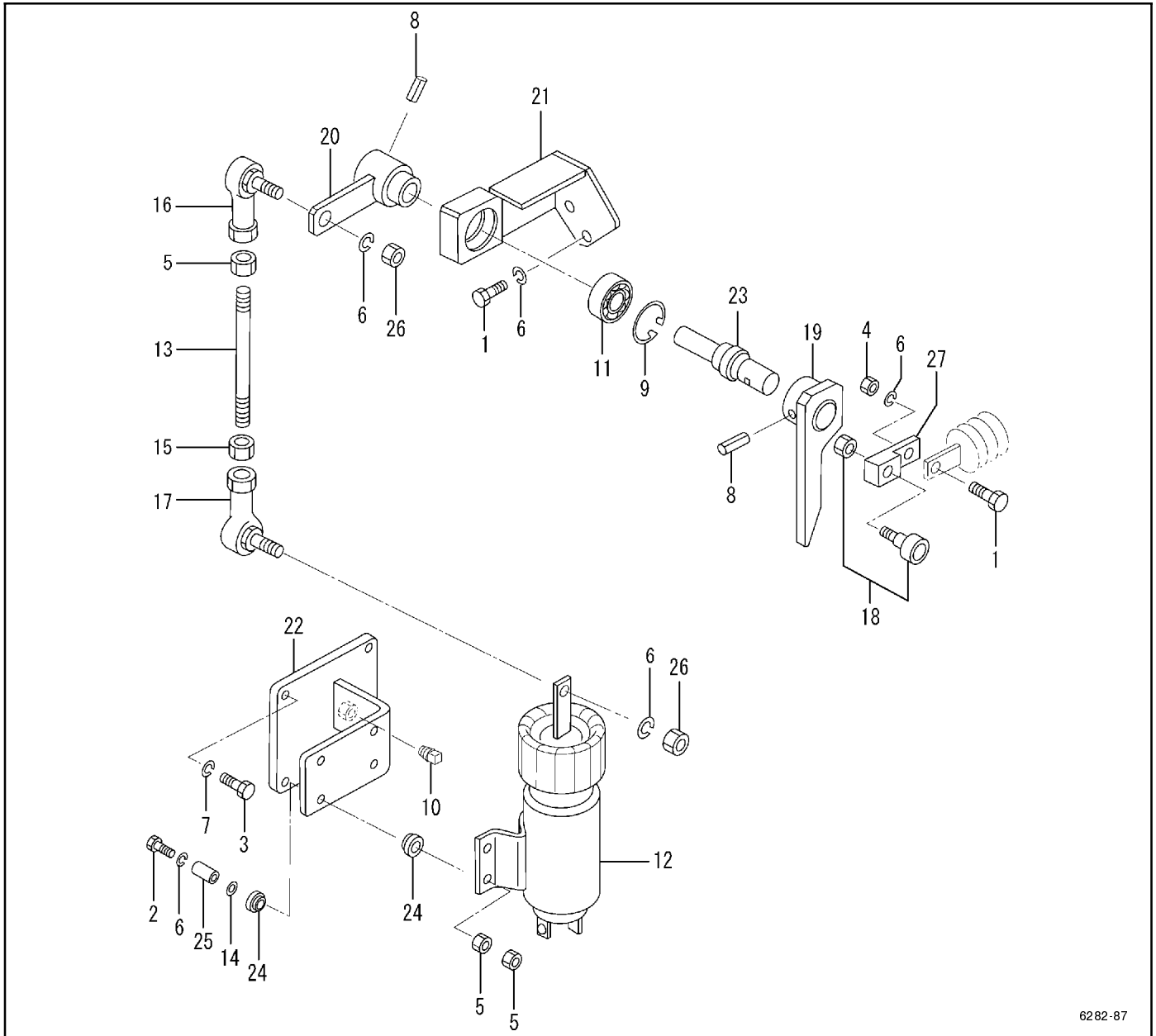
# Group 68.2: Alternator



6282-68.2

| Item | Part No. | Description             | Qty. |
|------|----------|-------------------------|------|
| 1    | GM36963  | Alternator assembly     | 1    |
| 101  | GM15092  | Nut set                 | 1    |
| 102  | GM36964  | Pulley assembly         | 1    |
| 103  | GM36965  | Screw, set              | 1    |
| 104  | GM36966  | Bracket assembly, front | 1    |
| 105  | GM36967  | Screw, set              | 1    |
| 106  | GM36968  | Bearing                 | 1    |
| 107  | GM36969  | Rotor assembly          | 1    |
| 108  | GM36970  | Bearing, rear           | 1    |
| 109  | GM36971  | Stator                  | 1    |
| 110  | GM36972  | Bracket                 | 1    |
| 111  | GM36973  | Terminal                | 1    |
| 112  | GM36974  | Regulator assembly      | 1    |
| 113  | GM36975  | Brush                   | 2    |
| 114  | GM36976  | Spring, brush           | 2    |
| 115  | GM36977  | Rectifier assembly      | 1    |
| 116  | GM36978  | Nut, set                | 1    |

# Group 87: Stop System

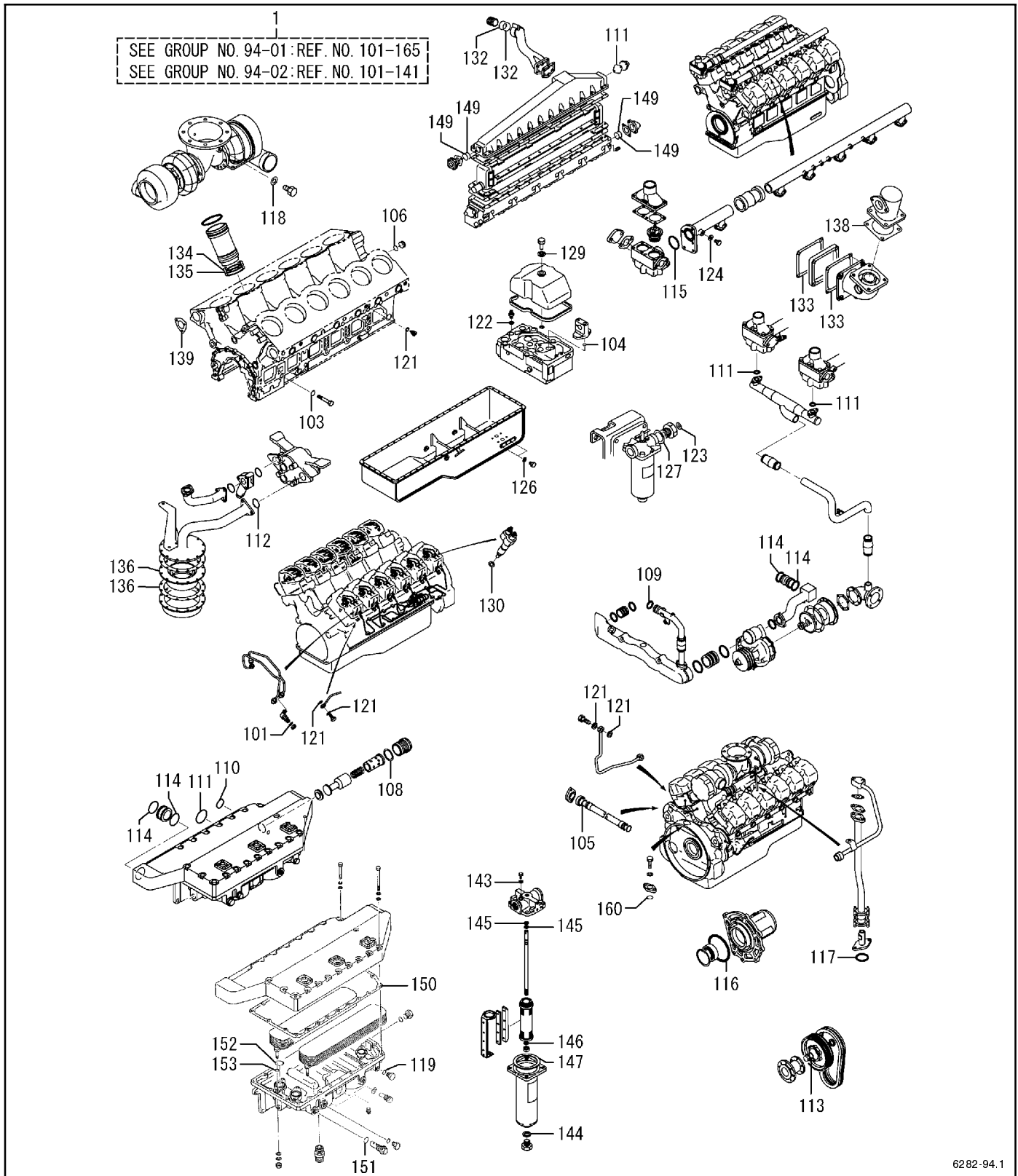


6282-87

| Item | Part No. | Description    | Qty. | Var. |
|------|----------|----------------|------|------|
| 1    | GM36628  | Bolt           | 3    |      |
| 2    | GM15101  | Bolt           | 4    |      |
| 3    | GM15129  | Bolt           | 4    |      |
| 4    | GM15162  | Nut            | 1    |      |
| 5    | GM15169  | Nut            | 9    |      |
| 6    | GM15177  | Washer, spring | 9    |      |
| 7    | GM15179  | Washer, spring | 4    |      |
| 8    | GM36979  | Pin, spring    | 2    |      |
| 9    | GM15220  | Ring, snap     | 1    |      |
| 10   | GM16035  | Plug, tapered  | 1    |      |
| 11   | GM15257  | Bearing, ball  | 1    |      |
| 12   | GM21598  | Solenoid, stop | 1    |      |
| 13   | GM34355  | Rod            | 1    |      |
| 14   | GM14555  | Washer         | 4    |      |

| Item | Part No. | Description     | Qty. | Var. |
|------|----------|-----------------|------|------|
| 15   | GM14556  | Nut             | 1    |      |
| 16   | GM31499  | Joint, ball     | 1    |      |
| 17   | GM31500  | Joint, ball     | 1    |      |
| 18   | GM14991  | Follower        | 1    |      |
| 19   | GM36980  | Lever           | 1    |      |
| 20   | GM36981  | Lever           | 1    |      |
| 21   | GM36982  | Support         | 1    |      |
| 22   | GM36983  | Cover           | 1    |      |
| 23   | GM36984  | Shaft           | 1    |      |
| 24   | GM14998  | Cushion, rubber | 8    |      |
| 25   | GM14999  | Spacer          | 4    |      |
| 26   | GM14522  | Nut, lock       | 2    |      |
| 27   | GM36985  | Connector       | 1    |      |

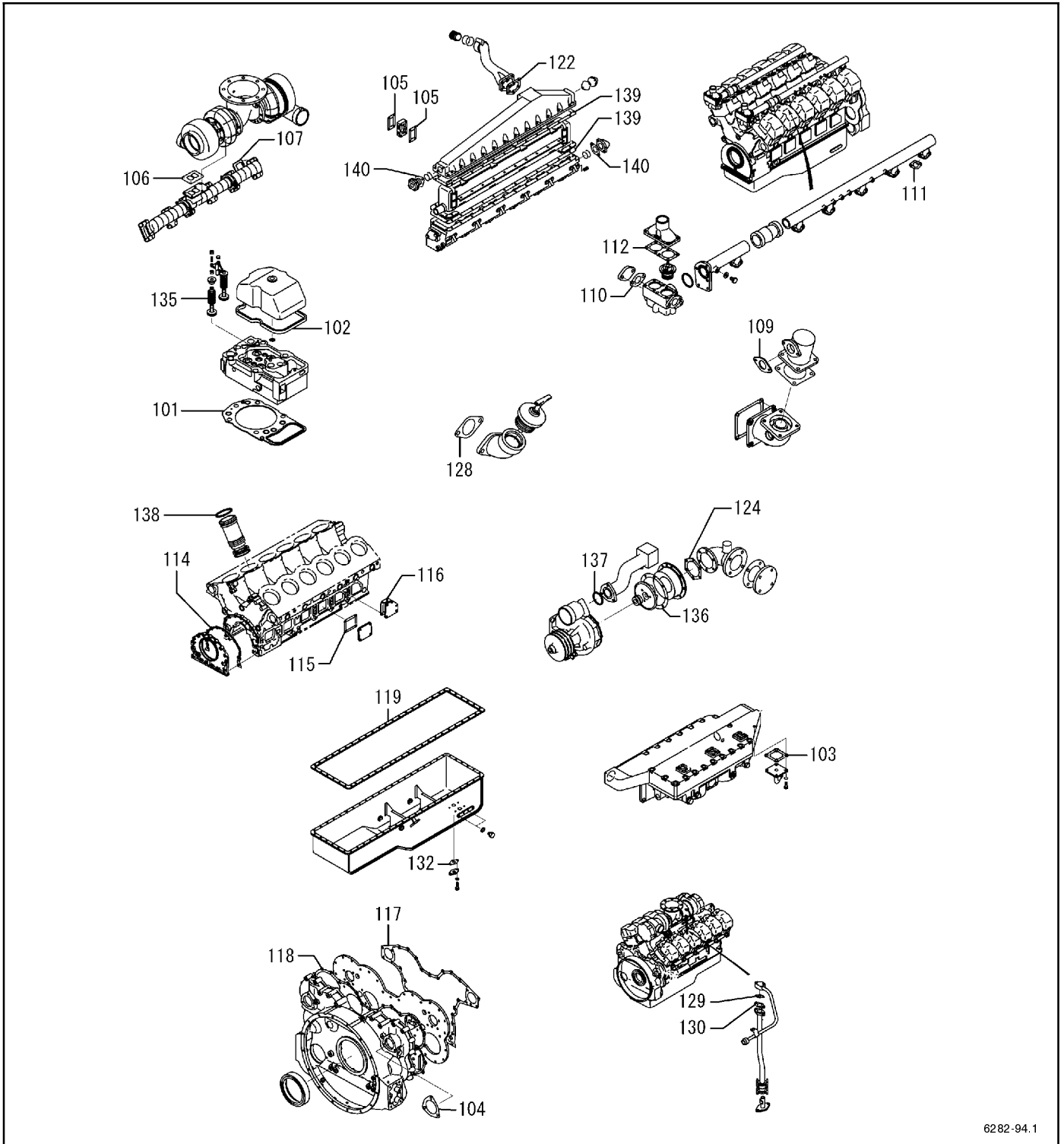
# Group 94.1: Overhaul Gasket Kit



6282-94.1

| Item | Part No. | Description          | Qty. | Var. |
|------|----------|----------------------|------|------|
| 1    | GM36986  | Gasket kit, overhaul | 1    | 1    |

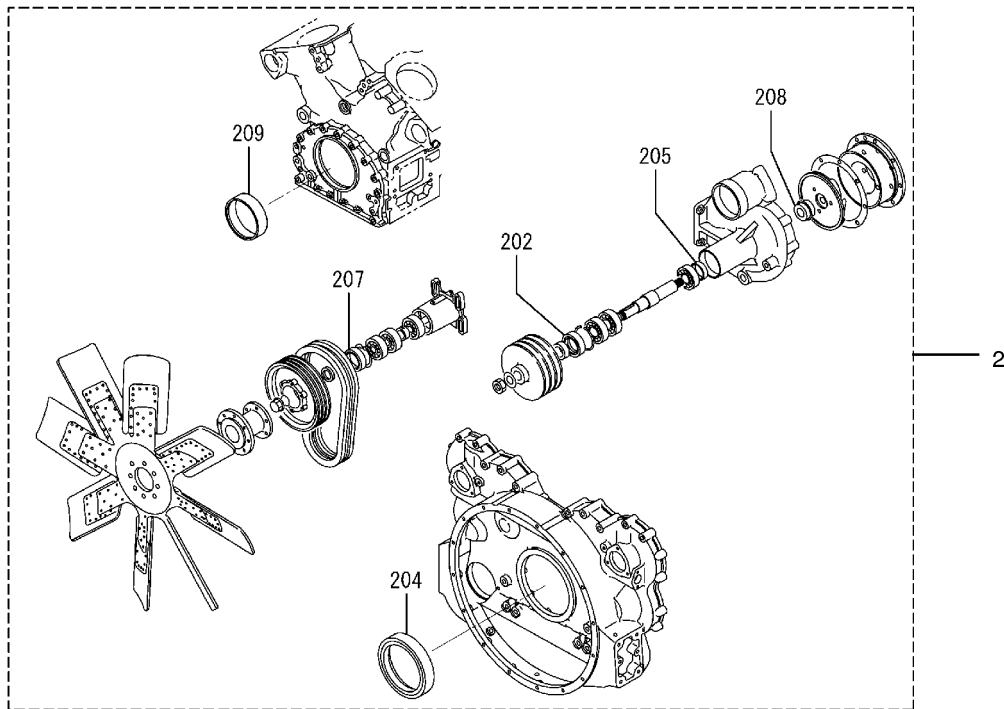
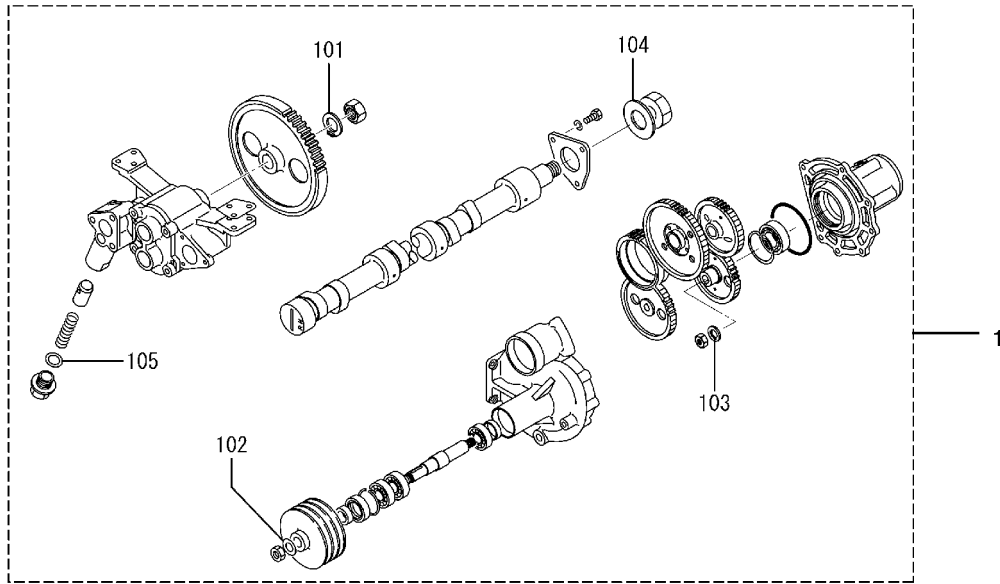
# Group 94.2: Overhaul Gasket Kit, continued



6282-94.1

| Item | Part No. | Description          | Qty.<br>Var. |
|------|----------|----------------------|--------------|
| 1    | GM36986  | Gasket kit, overhaul | 1            |

# Group 94.3: Oil Seal Kit



6282-94.2

| Item | Part No. | Description      | Qty. | Item | Part No. | Description        | Qty. |
|------|----------|------------------|------|------|----------|--------------------|------|
|      |          |                  | Var. |      |          |                    | Var. |
| 1    | GM36987  | Washer kit, lock | 1    | 202  | GM36542  | Seal, oil          | 1    |
| 101  | GM36447  | Washer           | 1    | 203  | GM36992  | Seal assembly, oil | 2    |
| 102  | GM36543  | Washer           | 1    | 204  | GM36993  | Seal, oil          | 1    |
| 103  | GM36988  | Washer, lock     | 2    | 205  | GM36551  | Seal, oil          | 1    |
| 104  | GM36989  | Washer, lock     | 2    | 206  | GM36994  | Seal, oil          | 2    |
| 105  | GM36990  | Washer           | 1    | 207  | GM36604  | Seal, oil          | 1    |
| 2    | GM36991  | Seal kit, oil    | 1    | 208  | GM31685  | Seal, unit         | 1    |
| 201  | GM36408  | Seal, oil        | 2    | 209  | GM36995  | Seal, oil          | 1    |



**TP-6282 5/12c**

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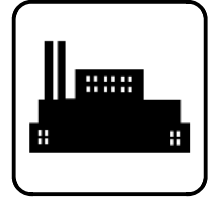
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# Service Parts

## Industrial Generator Sets



Models:

**600-2000REOZMB**

**750-2000REOZMD**

See Group 701: Literature, inside this manual for  
part numbers of engine parts catalogs

**KOHLER**<sup>®</sup>  
POWER SYSTEMS

**ISO 9001**  
**KOHLER**  
POWER SYSTEMS  
NATIONALLY REGISTERED

TP-6484 9/11a

# Routine Engine Service Parts

Figure 1 identifies routine engine service parts for generator set engines listed in this manual.

Refer to the groups on the following pages and the engine service parts manuals for a complete list of maintenance and service parts.

| Description             | Part Number (Quantity per Engine) |             |             |                |                             |                             |
|-------------------------|-----------------------------------|-------------|-------------|----------------|-----------------------------|-----------------------------|
|                         | 600 kW                            | 750/800 kW  | 900/1000 kW | 1250 kW        | 1600 kW                     | 1750/2000 kW                |
| Oil Filter              | GM13949 (2)                       | GM32057 (4) | GM13942 (4) | GM38852 (4)    | GM38852 (4)                 | GM38852 (4)                 |
| Oil Filter (bypass)     | GM13950 (1)                       | GM13950 (1) | GM13943 (1) | GM13950 (1)    | GM13950 (1)                 | GM13950 (1)                 |
| Fuel Filter (primary)   | GM13947 (2)                       | GM13947 (2) | GM13947 (4) | GM13947 (4)    | GM13947 (4)                 | GM13947 (4)                 |
| Fuel Filter (secondary) | -                                 | GM36914 (1) | -           | -              | -                           | -                           |
| Belt (alternator)       | GM55484 (1)                       | GM36962 (1) | GM55488 (1) | See Note Below | GM21917 (1)                 | GM21917 (1)                 |
| Belt (water pump)       | GM55485 (1)                       | GM35975 (1) | -           | -              | -                           | -                           |
| Belt (intercooler pump) | GM55486 (1)                       | GM55487 (1) | GM55488 (1) | See Note Below | GM55490 (1),<br>GM55491 (1) | GM55490 (1),<br>GM55491 (1) |
| Belt (fan drive)        | -                                 | GM36598 (1) | GM55489 (1) | See Group 104  | See Group 104               | See Group 104               |

**Figure 1** Routine Engine Service Parts

Alternator belt:  
 GM21917: Engine serial number before 13117  
 GM97166: Engine serial number 13117 and after  
 Intercooler pump belt (Qty 1=set of 2):  
 GM55491: Engine serial number before 14209  
 GM98766: Engine serial number 14209 and after

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# Introduction

This manual lists service replacement parts for 600-2000REOZMB/750-2000REOZMD generator sets.

At the time of print this manual applied to the generator set specification (spec) numbers listed in the Specification Number Index. On occasion this manual may apply to specs not listed in the Specification Number Index.

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This manual includes the following main sections:

**Table of Contents.** Lists the sections of the manual.

**Introduction (and other information sections).** Contains introductory material about part numbers, illustrations, and hardware.

**Specification Number Index.** Lists the generator set specs and groups.

**Group Parts Lists.** List the part numbers of parts in the groups.

**Kit Sections.** List modules and accessories and their parts.

**Appendices.** Include Abbreviations, Common Hardware Application Guidelines, General Torque Specifications, Common Hardware Identification, and Common Hardware List.

## Numbering System Significance

This manual uses the following numbering systems:

**Specification Number.** The product identification number located on the generator set nameplate. Spec numbers break down into groups.

**Group Number.** A unique number representing a parts group needed to assemble a generator set function. For example, Group 101 is the Air Intake group.

**Variation or Module Number.** A group might have several variations. Each variation performs the same function with different parts lists. For example, a 50 Hz generator alternator and a 60 Hz generator alternator both perform the same function; however, with different parts. Each difference requires a group variation or module number.

**Part Number.** The part number identifies an individual assembly, subassembly, component, or accessory kit.

## Illustrations

Illustrations (or exploded-view drawings) best representing the widest range of variations accompany most groups in this manual. Illustrations do not depict all details and may not show all parts. Do not use illustrations for assembly or disassembly.

## How to Find Part Numbers

Use the following steps to locate a service replacement part.

1. Locate the generator set nameplate to **identify the generator set spec number.**
2. Locate a second generator set nameplate listing accessories to **identify installed modules.** On some models the accessory nameplate is mounted inside the generator junction box.
3. **Turn to the Specification Number Index.** The first column lists the generator set spec numbers. The headings identify the groups of parts that make up the generator set.
4. **Identify the group** most likely to include the service part number.
5. **Find the group variation number** at the intersection of the spec number row and the group column. Note the variation number.
6. **Page forward to locate the group** identified in step 4 or find the appropriate page in the Table of Contents.
7. **Find the part on the illustration** and note the item number of the part or **find the part description in the parts list.**
8. Select **the part number that corresponds to your group variation.** The first column lists the illustration item number. Find the variation identified in the Specification Number Index or the module number found on the generator set nameplate in the appropriate column on the right side of the parts list table. Find the quantity used at the intersection of the item number row and the variation column. A blank space at the intersection means the variation/module does not use that part number.

## Hardware References

Many common hardware items do not appear in parts manuals or will appear as common hardware entries. A common hardware entry lists the size of the hardware. For example, an item that appears as "Hardware, 3/8-16" in the text means that the piece is 3/8-16 size. Obtain common hardware locally or, if contacting the factory, use the Common Hardware List in the appendix to identify the common hardware part number and specifications. See Common Hardware Application Guidelines in the appendix for mating hardware instructions.

Some hardware items require a specific size or some other characteristic. In that case, use the part number listed in the text.

**When replacing hardware, do not substitute inferior grade hardware.** Replacement hardware grade should be equal to or better than the grade of the manufacturer's original hardware. Use the Common Hardware List in the appendix to identify the common hardware hardness.

# Specification Number Index

| Group Title       | Air Intake       | Cooling System | Engine | Nameplates and Decals | Skid and Plant Mounting | Generator and Mounting | Controller and Mounting | Literature |
|-------------------|------------------|----------------|--------|-----------------------|-------------------------|------------------------|-------------------------|------------|
| Group No.         | 101              | 104            | 105    | 107                   | 109                     | 201                    | 301                     | 701        |
| Spec No.          | Variation Number |                |        |                       |                         |                        |                         |            |
| <b>600REOZMB</b>  |                  |                |        |                       |                         |                        |                         |            |
| GM50709-GA1       | *                | *              | 1      | 1                     | *                       | *                      | †                       | 241        |
| <b>750REOZMB</b>  |                  |                |        |                       |                         |                        |                         |            |
| GM31728-GA6       | *                | *              | 2      | 1                     | *                       | *                      | †                       | 242        |
| <b>800REOZMB</b>  |                  |                |        |                       |                         |                        |                         |            |
| GM31728-GA5       | *                | *              | 2      | 1                     | *                       | *                      | †                       | 243        |
| <b>900REOZMB</b>  |                  |                |        |                       |                         |                        |                         |            |
| GM31223-GA5       | *                | *              | 3      | 2                     | *                       | *                      | †                       | 244        |
| <b>1000REOZMB</b> |                  |                |        |                       |                         |                        |                         |            |
| GM31223-GA6       | *                | *              | 3      | 2                     | *                       | *                      | †                       | 245        |
| <b>1250REOZMB</b> |                  |                |        |                       |                         |                        |                         |            |
| GM19661-GA6       | *                | *              | 4      | 2                     | *                       | *                      | †                       | 246        |
| <b>1600REOZMB</b> |                  |                |        |                       |                         |                        |                         |            |
| GM19661-GA5       | *                | *              | 5      | 2                     | *                       | *                      | †                       | 247        |
| <b>1750REOZMB</b> |                  |                |        |                       |                         |                        |                         |            |
| GM19661-GA8       | *                | *              | 6      | 2                     | *                       | *                      | †                       | 248        |
| <b>2000REOZMB</b> |                  |                |        |                       |                         |                        |                         |            |
| GM19661-GA7       | *                | *              | 6      | 2                     | *                       | *                      | †                       | 249        |

- \* Configured group. Refer to the generator set nameplate for the module number.  
Turn to the respective group on the following pages for parts breakdowns.
- † Configured group. Refer to the generator set nameplate for the module number.  
See controller parts catalog for controller parts lists.

# Specification Number Index

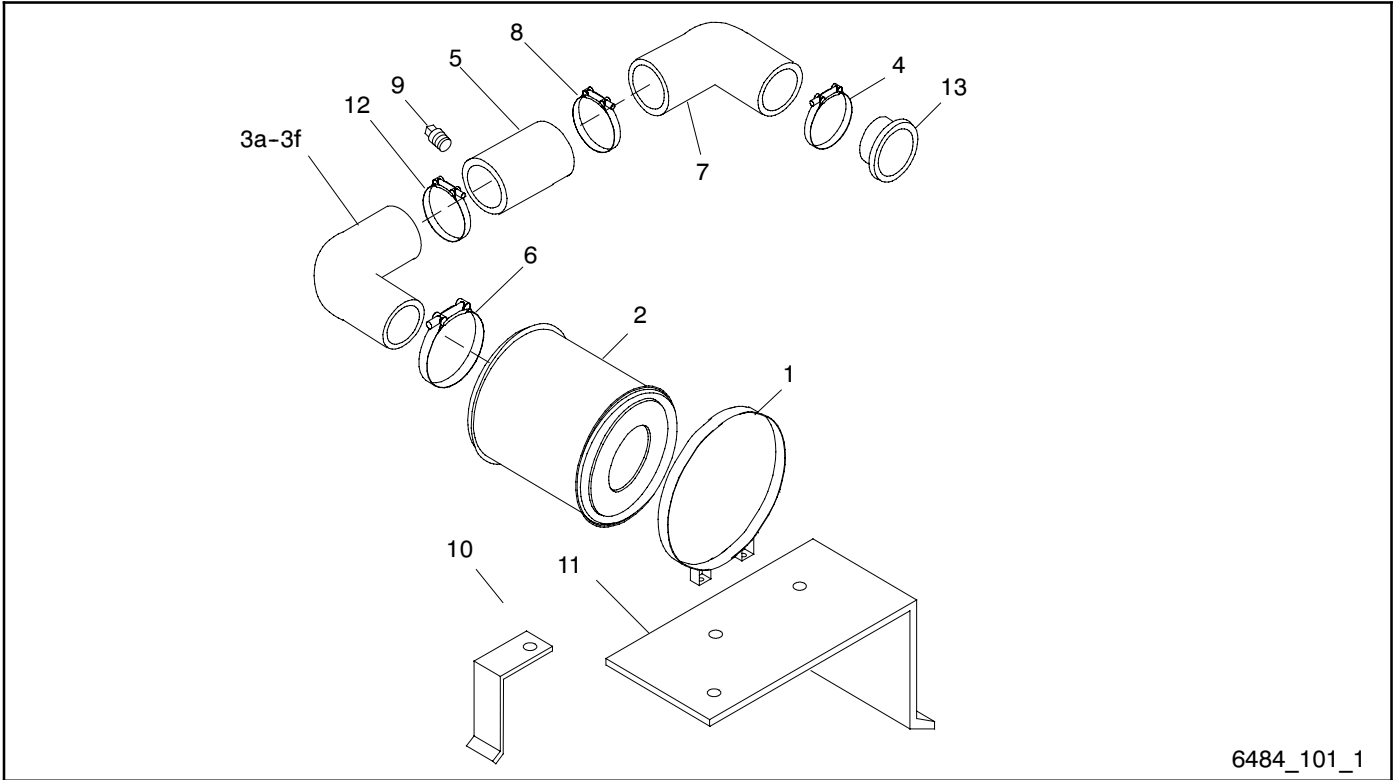
| Group Title       | <i>Air Intake</i> | <i>Cooling System</i> | <i>Engine</i> | <i>Nameplates and Decals</i> | <i>Skid and Plant Mounting</i> | <i>Generator and Mounting</i> | <i>Controller and Mounting</i> | <i>Literature</i> |
|-------------------|-------------------|-----------------------|---------------|------------------------------|--------------------------------|-------------------------------|--------------------------------|-------------------|
| Group No.         | 101               | 104                   | 105           | 107                          | 109                            | 201                           | 301                            | 701               |
| Spec No.          | Variation Number  |                       |               |                              |                                |                               |                                |                   |
| <b>750REOZMD</b>  |                   |                       |               |                              |                                |                               |                                |                   |
| GM81540-GA9       | *                 | *                     | 2             | 3                            | *                              | *                             | †                              | 297               |
| <b>800REOZMD</b>  |                   |                       |               |                              |                                |                               |                                |                   |
| GM81540-GA10      | *                 | *                     | 2             | 3                            | *                              | *                             | †                              | 298               |
| <b>900REOZMD</b>  |                   |                       |               |                              |                                |                               |                                |                   |
| GM81540-GA11      | *                 | *                     | 3             | 3                            | *                              | *                             | †                              | 299               |
| <b>1000REOZMD</b> |                   |                       |               |                              |                                |                               |                                |                   |
| GM81540-GA12      | *                 | *                     | 3             | 3                            | *                              | *                             | †                              | 300               |
| <b>1250REOZMD</b> |                   |                       |               |                              |                                |                               |                                |                   |
| GM80624-GA9       | *                 | *                     | 4             | 3                            | *                              | *                             | †                              | 287               |
| <b>1600REOZMD</b> |                   |                       |               |                              |                                |                               |                                |                   |
| GM80624-GA10      | *                 | *                     | 5             | 3                            | *                              | *                             | †                              | 288               |
| <b>1750REOZMD</b> |                   |                       |               |                              |                                |                               |                                |                   |
| GM80624-GA11      | *                 | *                     | 6             | 3                            | *                              | *                             | †                              | 289               |
| <b>2000REOZMD</b> |                   |                       |               |                              |                                |                               |                                |                   |
| GM80624-GA12      | *                 | *                     | 6             | 3                            | *                              | *                             | †                              | 290               |

\* Configured group. Refer to the generator set nameplate for the module number. Turn to the respective group on the following pages for parts breakdowns.

† Configured group. Refer to the generator set nameplate for the module number. See controller parts catalog for controller parts lists.

# Group 101: Air Intake

600-1000 kW



6484\_101\_1



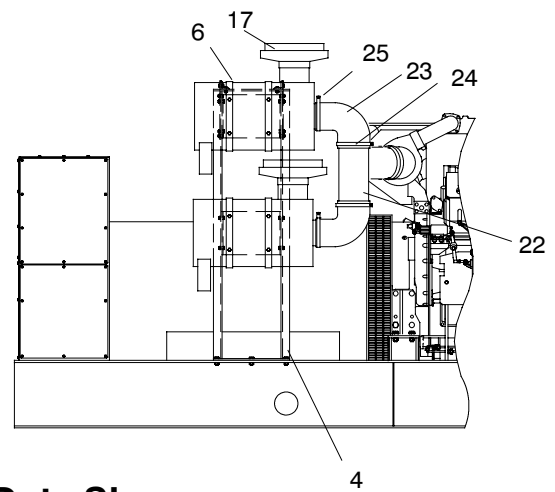
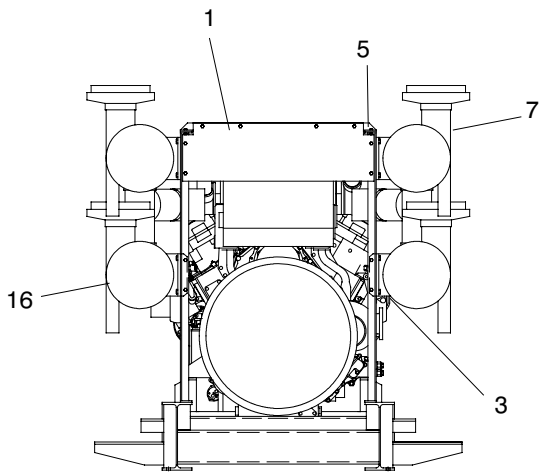
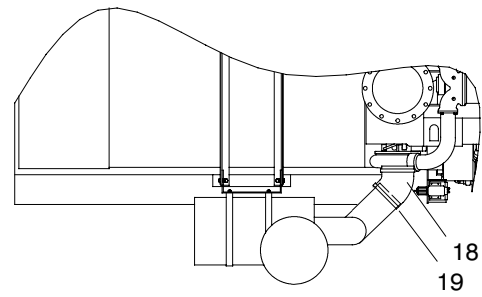
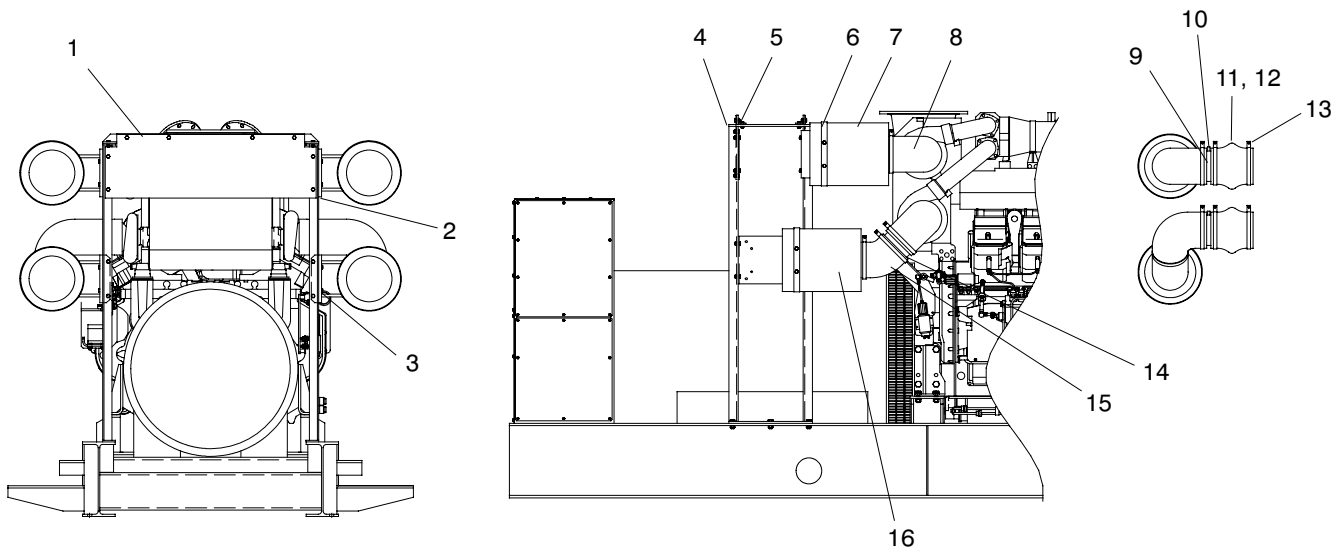
# Group 101: Air Intake

600-1000 kW

| Item | Part Number | Description                                     | Quantity    |             |             |             |             |             |             |             |
|------|-------------|---|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|      |             |   | Module      |             |             |             |             |             |             |             |
|      |             |   | GM30609-MA1 | GM30610-MA1 | GM31227-MA1 | GM31734-MA1 | GM31734-MA2 | GM39625-MA1 | GM51366-MA1 | GM51330-MA1 |
| 1    | 272983      | Clamp   | 1           |             | 2           | 2           | 2           |             |             | 4           |
| 1    | 279715      | Mount, air cleaner                              |             | 2           |             |             |             | 4           | 4           |             |
| 2    | 354842      | Air cleaner, industrial                         | 1           |             |             |             |             |             |             | 2           |
| 2    | 272981      | Air cleaner, industrial                         |             |             | 2           | 2           |             |             |             |             |
| 2    | 274821      | Air cleaner, industrial                         |             |             |             |             | 2           |             |             |             |
| 2    | A-279714    | Air cleaner                                     |             | 1           |             |             |             | 2           | 2           |             |
| 2    | 279738      | Element, air cleaner, heavy-duty                |             | 1           |             |             |             | 2           | 2           |             |
| 2    | 279739      | Element, air cleaner, inner                     |             | 1           |             |             |             | 2           | 2           |             |
| 2    | 279722      | Cap, rain (not shown)                           |             | 1           |             |             |             | 2           | 2           |             |
| 3a   | 272663      | Hose, elbow, 90°, molded, 7 in. ID              |             |             | 2           | 2           | 2           |             | 2           | 2           |
| 3a   | 279716      | Hose, elbow, 90°, 8 x 7 in. ID                  |             | 1           |             |             |             | 2           |             |             |
| 3b   | X-522-95    | Tube, steel, 177.8 OD x 165 long (not shown)    |             |             |             |             |             |             | 2           |             |
| 3c   | 279720      | Hose, hump, straight, 7 in. ID (not shown)      |             |             |             |             |             |             | 2           |             |
| 3d   | 279743      | Clamp, hose, 8.38/8.69 in. (not shown)          |             |             |             |             |             |             | 2           |             |
| 3e   | GM16083     | Hose, hump, 7 in. ID (not shown)                | 1           | 1           |             |             |             |             |             |             |
| 3f   | 343587      | Clamp, hose, 7.38/7.69 in. (not shown)          | 2           | 2           |             |             |             |             | 2           |             |
| 4    | 272960      | Clamp, hose, 6.56/6.87 in.                      |             |             |             | 2           | 2           |             |             |             |
| 4    | 280998      | Clamp, hose, 7.5/7.81 in.                       |             |             | 2           |             |             | 2           | 2           | 2           |
| 5    | 361278      | Tube assembly                                   |             |             | 2           |             | 2           |             |             | 2           |
| 5    | GM10757     | Tube assembly                                   |             |             |             |             |             |             | 2           |             |
| 5    | 279754      | Tube assembly                                   |             |             |             | 2           |             |             |             |             |
| 5    | X-522-96    | Tube, steel                                     |             | 1           |             |             |             |             |             |             |
| 5    | 354236      | Tube, air restriction, 7 in. OD x 7.5 in.       |             |             |             |             |             | 2           |             |             |
| 6    | 280998      | Clamp, hose, 7.5/7.81 in.                       |             |             | 2           |             |             |             | 2           | 2           |
| 6    | 279482      | Clamp, hose, 7.69/8 in.                         |             |             |             | 2           | 2           |             |             |             |
| 6    | 279717      | Clamp, hose, 8.63/8.94 in.                      |             | 1           |             |             |             | 2           |             |             |
| 7    | GM23198     | Hose, 90° reducer, 7 in. to 6 in.               |             |             | 2           | 2           | 2           |             | 2           | 2           |
| 7    | 291678      | Hose, 90° elbow, 7.00 in. ID                    |             |             |             |             |             | 2           |             |             |
| 8    | 254013      | Clamp, hose, 6.25/6.56 in.                      |             |             | 2           |             |             |             | 2           |             |
| 8    | 279482      | Clamp, hose, 7.69/8 in.                         |             |             |             | 2           | 2           |             |             |             |
| 8    | 280998      | Clamp, hose, 7.5/7.81 in.                       |             |             |             |             |             | 2           |             |             |
| 8    | 272960      | Clamp, hose, 6.56/6.87 in.                      |             |             |             |             |             |             |             | 2           |
| 9    | X-268-7     | Cap, pipe                                       |             |             | 2           | 2           | 2           | 2           | 2           | 2           |
| 10a  | GM10519     | Bracket, air cleaner                            |             |             | 2           |             |             |             |             | 3           |
| 10b  | GM60498     | Bracket   |             |             |             |             |             |             |             | 1           |
| 10c  | GM51323     | Bracket, air cleaner                            |             |             |             |             |             |             |             | 4           |
| 10d  | X-400-198   | Spacer, .437 ID x .875 OD x .25 in. (not shown) |             |             |             |             |             |             |             | 2           |
| 10e  | GM39406     | Bracket, air cleaner, heavy-duty                |             |             |             |             |             |             | 2           |             |
| 11a  | GM10518     | Bracket, air cleaner                            |             |             | 2           | 2           | 2           |             |             |             |
| 11b  | GM33099     | Plate, air cleaner                              |             |             |             | 2           | 2           |             |             |             |
| 11c  | GM11699     | Plate, air cleaner                              |             |             | 2           |             |             |             |             | 4           |
| 11a  | GM11994     | Bracket, air cleaner                            | 1           |             |             |             |             |             |             |             |
| 11a  | GM51367     | Bracket, air cleaner, heavy-duty                |             |             |             |             |             |             | 2           |             |
| 11a  | GM12034     | Bracket, air cleaner, heavy-duty                |             | 1           |             |             |             |             |             |             |
| 11a  | GM33097     | Bracket, air cleaner, heavy-duty (not shown)    |             |             |             |             |             | 2           |             |             |
| 11f  | GM39649     | Bracket, air cleaner, heavy-duty (not shown)    |             |             |             |             |             | 2           |             |             |
| 12   | 272960      | Clamp, hose, 6.56/6.87 in.                      |             |             | 2           |             |             |             | 2           | 2           |
| 12   | 280998      | Clamp, hose, 7.5/7.81 in.                       |             | 1           |             |             |             |             |             |             |
| 12   | 279482      | Clamp, hose, 7.69/8 in.                         |             |             |             |             |             | 2           |             |             |
| 13   | GM16748     | Insert, reducer, 7 in. to 6.25 in.              |             |             | 2           | 2           | 2           | 2           | 2           | 2           |

# Group 101: Air Intake, continued

1250-2000 kW



**1250 kW Heavy-Duty Shown**

6057\_101

# Group 101: Air Intake, continued

1250-2000 kW

| Item | Part Number | Description                                    | Quantity    |             |             |             |             |             |             |             |             |
|------|-------------|--|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|      |             |  | Module      |             |             |             |             |             |             |             |             |
|      |             |  | GM16714-MA1 | GM16714-MA2 | GM16761-MA1 | GM32743-MA1 | GM32744-MA1 | GM40747-MA1 | GM40747-MA2 | GM40748-MA1 | GM39472-MA1 |
| 1    | GM16694     | Plate, air cleaner support                     | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 2    | GM18403     | Bracket, air cleaner                           | 2           | 2           |             |             |             |             |             |             |             |
| 3    | GM16693     | Bracket, air cleaner                           | 2           | 2           | 2           | 4           | 4           | 4           | 4           | 4           | 4           |
| 4    | GM16709     | Support, air cleaner                           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 5    | GM16712     | Support, air cleaner, top                      | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 6    | 272983      | Clamp, air cleaner                             | 4           | 4           | 4           |             |             | 4           | 4           |             |             |
| 6    | 291666      | Mount, air cleaner 16" ID                      |             |             |             |             |             |             |             | 8           | 8           |
| 6    | 291666      | Bracket, air cleaner                           |             |             | 8           |             | 8           |             |             |             |             |
| 7    | 272981      | Air cleaner, industrial                        | 2           |             | 2           |             |             | 2           |             |             |             |
| 7    | 354842      | Air Cleaner                                    |             | 2           |             |             |             |             | 2           |             |             |
| 7    | A-279713    | Air cleaner (Use Service Kit. See note below.) |             |             | 2           |             | 2           |             |             | 2           | 2           |
| 7    | 279736      | Element, air cleaner                           |             |             | 2           |             | 2           |             |             | 2           | 2           |
| 7    | 279737      | Element, air cleaner (secondary)               |             |             | 2           |             | 2           |             |             | 2           | 2           |
| 8    | 291678      | Hose, 90° elbow, 7 in. x 7 in. ID              | 4           | 4           |             |             |             | 4           | 4           |             |             |
| 8    | GM16760     | Hose, hump, 152.4 mm ID                        |             |             | 2           |             |             |             |             |             | 2           |
| 8    | 272627      | Hose, 90° elbow, 6 in. x 6 in. ID              |             |             | 4           |             |             |             |             |             | 4           |
| 8    | X-522-59    | Tube, steel                                    |             |             | 2           |             |             |             |             |             | 2           |
| 9    | 274664      | Tube assembly                                  | 4           | 4           |             |             |             |             |             |             |             |
| 9    | 274623      | Tube assembly                                  |             |             | 4           |             |             |             |             |             | 2           |
| 9    | 279754      | Tube assembly                                  |             |             |             |             |             |             |             |             | 2           |
| 9    | GM40732     | Tube, intake                                   |             |             |             |             |             | 2           | 2           |             |             |
| 10   | X-75-1      | Plug, pipe, 1/8 in. NPT                        | 4           | 4           |             |             |             |             |             |             |             |
| 10   | X-268-1     | Cap, pipe, 1/8 in. NPT                         |             |             | 4           |             |             |             |             |             | 4           |
| 11   | 291679      | Hose, hump, 7 in. ID                           | 4           | 4           |             |             |             |             |             |             |             |
| 11   | 279744      | Hose, hump, 7 in. to 6 in. ID                  |             |             | 4           |             |             |             |             |             | 4           |
| 11   | GM40731     | Hose, straight air (7" ID)                     |             |             |             |             |             | 2           | 2           |             |             |
| 12   | GM16748     | Insert, hose insert                            | 4           | 4           | 4           |             |             | 2           | 2           | 2           | 4           |
| 13   | 280998      | Clamp, hose, 7.5/7.81 in.                      | 20          | 20          | 4           |             |             | 12          | 12          |             | 4           |
| 13   | 254013      | Clamp, hose, 6.25/6.56 in.                     |             |             | 20          |             |             |             |             |             | 20          |
| 14   | X-522-66    | Tube, steel                                    | 2           | 2           |             |             |             |             |             |             |             |
| 14   | X-522-86    | Tube, steel, 6 in. OD x 12 in.                 |             |             | 2           |             |             |             |             |             | 2           |
| 15   | 347958      | Hose, elbow, molded, 7 in. ID                  | 2           | 2           |             |             |             |             |             |             |             |
| 15   | 347806      | Hose, elbow, molded, 6 in. ID                  |             |             | 2           |             |             |             |             |             | 2           |
| 16   | 272981      | Air cleaner, industrial                        | 2           |             |             | 2           |             | 2           |             |             |             |
| 16   | 354842      | Air Cleaner                                    |             | 2           |             |             |             |             | 2           |             |             |
| 16   | A-354106    | Air cleaner                                    |             |             | 2           |             | 2           |             |             |             |             |
| 16   | 279736      | Element, air cleaner                           |             |             | 2           |             | 2           |             |             |             |             |
| 16   | A-279713    | Air cleaner (Use Service Kit. See note below.) |             |             |             |             |             |             |             | 2           | 2           |
| 16   | 279736      | Element, air cleaner                           |             |             |             |             |             |             |             | 2           | 2           |
| 16   | 279737      | Element, air cleaner (secondary)               |             |             |             |             |             |             |             | 2           | 2           |
| 17   | 272674      | Cap, rain                                      |             |             | 4           |             | 4           |             |             | 4           | 4           |
| 18   | 347806      | Hose, elbow, molded, 6 in. ID                  |             |             |             |             | 2           |             |             |             |             |
| 18   | 347958      | Hose, 45 deg. elbow, 7 in. ID                  |             |             |             | 2           |             |             |             |             |             |
| 18   | GM40731     | Hose, straight air (7 in. ID)                  |             |             |             |             |             |             |             | 2           |             |
| 19   | 280998      | Clamp, hose, 7.5/7.81 in.                      |             |             |             | 4           | 4           |             |             |             |             |
| 22   | GM32762     | Tube, intake                                   |             |             |             | 2           | 2           |             |             |             |             |
| 22   | GM40733     | Tube, intake (RS)                              |             |             |             |             |             |             |             | 1           |             |
| 22   | GM40734     | Tube, intake (LS)                              |             |             |             |             |             |             |             | 1           |             |
| 23   | 291678      | Hose, 90° elbow, 7 in. x 7 in. ID              |             |             |             | 4           |             |             |             |             |             |
| 23   | 272627      | Hose, 90° elbow, 6 in. x 6 in. ID              |             |             |             |             | 4           |             |             |             |             |
| 23   | 272663      | Hose, 90° deg. reducer (7-6 in. ID)            |             |             |             |             |             |             |             |             | 4           |
| 24   | 280998      | Clamp, hose, 7.5/7.81 in.                      |             |             |             | 4           |             |             |             |             | 4           |
| 24   | 254013      | Clamp, hose, 6.25/6.56 in.                     |             |             |             |             | 4           |             |             |             | 4           |
| 25   | 280998      | Clamp, hose, 7.5/7.81 in.                      |             |             |             | 4           | 4           |             |             |             | 4           |

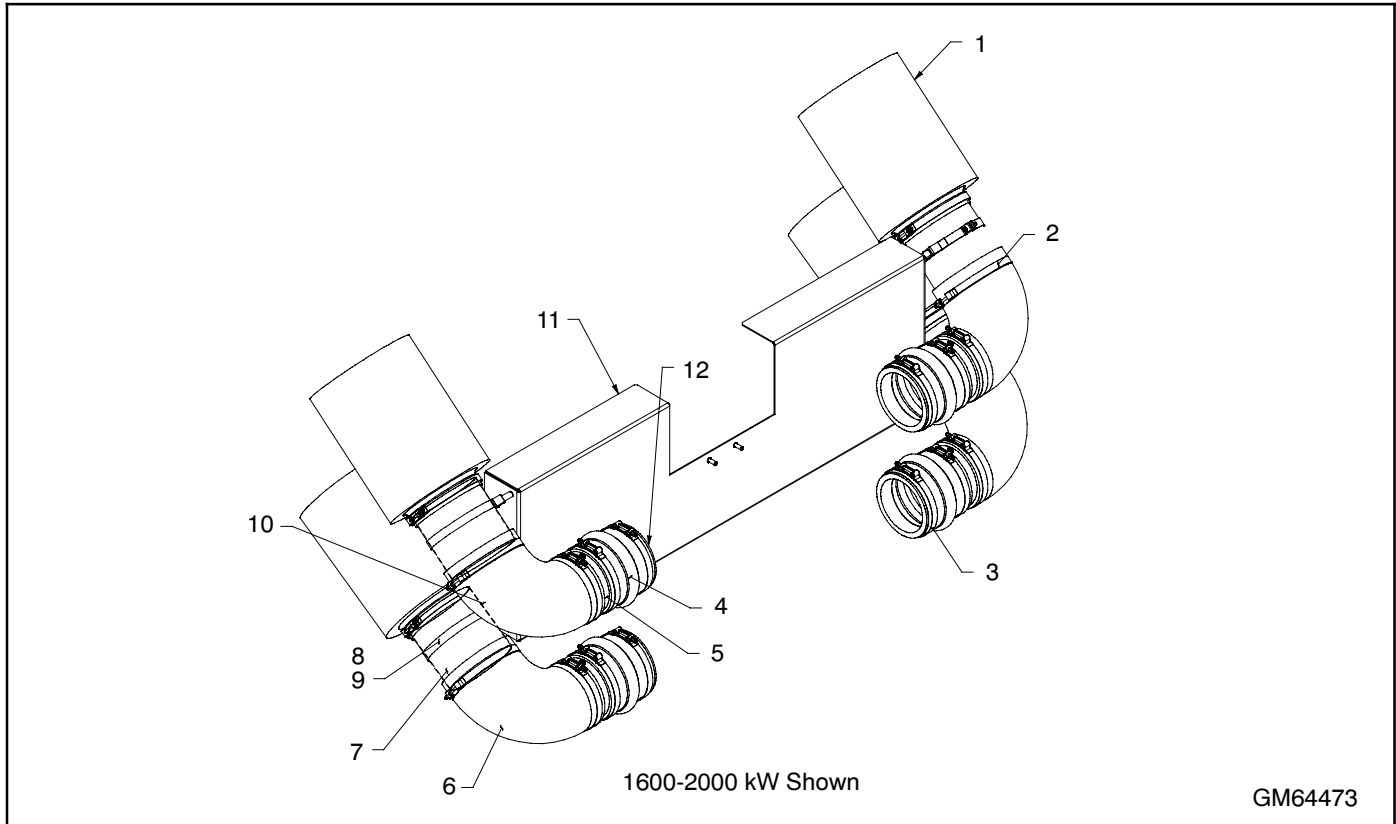
Note: A-279713 air cleaner assembly is no longer available. Replace with kit GM75957-S (1250 kW) or GM75958-S (1600/2000 kW).

GM75957-S includes mounts 291501 (qty. 8) and air cleaner assy. GM69933 (qty. 4).

GM75958-S includes rain cap 272675 (qty. 4) and air cleaner assy. GM69932 (qty. 4).

# Group 101: Air Intake, continued

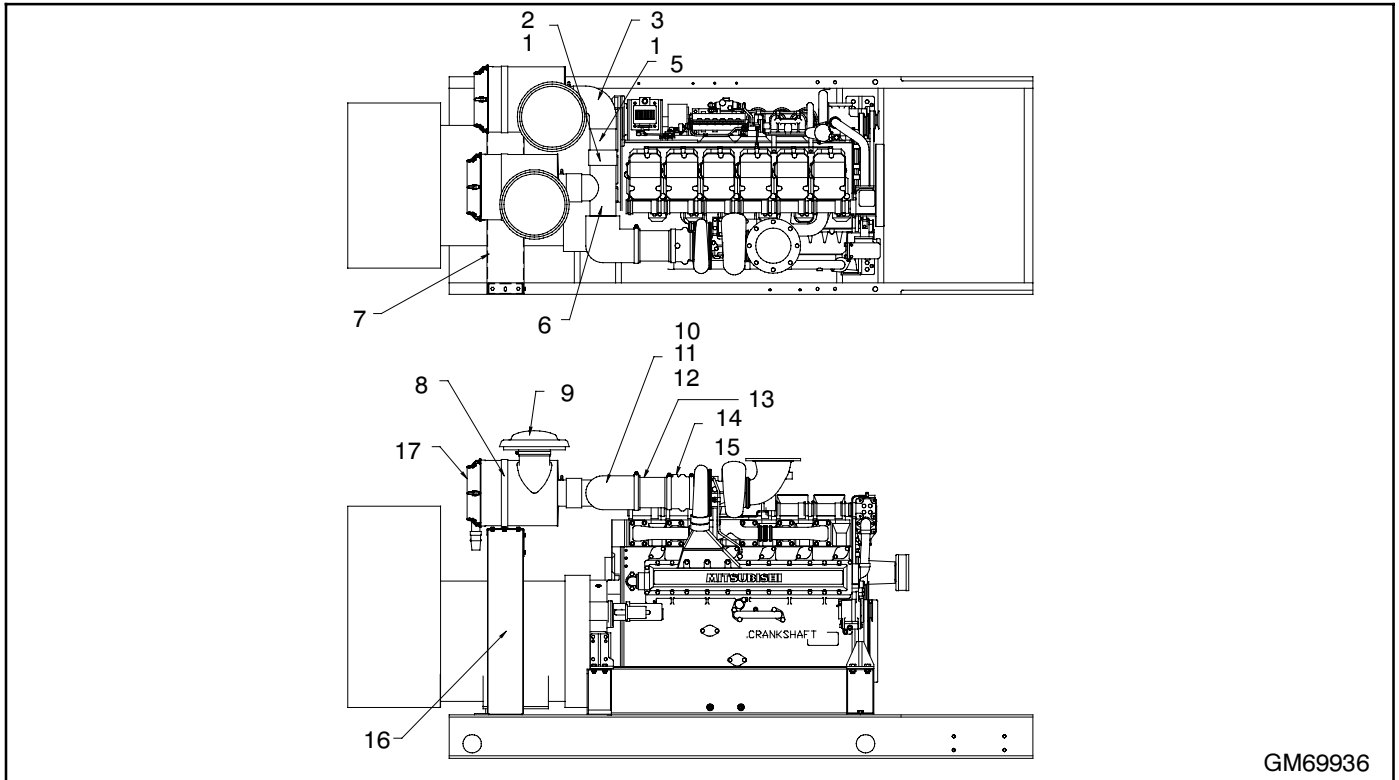
1250-2000 kW



| Item | Part Number | Description                             | Quantity Module |              |
|------|-------------|---|-----------------|--------------|
|      |             |   | GM64472-MA 1    | GM64473-MA 1 |
| 1    | GM28399     | Element, Air Cleaner                    | 2               | 4            |
| 2    | 279743      | Clamp, hose, 8.38/8.69 in.              | 4               | 8            |
| 3    | 280998      | Clamp, hose, 7.5/7.81 in.               | 6               | 12           |
| 4    | 291679      | Hose, hump (7.00" id)                   | 2               | 4            |
| 5    | 274664      | Tube assembly                           | 2               | 4            |
| 6    | 279716      | Hose, 90 deg. reducer (8.00 - 7.00" ID) | 2               | 2            |
| 7    | X-522-114   | Tube, Steel                             | 2               | 4            |
| 8    | 279380      | Mount, Air Cleaner/Exhaust ( 8.00" id)  | 2               | 4            |
| 9    | X-400-260   | Spacer                                  |                 | 8            |
| 10   | 279716      | Hose, 90 deg. reducer (8.00 - 7.00" ID) |                 | 2            |
| 11   | GM67012     | Support, Air Cleaner (Top)              |                 | 1            |
| 11   | GM60823     | Support, Air Cleaner (Top)              | 1               |              |
| 12   | GM16748     | Insert, hose reducer (7.00" to 6.25")   |                 | 4            |

# Group 101: Air Intake, continued

600 kW, Heavy Duty

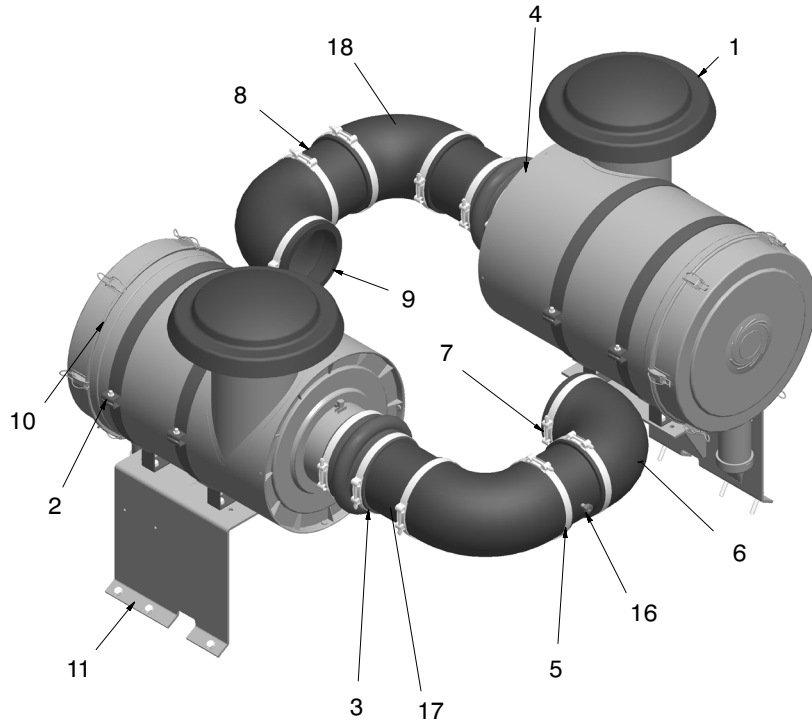


GM69936

| Item | Part Number | Description                            | Quantity<br>Module Number<br>GM69936-MA1 |
|------|-------------|--|--|
| 1    | 254013      | Clamp, hose, 6.25/6.56 in.             | 6  |
| 2    | 361277      | Hose, straight air (6.00" id)          | 2  |
| 3    | GM23198     | Hose, 90 Deg. Reducer (7.00" to 6.00") | 1  |
| 5    | X-522-59    | Tube, Steel                            | 1  |
| 6    | GM71062     | Tee, Steel Tube                        | 1  |
| 7    | GM71068     | Bracket, HD Air Cleaner Top            | 1  |
| 8    | 291501      | Mount, Air Cleaner/Exhaust (15.00" id) | 2  |
| 9    | 272674      | Cap, rain                              | 2  |
| 10   | 272627      | Hose, 90 deg. elbow (6.00" id)         | 1  |
| 11   | 280998      | Clamp, hose, 7.5/7.81 in.              | 1  |
| 12   | 272960      | Clamp, hose, 6.56/6.87 in.             | 1  |
| 13   | X-522-72    | Tube, steel                            | 1  |
| 14   | GM16083     | Hose, hump (7.00" id)                  | 1  |
| 15   | 343587      | Clamp, hose, 7.38/7.69 in. (NRP)       | 2  |
| 16   | GM71067     | Bracket, HD Air Cleaner Side           | 2  |
| 17   | GM69933     | Cleaner Ass'y, Air                     | 2  |
| 17   | GM69999     | Element, Primary (Outer)               | 1  |
| 17   | GM70000     | Element, Secondary (Inner)             | 1  |

# Group 101: Air Intake, continued

750-1000 kW, Heavy Duty

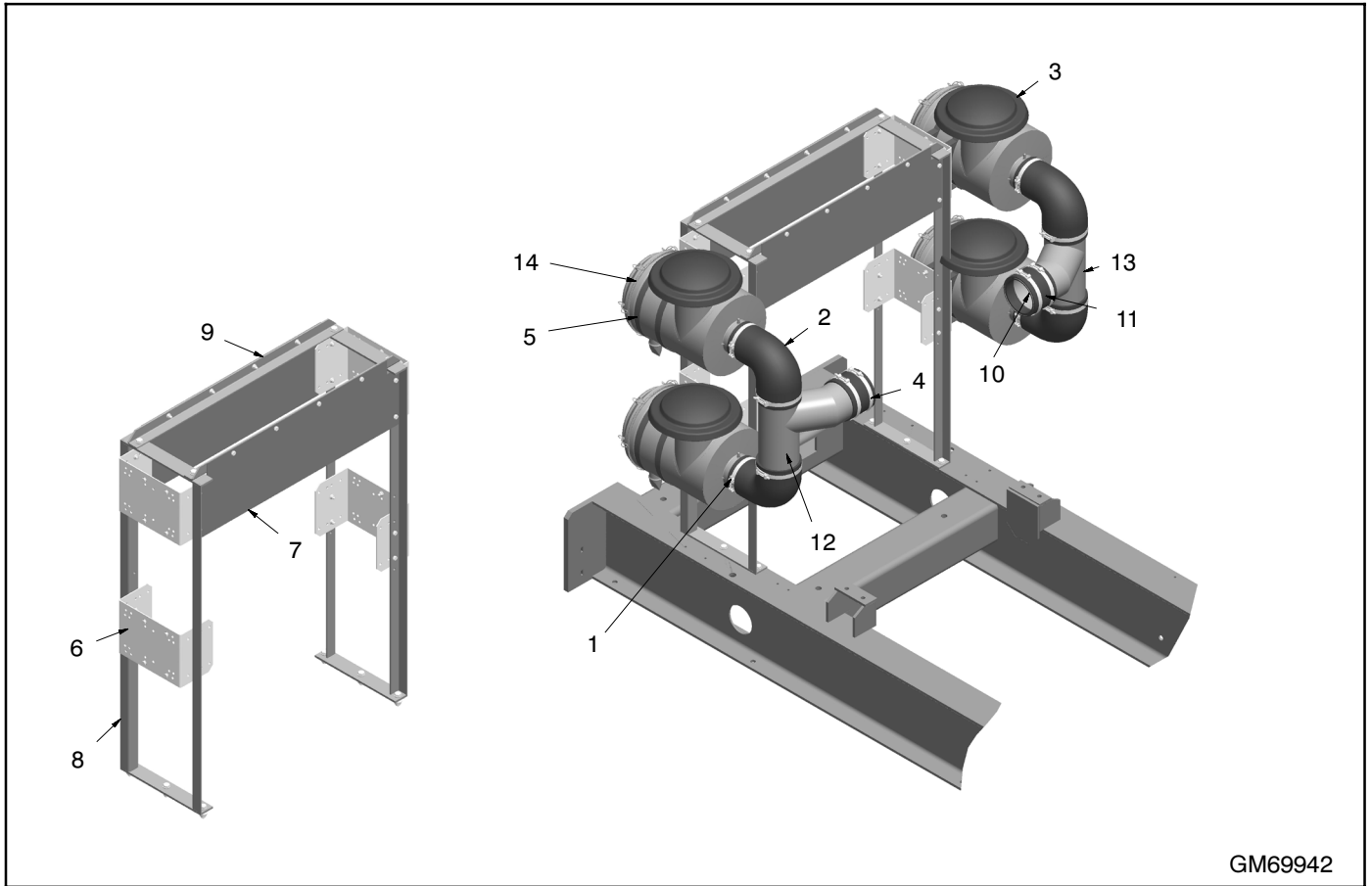


GM69937

| Item | Part Number | Description                             | Quantity      |             |             |
|------|-------------|---|---------------|-------------|-------------|
|      |             |   | Module Number |             |             |
|      |             |   | GM69937-MA1   | GM69938-MA1 | GM69938-MA2 |
| 1    | 272675      | Cap, rain                               | 2             | 2           | 2           |
| 2    | 279715      | Mount, Air Cleaner/Exhaust (18.00" id)  | 4             | 4           | 4           |
| 3    | 279720      | Hose, hump reducer (8.00 to 7.00" id)   | 2             | 2           | 2           |
| 4    | 279743      | Clamp, hose, 8.38/8.69 in.              | 2             |             |             |
| 5    | 280998      | Clamp, hose, 7.5/7.81 in.               | 6             | 4           | 4           |
| 5    | 279743      | Clamp, hose, 8.38/8.69 in.              |               | 2           | 2           |
| 6    | 291678      | Hose, 90 deg. elbow (7.00" id)          | 2             |             |             |
| 6    | GM23198     | Hose, 90 Deg. Reducer (7.00" to 6.00")  |               | 2           | 2           |
| 7    | 343587      | Clamp, hose, 7.38/7.69 in.              | 4             |             | 2           |
| 7    | 272960      | Clamp, hose, 6.56/6.87 in.              |               | 4           | 4           |
| 8    | 354236      | Tube, air restriction, 7 in. OD x 7.5 i | 2             |             |             |
| 8    | GM10757     | Tube, Assembly                          |               | 2           | 2           |
| 9    | GM16748     | Insert, hose reducer (7.00" to 6.25")   | 2             | 2           | 2           |
| 10   | GM69932     | Cleaner Ass'y, Air                      | 2             | 2           | 2           |
| 10   | GM69997     | Element, Primary (Outer)                | 2             | 2           | 2           |
| 10   | GM69998     | Element, Secondary (Inner)              | 2             | 2           | 2           |
| 11   | GM79188     | Bracket, Air Cleaner (HD)               | 2             |             |             |
| 11   | GM39406     | Bracket, Air Cleaner (H.D.)             |               | 2           | 2           |
| 11   | GM39395     | Bracket, Air Cleaner (H.D.)             |               | 4           |             |
| 11   | GM51367     | Bracket, Air Cleaner (H.D.)             |               |             | 2           |
| 16   | X-268-7     | Cap, pipe (1/8" npt)                    | 2             | 2           | 2           |
| 17   | X-522-95    | Tube, Steel (177.8 O.D. X 165 Long)     | 2             |             |             |
| 17   | X-522-126   | Tube, Steel (177.8 O.D. X 216 Long)     |               | 2           | 2           |
| 18   | 291678      | Hose, 90 deg. elbow (7.00" id)          | 2             |             |             |
| 18   | 272663      | Hose, 90 deg. reducer (7.00 - 6.00" id) |               | 2           | 2           |

# Group 101: Air Intake, continued

1250 kW, Heavy Duty

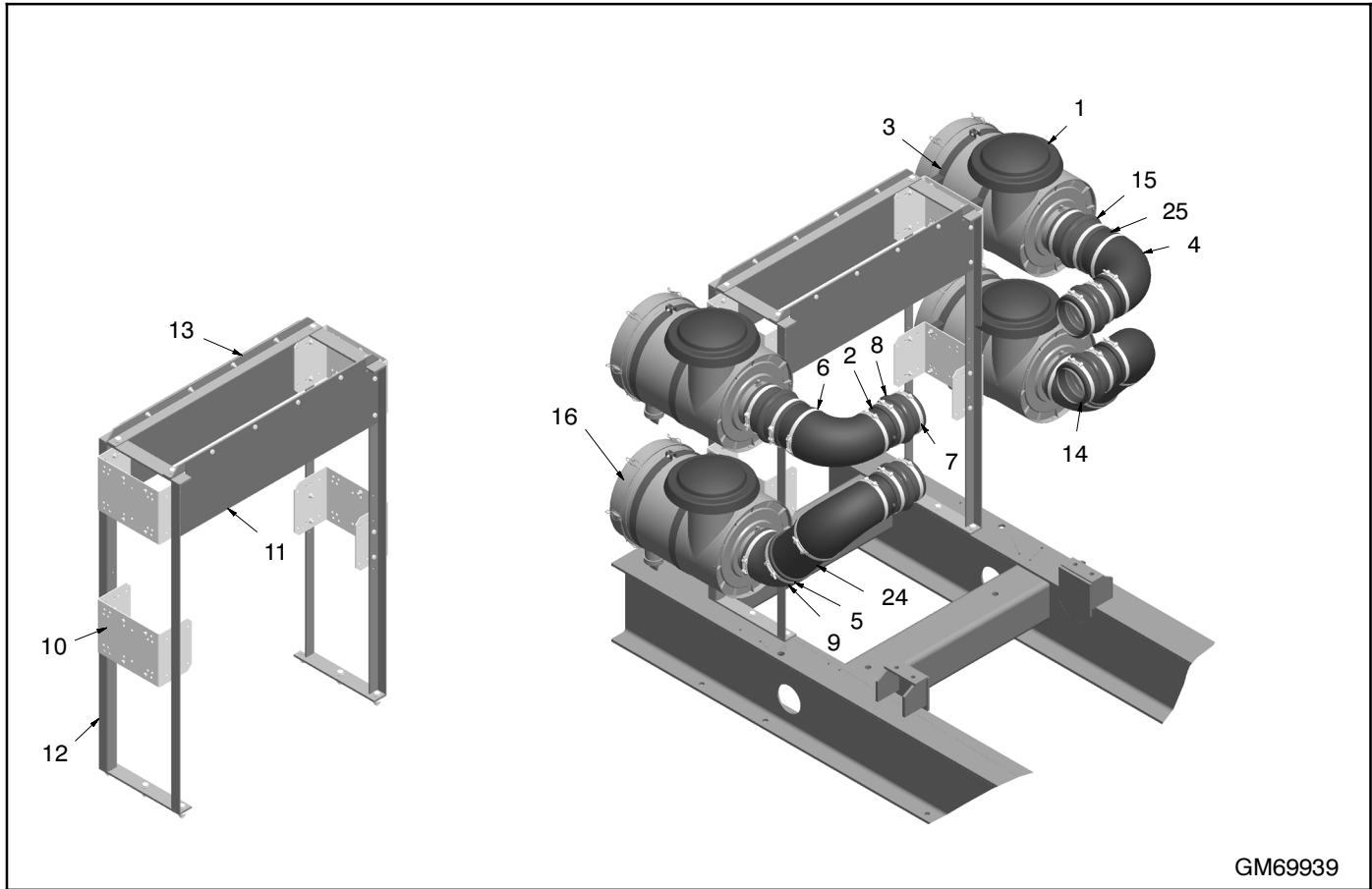


GM69942

| Item | Part Number        | Description                                      | Quantity    |        |
|------|--------------------|--|-------------|--------|
|      |                    |  | GM69942-MA1 | Module |
| 1    | 254013             | Clamp, hose, 6.25/6.56 in.                       | 4           |        |
| 2    | 272663             | Hose, 90 deg. reducer (7.00 - 6.00" id)          | 4           |        |
| 3    | 272674             | Cap, rain  | 4           |        |
| 4    | 280998             | Clamp, hose, 7.5/7.81 in.                        | 8           |        |
| 5    | 291501             | Mount, Air Cleaner/Exhaust (15.00" id)           | 8           |        |
| 6    | GM16693            | Bracket, Air Cleaner                             | 4           |        |
| 7    | GM16694            | Plate, Air Cleaner Support                       | 2           |        |
| 8    | GM16709            | Support, Air Cleaner                             | 2           |        |
| 9    | GM16712            | Support, Air Cleaner (Top)                       | 2           |        |
| 10   | <del>GM16748</del> | <del>Insert, hose reducer (7.00" to 6.25")</del> | 2           |        |
| 11   | GM40731            | Hose, Straight Air (7.00" ID)                    | 2           |        |
| 12   | GM40733            | Tube, Intake (R.S.)                              | 1           |        |
| 13   | GM40734            | Tube, Intake (L.S.)                              | 1           |        |
| 14   | GM69933            | Cleaner Ass'y, Air                               | 4           |        |
| 14   | GM69999            | Element, Primary (Outer)                         | 4           |        |
| 14   | GM70000            | Element, Secondary (Inner)                       | 4           |        |

# Group 101: Air Intake, continued

1600-2000 kW, Heavy Duty



GM69939

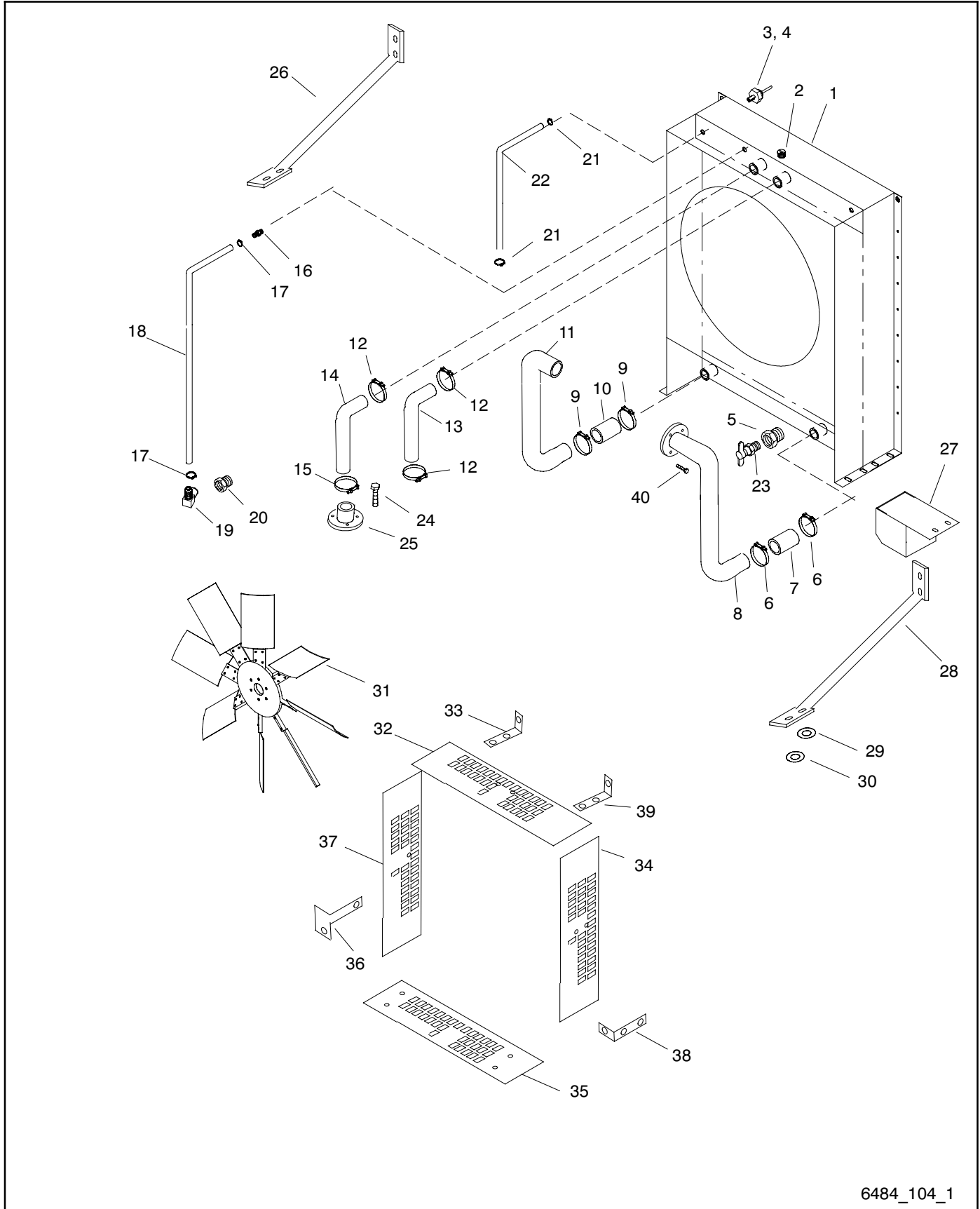
| Item | Part Number | Description                             | Quantity           |  |
|------|-------------|---|--------------------|--|
|      |             |   | Module             |  |
|      |             |   | <b>GM69939-MA1</b> |  |
| 1    | 272675      | Cap, rain                               | 4                  |  |
| 2    | 274664      | Tube assembly                           | 4                  |  |
| 3    | 279715      | Mount, Air Cleaner/Exhaust (18.00" id)  | 8                  |  |
| 4    | 279716      | Hose, 90 deg. reducer (8.00 - 7.00" ID) | 4                  |  |
| 5    | 279717      | Clamp, hose, 8.63/8.94 in.              | 2                  |  |
| 6    | 279743      | Clamp, hose, 8.38/8.69 in.              | 10                 |  |
| 7    | 280998      | Clamp, hose, 7.5/7.81 in.               | 12                 |  |
| 8    | 291679      | Hose, hump (7.00" id)                   | 4                  |  |
| 9    | 347957      | Hose, 45 deg. elbow (8.00" id)          | 2                  |  |
| 10   | GM16693     | Bracket, Air Cleaner                    | 4                  |  |
| 11   | GM16694     | Plate, Air Cleaner Support              | 2                  |  |
| 12   | GM16709     | Support, Air Cleaner                    | 2                  |  |
| 13   | GM16712     | Support, Air Cleaner (Top)              | 2                  |  |
| 14   | GM16748     | Insert, hose reducer (7.00" to 6.25")   | 4                  |  |
| 15   | GM23518     | Hose, hump (8.00" id)                   | 2                  |  |
| 16   | GM69932     | Cleaner Ass'y, Air                      | 4                  |  |
| 16   | GM69997     | Element, Primary (Outer)                | 4                  |  |
| 16   | GM69998     | Element, Secondary (Inner)              | 4                  |  |
| 24   | X-522-107   | Tube, Steel                             | 2                  |  |
| 25   | X-522-114   | Tube, Steel                             | 2                  |  |



# Notes

# Group 104: Cooling System

600 kW



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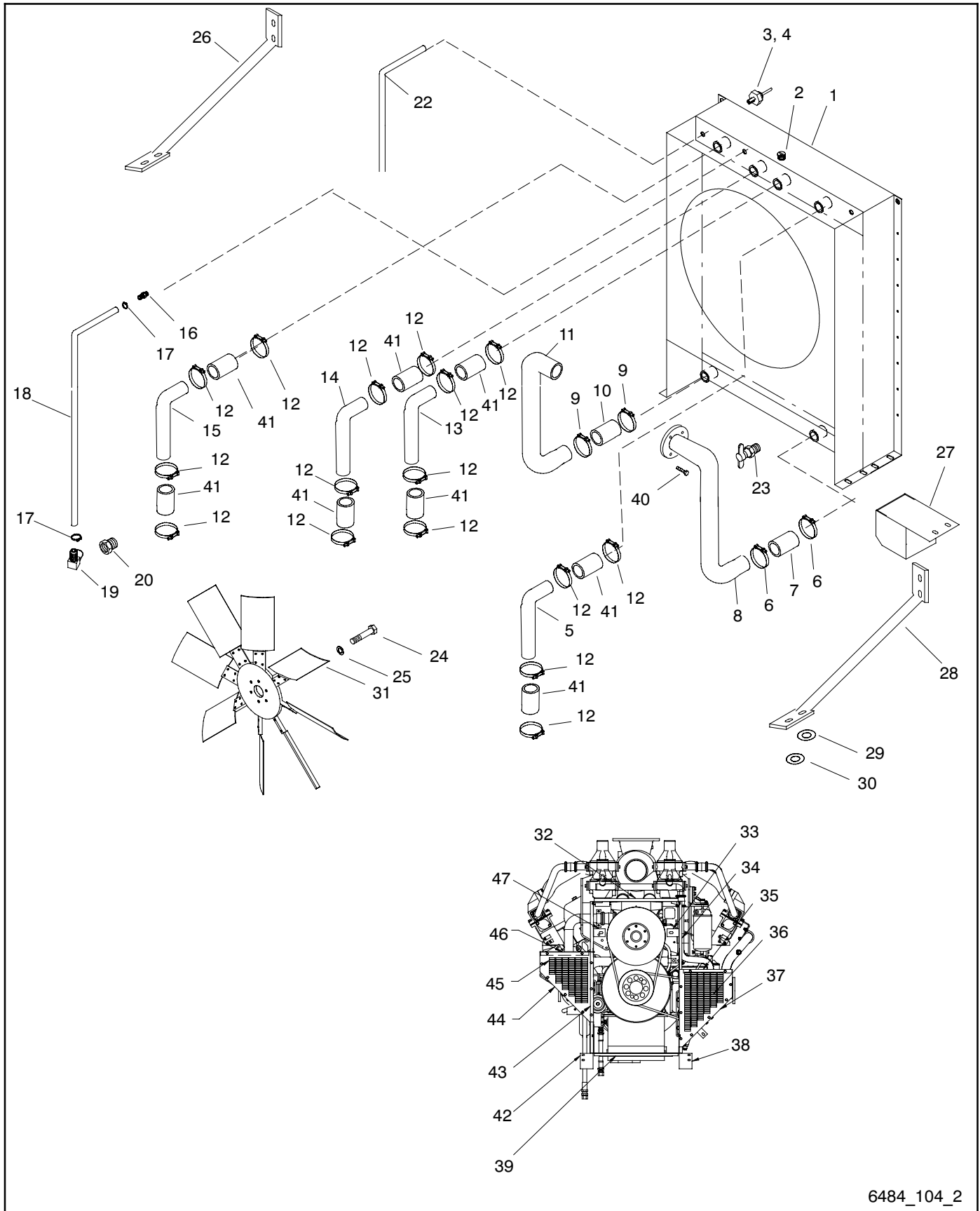
# Group 104: Cooling System

600 kW

| Item | Part Number   | Description                             | Quantity    |             |             |
|------|---------------|---|-------------|-------------|-------------|
|      |               |   | Module      |             |             |
|      |               |   | GM50711-MA1 | GM50711-MA2 | GM77855-MA1 |
| 1    | GM50718       | Radiator assembly                       | 1           |             |             |
| 1    | GM50719       | Radiator assembly                       |             | 1           |             |
| 1    | GM77845       | Radiator assembly                       |             |             | 1           |
| 2    | 276954        | Cap, radiator                           | 1           | 1           | 1           |
| 3    | 365289        | Sensor, low fluid                       | 1           | 1           | 1           |
| 4    | X-6003-120    | Conduit, convoluted                     | 1           | 1           | 1           |
| 5    | X-215-9       | Elbow, pipe (90 deg x 3/8"npt)          | 1           | 1           | 1           |
| 6    | 275527        | Clamp, hose, 2.81/3.12 in.              | 2           | 2           | 2           |
| 7    | X-6014-131    | Hose, radiator, wire insert             | 1           | 1           | 1           |
| 8    | GM50750       | Tube, lower radiator AC                 | 1           | 1           | 1           |
| 9    | 274824        | Clamp, hose, 3.68/4 in.                 | 2           | 2           | 2           |
| 10   | X-6014-130    | Hose, radiator, wire insert, 3.5 in. ID | 1           | 1           | 1           |
| 11   | GM50763       | Tube, lower radiator JW                 | 1           | 1           | 1           |
| 12   | 291542        | Clamp, hose, 3.25/3.56 in.              | 3           | 3           | 3           |
| 13   | GM50749       | Tube, upper radiator                    | 1           | 1           | 1           |
| 14   | GM50762       | Hose, upper radiator AC                 | 1           | 1           | 1           |
| 15   | 275527        | Clamp, hose, 2.81/3.12 in.              | 1           | 1           | 1           |
| 16   | X-582-25      | Connector, hose                         | 2           | 2           | 2           |
| 17   | X-426-9       | Clamp, hose, 0.25/0.70 in.              | 4           | 4           | 4           |
| 18   | X-6359-13     | Hose, rubber, straight, .25 in. ID      | 2           | 2           | 2           |
| 19   | X-391-44      | Elbow, hose                             | 1           | 1           | 1           |
| 20   | X-202-28      | Bushing, reducing, 3/8 x 1/2 in. NPT    | 1           | 1           | 1           |
| 20   | X-380-5       | Connector, hose + Vibra Seal            | 1           | 1           | 1           |
| 21   | X-426-8       | Clamp, hose, 0.81/1.75 in.              | 4           | 4           | 4           |
| 22   | X-6014-117    | Hose, radiator, wire insert 1 in. ID    | 2           | 2           | 2           |
| 23   | 278788        | Valve, drain ( 3/8"nptf)                | 2           | 2           | 2           |
| 24   | M961-10030-60 | Screw, hex cap                          | 4           | 4           | 4           |
| 25   | GM11962       | Flange, water connection outlet         | 1           | 1           | 1           |
| 26   | GM50706       | Support, radiator, left side            | 1           | 1           | 1           |
| 27   | GM50751       | Support, radiator, left                 | 1           | 1           | 1           |
| 27   | GM52737       | Support, radiator, right                | 1           | 1           | 1           |
| 28   | GM50705       | Support, radiator, right side           | 1           | 1           | 1           |
| 29   | X-6011-3      | Washer, beveled, 0.68 ID x 1.5 in. OD   | 4           | 4           | 4           |
| 30   | X-801-9       | Washer, hardened, 0.688 ID x 1.373 in.  | 12          | 12          | 12          |
| 31   | GM51997       | Fan, pusher                             | 1           | 1           | 1           |
| 32   | GM50758       | Guard, belt, top                        | 1           | 1           | 1           |
| 33   | GM55038       | Bracket, belt guard mounting            | 1           | 1           | 1           |
| 34   | GM50754       | Guard, belt, right side                 | 1           | 1           | 1           |
| 34   | GM51583       | Guard, belt, right side top             | 1           | 1           | 1           |
| 35   | GM50755       | Guard, belt, bottom                     | 1           | 1           | 1           |
| 36   | GM51724       | Bracket, belt guard mounting            | 1           | 1           | 1           |
| 37   | GM51850       | Guard, belt, left side rear             | 1           | 1           | 1           |
| 37   | GM50757       | Guard, belt, left side                  | 1           | 1           | 1           |
| 38   | GM51725       | Bracket, belt guard mounting            | 1           | 1           | 1           |
| 39   | GM12351       | Bracket, belt guard mounting            | 1           | 1           | 1           |
| 40   | M961-12030-60 | Screw, hex cap                          | 5           | 5           | 5           |

# Group 104: Cooling System, continued

750/800 kW



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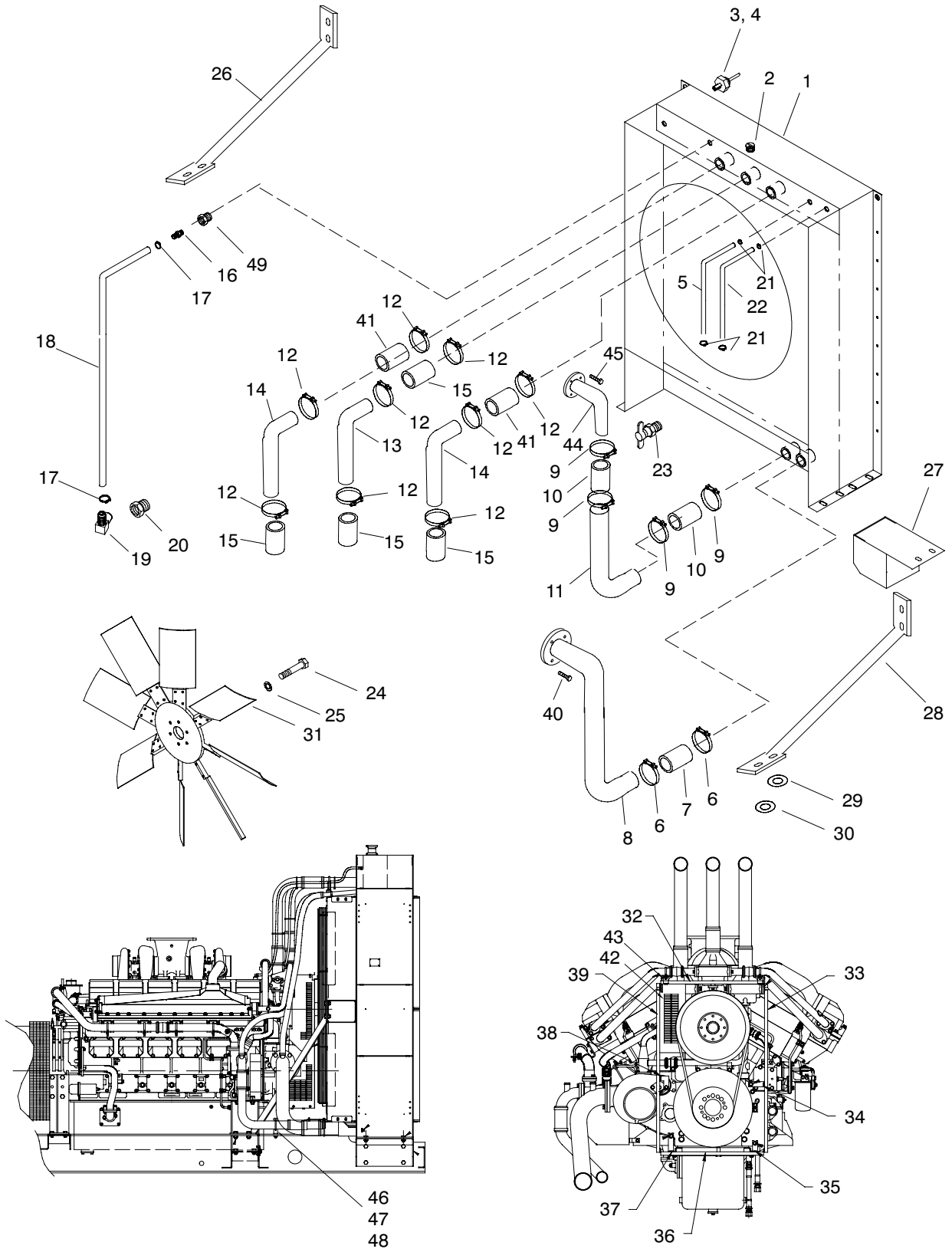
# Group 104: Cooling System, continued

750/800 kW

| Item | Part Number   | Description                                   | Quantity    |             |             |             |             |             |             |
|------|---------------|---|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|      |               |   | Module      |             |             |             |             |             |             |
|      |               |   | GM51077-MA1 | GM51077-MA2 | GM66994-MA2 | GM66994-MA3 | GM75863-MA1 | GM81552-MA1 | GM81552-MA2 |
| 1    | GM50720       | Radiator assembly                             | 1           |             |             |             |             |             |             |
| 1    | GM50721       | Radiator assembly                             |             | 1           | 1           |             |             | 1           |             |
| 1    | GM78583       | Radiator assembly                             |             |             |             | 1           |             |             | 1           |
| 1    | GM75663       | Radiator assembly                             |             |             |             |             | 1           |             |             |
| 2    | 276954        | Cap, radiator                                 | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 3    | 365289        | Sensor, low fluid                             | 1           | 1           | 1           | 1           | 1           |             |             |
| 4    | X-6003-120    | Conduit, convoluted                           | 1           | 1           | 1           | 1           | 1           |             |             |
| 5    | GM51281       | Hose, upper radiator JW, right hand           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 6    | 336228        | Clamp, hose, 2.63/2.94 in.                    | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 7    | X-6014-69     | Hose, radiator, wire insert 2.5 ID            | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 8    | GM51284       | Tube, lower radiator AC                       | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 9    | 274824        | Clamp, hose, 3.68/4 in.                       | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 10   | X-6014-89     | Hose, radiator, wire insert, 3.5 in. ID       | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 11   | GM51283       | Tube, lower radiator                          | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 12   | 291542        | Clamp, hose, 3.25/3.56 in.                    | 20          | 20          | 20          | 20          | 20          | 20          | 20          |
| 13   | GM51282       | Tube, upper radiator                          | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 14   | GM51282       | Tube, upper radiator                          | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 15   | GM51277       | Hose, upper radiator JW, left hand            | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 16   | X-582-25      | Connector, hose                               | 4           | 4           | 4           | 4           | 4           | 4           | 4           |
| 17   | X-426-9       | Clamp, hose, 0.25/0.70 in.                    | 8           | 8           | 8           | 8           | 8           | 8           | 8           |
| 18   | X-6359-3      | Hose, rubber, straight, 0.25 in. ID, 8.33 ft. | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 18   | X-6359-9      | Hose, rubber, straight, 0.25 in. ID, 11 ft.   | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 19   | X-391-44      | Elbow, hose                                   | 4           | 4           | 4           | 4           | 4           | 4           | 4           |
| 20   | X-202-28      | Bushing, reducing, 3/8 x 1/2 in. NPT          | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 20   | 225127        | Adapter, bushing                              | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 22   | X-6014-4      | Hose, radiator, wire insert 1.25 in. ID       | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 23   | 278788        | Valve, drain, 3/8 in. NPTF                    | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 24   | M961-12050-82 | Screw, hex cap                                | 6           | 6           | 6           | 6           | 6           | 6           | 6           |
| 25   | 290945        | Washer, hardened, 0.531 ID x 1.06 in. OD      | 6           | 6           | 6           | 6           | 6           | 6           | 6           |
| 26   | GM51279       | Support, radiator, left side                  | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 27   | GM51280       | Support, radiator                             | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 28   | GM51278       | Support, radiator, right side                 | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 29   | X-6011-3      | Washer, beveled, 0.68 ID x 1.5 in. OD         | 4           | 4           | 4           | 4           | 4           | 4           | 4           |
| 30   | X-801-9       | Washer, hardened, 0.688 ID x 1.373 in.        | 20          | 20          | 20          | 20          | 20          | 20          | 20          |
| 31   | GM47608       | Fan, pusher                                   | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 32   | GM51285       | Guard, belt, top                              | 1           | 1           | 1           | 1           |             | 1           | 1           |
| 32   | GM75664       | Guard, belt, top                              |             |             |             |             | 1           |             |             |
| 33   | GM52139       | Bracket, guard, left side                     | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 34   | GM51292       | Guard, belt, left side                        | 1           | 1           |             |             |             |             |             |
| 34   | GM67000       | Guard, belt, left side                        |             |             | 1           | 1           |             | 1           | 1           |
| 34   | GM75667       | Guard, belt, left side                        |             |             |             |             | 1           |             |             |
| 35   | GM51291       | Guard, belt (chg alt), left                   | 1           | 1           |             |             |             |             |             |
| 35   | GM66999       | Guard, belt (chg alt), left                   |             |             | 1           | 1           | 1           | 1           | 1           |
| 36   | GM52270       | Guard, belt, left hand (BCA)                  | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 37   | GM51290       | Guard, belt (chg alt) left                    | 1           | 1           |             |             |             |             |             |
| 37   | GM66998       | Guard, belt (chg alt) left                    |             |             | 1           | 1           | 1           | 1           | 1           |
| 38   | GM51289       | Bracket, guard, left side                     | 1           | 1           | 1           | 1           |             | 1           | 1           |
| 38   | GM75669       | Bracket, guard, left side                     |             |             |             |             | 1           |             |             |
| 39   | GM51288       | Guard, belt, bottom                           | 1           | 1           | 1           | 1           |             | 1           | 1           |
| 39   | GM75665       | Guard, belt, bottom                           |             |             |             |             | 1           |             |             |
| 40   | M961-12030-60 | Screw, hex cap                                | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 41   | X-507-7       | Hose, radiator, straight, 3 in. ID            | 8           | 8           | 8           | 8           | 8           | 8           | 8           |
| 42   | GM51287       | Bracket, guard, right side                    | 1           | 1           | 1           | 1           |             | 1           | 1           |
| 42   | GM75668       | Bracket, guard, right side                    |             |             |             |             | 1           |             |             |
| 43   | GM51286       | Guard, belt, right side                       | 1           | 1           |             |             |             |             |             |
| 43   | GM66997       | Guard, belt, right side                       |             |             | 1           | 1           |             | 1           | 1           |
| 43   | GM75666       | Guard, belt, right side                       |             |             |             |             | 1           |             |             |
| 44   | GM51363       | Guard, belt (chg alt), right                  | 1           | 1           |             |             |             |             |             |
| 44   | GM66996       | Guard, belt (chg alt), right                  |             |             | 1           | 1           | 1           | 1           | 1           |
| 45   | GM51338       | Guard, chg alt                                | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 46   | GM51037       | Guard, belt (chg alt), right                  | 1           | 1           |             |             |             |             |             |
| 46   | GM66995       | Guard, belt (chg alt), right                  |             |             | 1           | 1           | 1           | 1           | 1           |
| 47   | GM52138       | Bracket, guard, right side                    | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 47   | X-400-230     | Spacer, 0.531 ID x 1 OD x 1 in.               | 2           | 2           | 2           | 2           | 2           | 2           | 2           |

# Group 104: Cooling System, continued

900/1000 kW



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# Group 104: Cooling System, continued

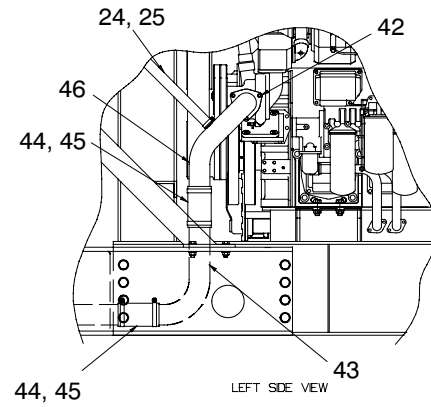
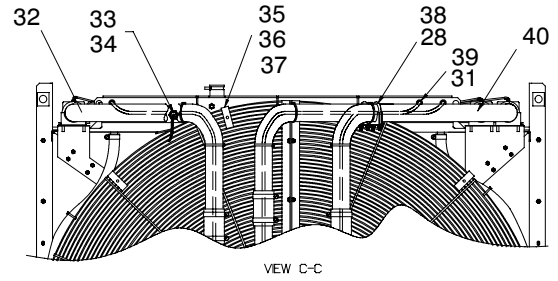
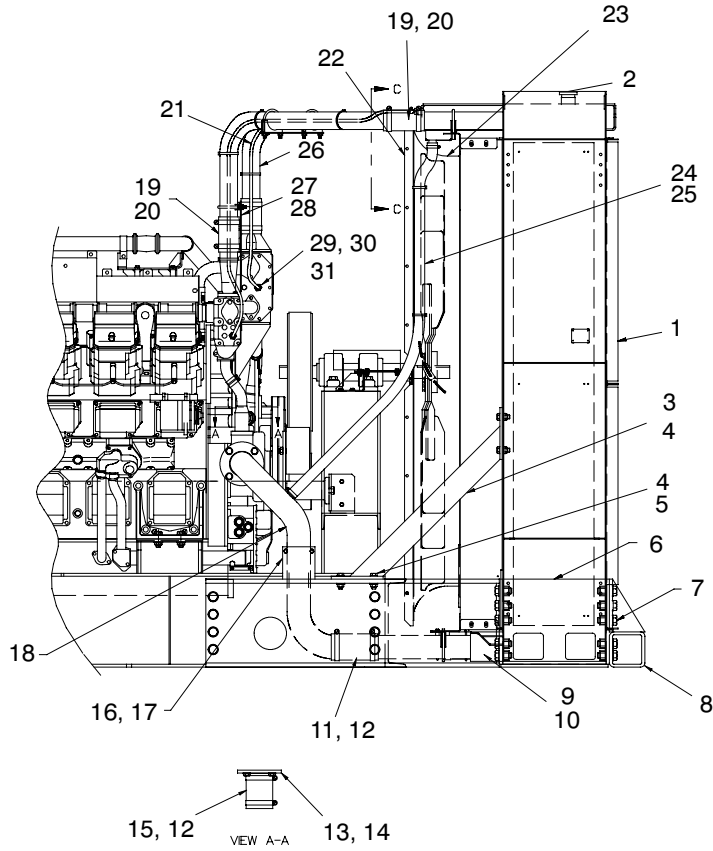
900/1000 kW

| Item | Part Number   | Description                                   | Quantity<br>Module |             |             |             |
|------|---------------|---|--------------------|-------------|-------------|-------------|
|      |               |   | GM51329-MA1        | GM51329-MA2 | GM81189-MA1 | GM81189-MA2 |
| 1    | GM50722       | Radiator assembly                             | 1                  |             | 1           |             |
| 1    | GM50723       | Radiator assembly                             |                    | 1           |             | 1           |
| 2    | 276954        | Cap, radiator                                 | 1                  | 1           | 1           | 1           |
| 3    | 365289        | Sensor, low fluid                             | 1                  | 1           |             |             |
| 4    | X-6003-120    | Conduit, convoluted                           | 1                  | 1           |             |             |
| 5    | X-6014-115    | Hose, radiator, wire insert, 1.25 in. ID      | 1                  | 1           | 1           | 1           |
| 6    | 274545        | Clamp, hose, 4.31/4.62 in.                    | 2                  | 2           | 2           | 2           |
| 7    | X-6014-92     | Hose, radiator, wire insert, 4.00 ID          | 1                  | 1           | 1           | 1           |
| 8    | GM50953       | Tube, lower radiator                          | 1                  | 1           | 1           | 1           |
| 9    | 275527        | Clamp, hose, 2.81/3.12 in.                    | 4                  | 4           | 4           | 4           |
| 10   | X-6014-69     | Hose, radiator, wire insert, 2.5 in. ID       | 2                  | 2           | 2           | 2           |
| 11   | GM52582       | Tube, lower radiator                          | 1                  | 1           | 1           | 1           |
| 12   | 291542        | Clamp, hose, 3.25/3.56 in.                    | 12                 | 12          | 12          | 12          |
| 13   | GM50985       | Tube, upper radiator                          | 1                  | 1           | 1           | 1           |
| 14   | 361560        | Tube, upper radiator                          | 2                  | 2           | 2           | 2           |
| 15   | X-507-7       | Hose, radiator, straight, 3 in. ID            | 4                  | 4           | 4           | 4           |
| 16   | X-582-25      | Connector, hose                               | 3                  | 3           | 3           | 3           |
| 17   | X-426-9       | Clamp, hose, 0.25/0.70 in.                    | 6                  | 6           | 6           | 6           |
| 18   | X-6359-7      | Hose, rubber, straight, 0.25 in. ID, 4.75 ft. | 1                  | 1           | 1           | 1           |
| 18   | X-582-25      | Connector, hose (not shown)                   | 4                  | 4           | 4           | 4           |
| 18   | X-6359-9      | Hose, rubber, straight, 0.25 in. ID, 11 ft.   | 2                  | 2           | 2           | 2           |
| 19   | X-391-44      | Elbow, hose                                   | 2                  | 2           | 2           | 2           |
| 20   | 225127        | Adapter, bushing                              | 2                  | 2           | 2           | 2           |
| 21   | X-426-19      | Clamp, hose, 1.00/2.00 in.                    | 4                  | 4           | 4           | 4           |
| 22   | X-6014-82     | Hose, radiator, wire insert 1.25 in. ID       | 1                  | 1           | 1           | 1           |
| 23   | 278788        | Valve, drain, 3/8 in. NPT                     | 2                  | 2           | 2           | 2           |
| 24   | M961-12040-82 | Screw, hex cap                                | 8                  | 8           | 8           | 8           |
| 25   | 290945        | Washer, hardened, 0.531 ID x 1.06 in. OD      | 8                  | 8           | 8           | 8           |
| 26   | GM50982       | Support, radiator, left side                  | 1                  | 1           | 1           | 1           |
| 27   | GM50980       | Support, radiator                             | 2                  | 2           | 2           | 2           |
| 28   | GM50981       | Support, radiator, right side                 | 1                  | 1           | 1           | 1           |
| 29   | X-6011-3      | Washer, beveled, 0.68 ID x 1.5 in. OD         | 4                  | 4           | 4           | 4           |
| 30   | X-801-9       | Washer, hardened, 0.688 ID x 1.373 in.        | 20                 | 20          | 20          | 20          |
| 31   | GM10378       | Fan, pusher                                   | 1                  | 1           | 1           | 1           |
| 32   | GM51324       | Guard, belt, top                              | 1                  | 1           | 1           | 1           |
| 33   | GM51326       | Guard, belt left side                         | 1                  | 1           | 1           | 1           |
| 34   | GM10545       | Bracket, belt guard                           | 1                  | 1           | 1           | 1           |
| 35   | GM10547       | racket, belt guard mtg.                       | 1                  | 1           | 1           | 1           |
| 36   | GM10542       | Guard, belt, bottom                           | 1                  | 1           | 1           | 1           |
| 37   | GM10546       | Bracket, belt guard mtg.                      | 1                  | 1           | 1           | 1           |
| 38   | GM10544       | Bracket, belt guard mtg.                      | 1                  | 1           | 1           | 1           |
| 39   | GM51325       | Guard, belt right side                        | 1                  | 1           | 1           | 1           |
| 40   | M961-16040-60 | Screw, hex cap                                | 4                  | 4           | 4           | 4           |
| 41   | X-507-6       | Hose, straight coolant, 3 in. ID              | 2                  | 2           | 2           | 2           |
| 42   | GM51327       | Guard, belt                                   | 1                  | 1           | 1           | 1           |
| 43   | GM51328       | Bracket, belt guard mtg.                      | 2                  | 2           | 2           | 2           |
| 44   | GM50984       | Tube, lower radiator                          | 1                  | 1           | 1           | 1           |
| 45   | M961-12030-60 | Screw, hex cap                                | 2                  | 2           | 2           | 2           |
| 46   | GM52629       | Bracket, tube support                         | 1                  | 1           | 1           | 1           |
| 47   | X-722-2       | Clamp, muffler, 2.62 in.                      | 1                  | 1           | 1           | 1           |
| 48   | X-6011-4      | Washer, beveled, 0.44 ID x 1.25 in. OD        | 1                  | 1           | 1           | 1           |

# Group 104: Cooling System, continued

1250-2000 kW

## 1250 kW Shown



6484\_104\_4



## Group 104: Cooling System, continued

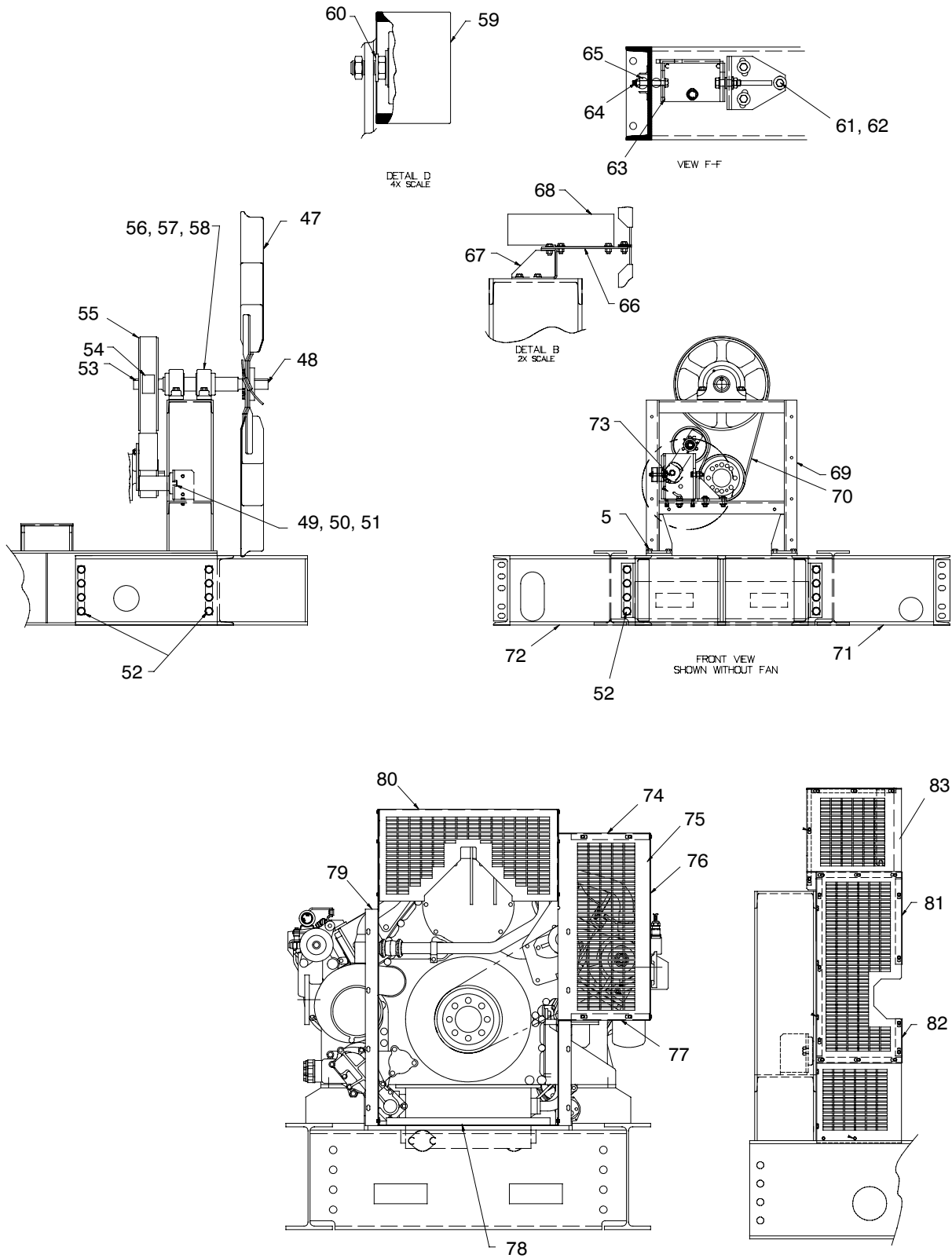
| Item | Part Number   | Description                               | Quantity    |             |             |             |             |             |             |             |             |
|------|---------------|---|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|      |               |   | Module      |             |             |             |             |             |             |             |             |
|      |               |   | GM51417-MA1 | GM51417-MA2 | GM50812-MA1 | GM50812-MA2 | GM50812-MA3 | GM51782-MA1 | GM75499-MA1 | GM75499-MA2 | GM75499-MA3 |
| 1    | GM50724       | Radiator assembly                         | 1           |             |             |             |             |             |             |             |             |
| 1    | GM50725       | Radiator assembly                         |             | 1           |             |             |             |             |             |             |             |
| 1    | GM50726       | Radiator assembly                         |             |             | 1           |             |             |             |             |             |             |
| 1    | GM50727       | Radiator assembly                         |             |             |             | 1           |             |             |             |             |             |
| 1    | GM50728       | Radiator assembly                         |             |             |             |             | 1           |             |             |             |             |
| 1    | GM50729       | Radiator assembly                         |             |             |             |             |             | 1           |             |             |             |
| 1    | GM75471       | Radiator assembly                         |             |             |             |             |             |             | 1           |             |             |
| 1    | GM75472       | Radiator assembly                         |             |             |             |             |             |             |             | 1           |             |
| 1    | GM75473       | Radiator assembly                         |             |             |             |             |             |             |             |             | 1           |
| 2    | 276954        | Cap, radiator                             | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 3    | 354969        | Brace, radiator                           | 2           | 2           |             |             | 2           |             |             |             | 2           |
| 3    | GM22413       | Brace, radiator                           |             |             | 2           | 2           |             |             | 2           | 2           |             |
| 3    | 347436        | Brace, radiator                           |             |             |             |             |             | 2           |             |             |             |
| 4    | X-801-9       | Washer, hardened, 0.688 ID x 1.373 in. OD | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           |
| 5    | X-6011-3      | Washer, beveled, 0.68 ID x 1.5 in. OD     | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           |
| 6    | 354999        | Bracket, radiator mounting                | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 7    | X-801-10      | Washer, hardened, 1.062 ID x 2 in. OD     | 20          | 20          | 20          | 20          | 20          | 20          | 20          | 20          | 20          |
| 8    | 361046        | Guard, radiator                           | 1           | 1           |             | 1           |             |             |             | 1           |             |
| 8    | GM22413       | Guard, radiator                           |             |             | 1           |             |             |             | 1           |             |             |
| 8    | GM50599       | Guard, radiator                           |             |             |             |             | 1           |             |             |             | 1           |
| 8    | 347419        | Guard, radiator                           |             |             |             |             |             | 1           |             |             |             |
| 10   | 278788        | Valve, drain, 3/8 in. NPTF                | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 11   | X-6014-31     | Hose, radiator wire inset, 4.00 ID        | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 12   | 274545        | Clamp, hose, 4.31/4.62 in.                | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           |
| 13   | GM19337       | Flange, water connection, inlet           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 14   | M961-16040-60 | Screw, hex cap                            | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           |
| 15   | X-6014-91     | Hose, radiator wire inset, 4.00 ID        | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 16   | GM19963       | Bracket, inlet tube                       | 1           | 1           |             |             |             | 1           |             |             |             |
| 16   | GM50773       | Bracket, inlet tube                       |             |             | 1           | 1           |             |             | 1           | 1           |             |
| 16   | GM50828       | Bracket, inlet tube                       |             |             |             |             | 1           |             |             |             | 1           |
| 17   | 289372        | Clamp, muffler, 4.12 in.                  | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 18   | GM19322       | Tube, lower radiator                      | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 19   | X-507-6       | Hose, straight coolant, 3.00 in. ID       | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           |
| 19   | X-6006-3      | Hose, radiator, straight, 3.5 in. ID      | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 20   | 291542        | Clamp, hose, 3.25/3.56 in.                | 12          | 12          | 12          | 12          | 12          | 12          |             |             |             |
| 20   | GM51502       | Clamp, hose                               |             |             |             |             |             |             | 8           | 8           | 8           |
| 21   | X-6359-14     | Hose, rubber                              | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3           |
| 22   | 354959        | Guard, flat fan                           | 4           | 4           |             |             |             |             |             |             |             |
| 22   | GM79943       | Guard, flat fan                           |             |             |             |             |             | 4           |             |             |             |
| 22   | GM21308       | Guard, wire fan, upper                    |             |             | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 22   | GM21309       | Guard, wire fan, lower                    |             |             | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 23   | 354195        | Shroud, venturi fan                       | 3           | 3           |             |             |             |             |             |             |             |
| 23   | GM60517       | Shroud                                    |             |             |             |             |             | 4           |             |             |             |
| 24   | X-6014-115    | Hose, radiator wire inset, 1.25 ID        | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 25   | X-426-4       | Clamp, hose, 1.31/2.25 in.                | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           |
| 26   | GM51408       | Tube, radiator upper, middle              | 1           | 1           |             |             |             |             |             |             |             |
| 26   | GM50605       | Tube, radiator upper, middle              |             |             | 1           | 1           | 1           |             | 1           | 1           | 1           |
| 26   | GM51779       | Tube, radiator upper, middle              |             |             |             |             |             | 1           |             |             |             |
| 27   | GM19607       | Support, radiator tube                    | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 28   | 286283        | Clamp, muffler, 3.12 in.                  | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           |
| 29   | X-391-44      | Elbow, hose                               | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 30   | X-202-28      | Bushing, reducing, 3/8 x 1/2 in. NTP      | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 30   | X-380-5       | Connector, hose                           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 31   | X-426-9       | Clamp, hose, 0.25/0.70 in.                | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           |
| 32   | GM51406       | Tube, radiator upper, left                | 1           | 1           |             |             |             |             |             |             |             |
| 32   | GM50603       | Tube, radiator upper, left                |             |             | 1           | 1           | 1           |             | 1           | 1           | 1           |
| 32   | GM51777       | Tube, radiator upper, left                |             |             |             |             |             | 1           |             |             |             |
| 33   | 365289        | Sensor, low fluid assembly                | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 34   | X-6003-8      | Conduit, convoluted                       | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 35   | GM17890       | Plate, support                            | 12          | 12          |             |             |             |             |             |             |             |
| 35   | GM22400       | Plate, support                            |             |             |             |             |             | 16          |             |             |             |
| 36   | M982-10-80    | Nut, hex elastic stop                     | 12          | 12          |             |             |             | 16          |             |             |             |
| 37   | X-801-6       | Washer, hardened, 0.469 ID x 0.922 in. OD | 12          | 12          |             |             |             | 16          |             |             |             |
| 38   | GM50811       | Bracket                                   | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 39   | X-582-25      | Connector, hose + vibra seal              | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3           |

Parts list continues on next page

# Group 104: Cooling System, continued

1250-2000 kW, continued

1250 kW Shown



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## Group 104: Cooling System, continued

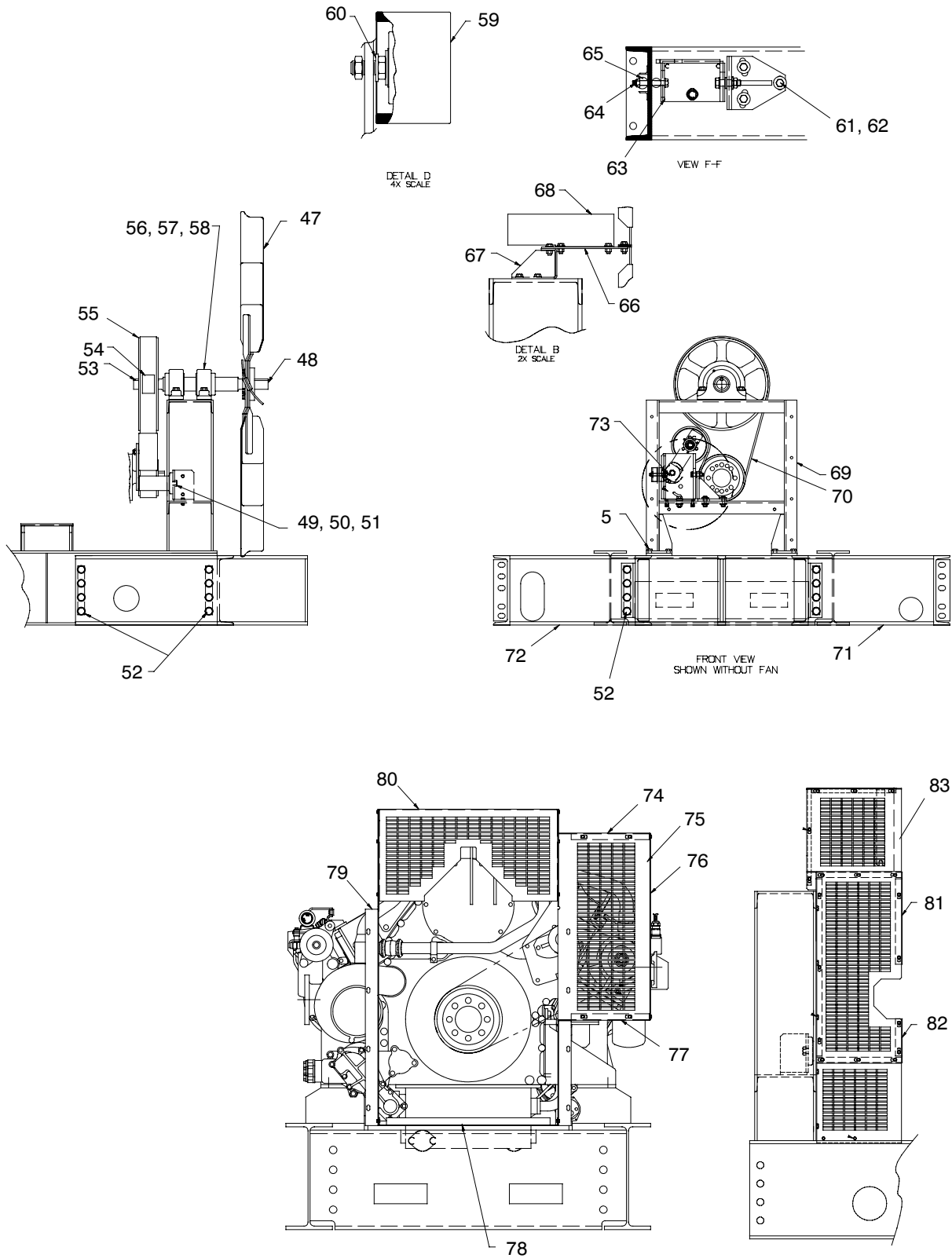
| Item | Part Number   | Description                            | Quantity    |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |    |
|------|---------------|--|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|----|----|----|----|----|----|----|----|----|
|      |               |  | Module      |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |    |
|      |               |  | GM51417-MA1 | GM51417-MA2 | GM50812-MA1 | GM50812-MA2 | GM50812-MA3 | GM75499-MA1 | GM75499-MA2 | GM75499-MA3 | GM51782-MA1 |    |    |    |    |    |    |    |    |    |
| 40   | GM51407       | Tube, radiator upper, right            | 1           | 1           |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |    |
| 40   | GM50604       | Tube, radiator upper, right            |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |    |
| 40   | GM51778       | Tube, radiator upper, right            |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    | 1  |
| 42   | M960-12050-60 | Screw, hex cap                         | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  |
| 43   | GM50600       | Tube, lower radiator                   | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 44   | X-6014-74     | Hose, radiator wire inset, 3.50 ID     | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| 45   | 291536        | Clamp, hose, 3.75/4.06 in.             | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  |
| 45   | 291537        | Clamp, hose, 3.75/4.06 in.             |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    | 4  |
| 46   | GM50601       | Tube, lower radiator                   | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 47   | 328246        | Fan, pusher                            | 1           | 1           |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |    |
| 47   | GM19513       | Fan, pusher                            |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |    |
| 47   | GM40814       | Fan                                    |             |             | 1           | 1           | 1           | 1           | 1           |             |             |    |    |    |    |    |    |    |    | 1  |
| 47   | GM75475       | Fan GM84866                            |             |             |             |             |             |             |             | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 48   | GM19587       | Shaft, fan                             | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 48   | 347431        | Shaft                                  |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    | 1  |
| 49   | GM28243       | Shim, 110 mm OD x 16 gauge stainless   | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8  | 8  | 8  | 8  | 8  | 8  | 8  | 8  | 8  |
| 50   | GM28244       | Shim, 110 mm OD x 22 gauge stainless   | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| 51   | GM28245       | Shim, 110 mm OD x 28 gauge stainless   | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| 52   | GM20151       | Plate, bolting                         | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6  | 6  | 6  | 6  | 6  | 6  | 6  | 6  | 6  |
| 53   | 328256        | Key                                    | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 54   | 274905        | Bushing, pulley, 3.998 in. NPT         | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 54   | GM26225       | Bushing, pulley                        |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    | 1  |
| 55   | 354984        | Pulley                                 | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 55   | 274906        | Pulley                                 |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    | 1  |
| 56   | 347430        | Block, pillow                          | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| 57   | M934-20-80    | Nut, hex                               | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  |
| 58   | GM30510       | Shim                                   | AR          | AR          | AR          | AR          | AR          | AR          | AR          | AR          | AR          | AR | AR | AR | AR | AR | AR | AR | AR | AR |
| 59   | GM19453       | Pulley, idler                          | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 60   | X-25-29       | Washer, plain, 0.812 ID x 1.469 in. OD | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 61   | GM26339       | Bracket, adjusting (idler mtg. plate)  | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 62   | X-801-15      | Washer, hardened                       | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6  | 6  | 6  | 6  | 6  | 6  | 6  | 6  | 6  |
| 63   | GM26338       | Plate, mounting (idler)                | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 64   | M982-12-80    | Nut, hex elastic stop                  | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 65   | GM26579       | Shaft, pivot                           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 66   | GM52961       | Support, fan guard                     | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| 66   | GM53089       | Support, shaft guard                   |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    | 2  |
| 67   | 365644        | Support, fan guard                     | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| 68   | GM52960       | Guard, shaft                           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 68   | GM53088       | Guard, shaft                           |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    | 1  |
| 69   | GM64371       | Frame, fan support                     | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 69   | GM64373       | Frame, fan support                     |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    | 1  |
| 70   | GM19618       | Belt, poly V                           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 70   | GM66038       | Belt, poly V                           |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    | 1  |
| 71   | GM19304       | Frame, radiator, right hand            | 1           | 1           |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |    |
| 71   | GM50716       | Frame, radiator, right hand            |             |             | 1           | 1           |             |             |             | 1           | 1           |    |    |    |    |    |    |    |    |    |
| 71   | GM50598       | Frame, radiator, right hand            |             |             |             |             |             |             | 1           |             |             |    |    |    |    |    |    |    |    | 1  |
| 71   | GM51781       | Frame, radiator, right hand            |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    | 1  |
| 72   | GM19303       | Frame, radiator, right hand            | 1           | 1           |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |    |
| 72   | GM50715       | Frame, radiator, right hand            |             |             | 1           | 1           |             |             |             | 1           | 1           |    |    |    |    |    |    |    |    |    |
| 72   | GM50597       | Frame, radiator, right hand            |             |             |             |             |             |             | 1           |             |             |    |    |    |    |    |    |    |    | 1  |
| 72   | GM51780       | Frame, radiator, right hand            |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    | 1  |
| 73   | GM19558       | Tensioner, belt                        | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |

Parts list continues on next page

# Group 104: Cooling System, continued

1250-2000 kW, continued

1250 kW Shown



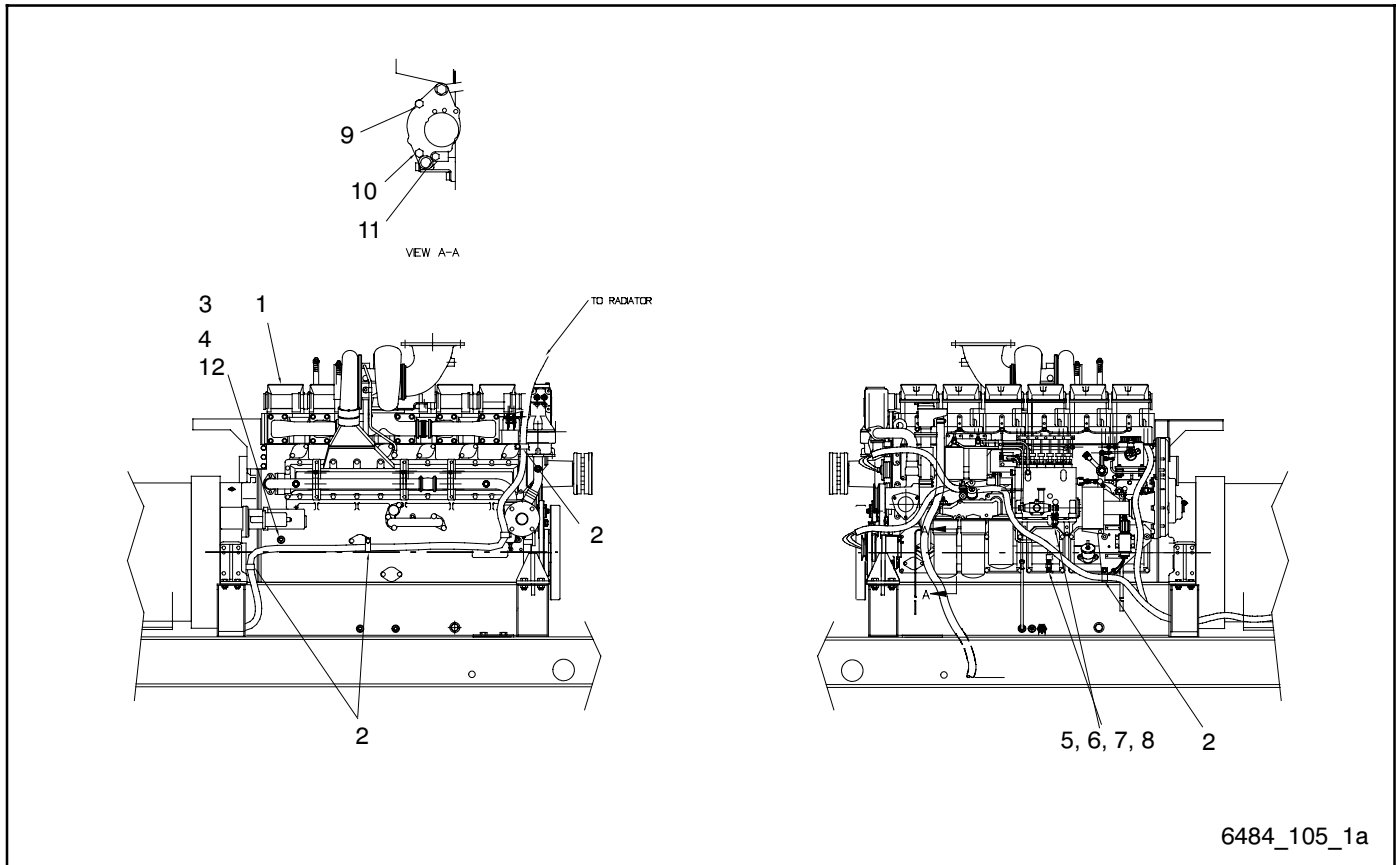
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## Group 104: Cooling System, continued

| Item | Part Number | Description                    | Quantity    |             |             |             |             |             |             |             |             |
|------|-------------|--------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|      |             |                                | Module      |             |             |             |             |             |             |             |             |
|      |             |                                | GM51417-MA1 | GM51417-MA2 | GM50812-MA1 | GM50812-MA2 | GM50812-MA3 | GM75499-MA1 | GM75499-MA2 | GM75499-MA3 | GM51782-MA1 |
| 74   | GM50784     | Guard, belt, left side, top    | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 74   | GM51773     | Guard, belt, left side, top    |             |             |             |             |             |             |             |             | 1           |
| 75   | GM50785     | Guard, belt front              | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |             |
| 75   | GM51774     | Guard, belt front              |             |             |             |             |             |             |             |             | 1           |
| 76   | GM50783     | Guard, belt, left side, middle | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 77   | GM50782     | Guard, belt, left side, bottom | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 78   | GM19961     | Guard, bottom                  | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 79   | GM50786     | Guard, belt, right side        | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |             |
| 79   | GM51775     | Guard, belt, right side        |             |             |             |             |             |             |             |             |             |
| 80   | GM50781     | Guard, belt top                | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |             |
| 80   | GM51776     | Guard, belt top                |             |             |             |             |             |             |             |             | 1           |
| 80   | GM53048     | Bracket, support (not shown)   |             |             | 1           | 1           | 1           | 1           | 1           | 1           |             |
| 80   | GM53085     | Bracket, support (not shown)   |             |             |             |             |             |             |             |             | 1           |
| 81   | GM52747     | Guard, belt                    | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 82   | GM53047     | Guard, belt                    | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 83   | GM60623     | Guard, Belt (RS)               |             |             |             |             |             |             |             |             | 1           |
| 83   | GM60624     | Guard, Belt (LS)               |             |             |             |             |             |             |             |             | 1           |

# Group 105: Engine

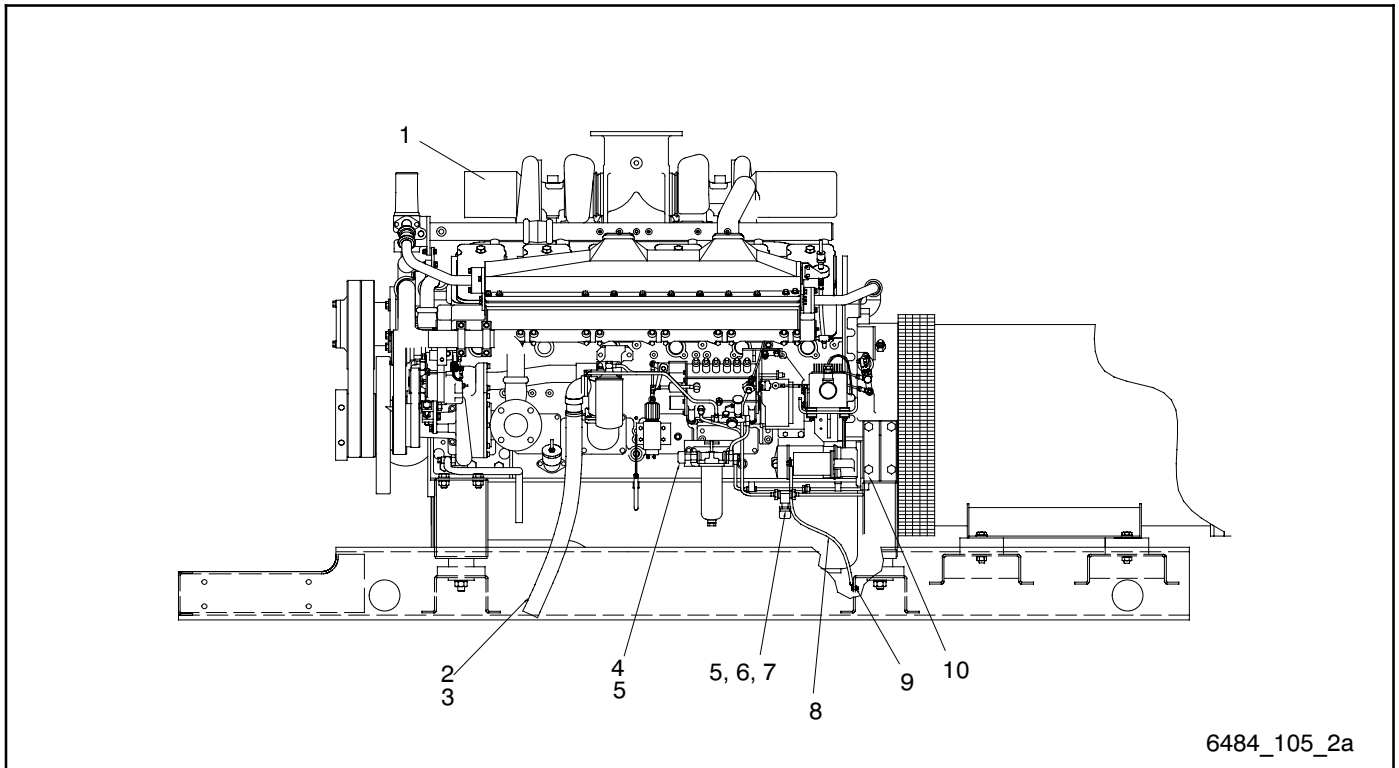
600 kW



| Item | Part Number   | Description                          | Qty. |
|------|---------------|--------------------------------------|------|
|      |               |                                      | Var. |
| 1    | GM49797       | Engine assembly, S6R, 600 kW         | 1    |
| 2    | X-672-37      | Clamp                                | 4    |
| 3    | M961-12030-60 | Screw, hex cap                       | 1    |
| 4    | M125A-12-80   | Washer, plain                        | 1    |
| 5    | GM10841       | Adapter bushing                      | 2    |
| 6    | X-204-8       | Pipe (3/8"npt x 1.50")               | 2    |
| 7    | X-202-23      | Bushing, reducing, 3/8 x 3/4 in. NPT | 2    |
| 8    | X-268-1       | Cap, pipe, 3/4 in.                   | 2    |
| 9    | M934-05-50    | Nut, hex, 5 mm                       | 1    |
| 10   | X-22-11       | Washer, lock, 0.262 ID x 0.469 OD    | 1    |
| 11   | X-672-13      | Clamp, insulated, 0.88 in.           | 1    |
| 12   | GM74535       | Terminal, Ground                     | 1    |

# Group 105: Engine

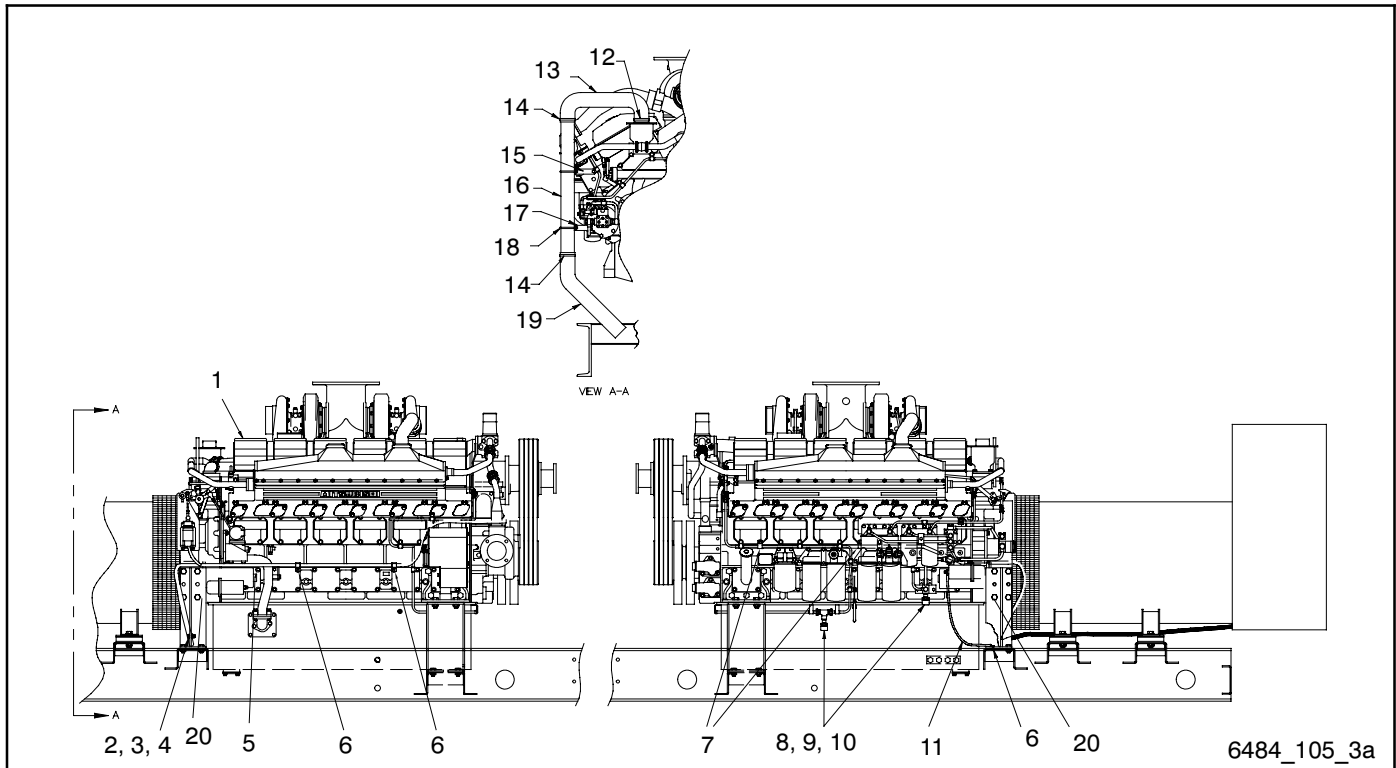
750/800 kW



| Item | Part Number | Description                            | Qty. |
|------|-------------|--|------|
|      |             |  | Var. |
| 1    | GM41080     | Engine assembly, S12A2, 800 kW         | 1    |
| 2    | X-6292-4    | Hose                                   | 1    |
| 3    | X-426-19    | Clamp, hose, 1.00/2.00 in.             | 3    |
| 4    | X-206-9     | Pipe, 3/4 in. NPT x 1.38 in.           | 1    |
| 5    | X-268-1     | Cap, pipe, 3/4 in. NPTF                | 2    |
| 6    | X-209-5     | Pipe, 1/2 in. NPT x 1.50 in.           | 1    |
| 7    | 153659      | Bushing, reducing, 1/2 x 3/4 in. NPT   | 1    |
| 8    | X-545-145   | Cable, battery, No. 2/0 x 62 in., RED+ | 1    |
| 9    | X-672-32    | Clamp, insulated, 1.06 in.             | 2    |
| 10   | GM74535     | Terminal, Ground                       | 1    |

# Group 105: Engine, continued

900/1000 kW



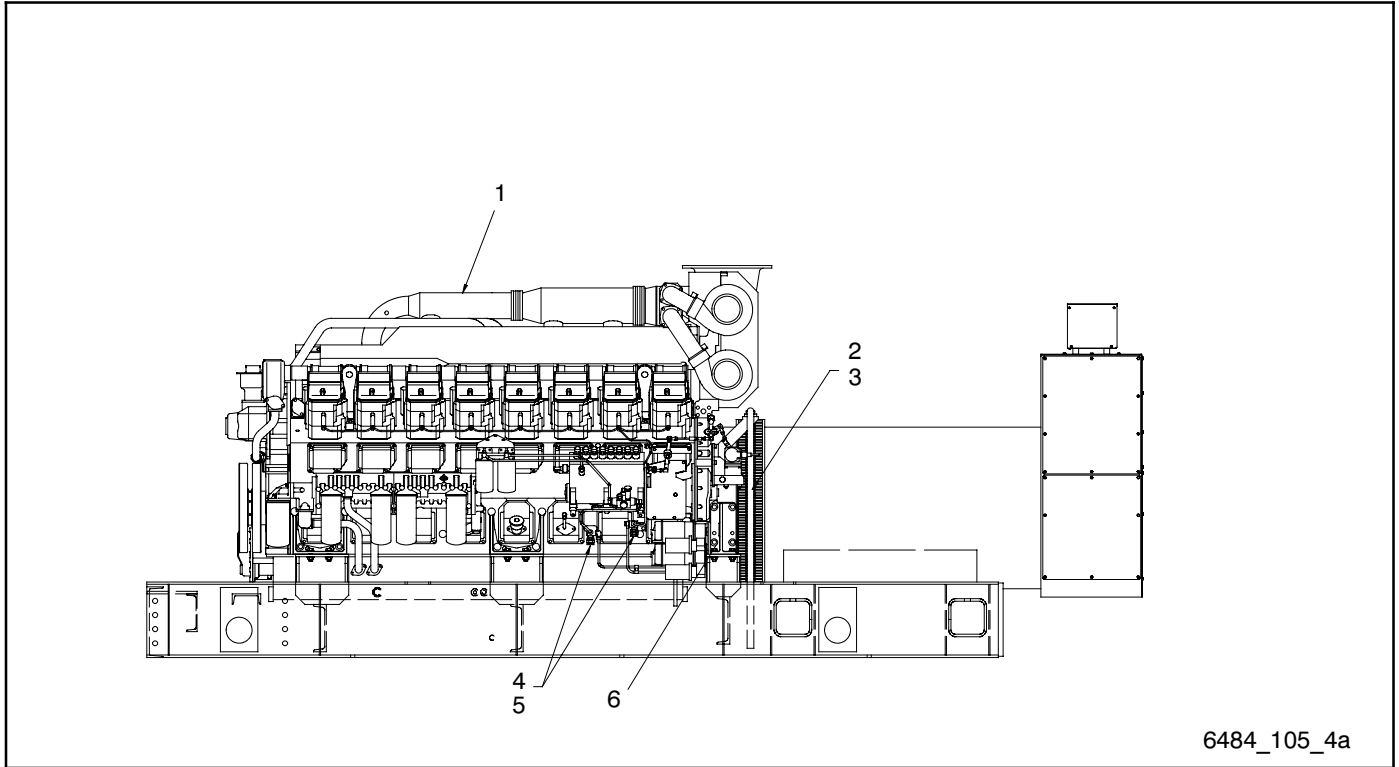
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| Item | Part Number | Description                            | Qty. |
|------|-------------|--|------|
|      |             |  | Var. |
| 1    | GM49798     | Engine assembly, S12H, 1000 kW         | 1    |
| 2    | X-22-15     | Washer, lock, 0.456 ID x 1.058 in. OD  | 2    |
| 3    | X-6214-4    | Cap                                    | 1    |
| 4    | 226917      | Decal, negative battery connection     | 1    |
| 5    | X-22-15     | Washer, lock, 0.456 ID x 1.058 in. OD  | 1    |
| 6    | X-672-32    | Clamp, insulated, 1.06 in.             | 4    |
| 7    | X-672-3     | Clamp, insulated                       | 2    |
| 8    | X-209-5     | Nipple, pipe, 1/2 x 1 1/2 in.          | 2    |
| 9    | 168848      | Bushing, reducing, 1/2 x 1 in. NPT     | 2    |
| 10   | X-268-4     | Cap, pipe                              | 2    |
| 11   | X-545-145   | Cable, battery, No. 2/0 x 62 in., RED+ | 1    |
| 12   | 324342      | Clamp, hose, 3.43/3.75 in.             | 1    |
| 13   | GM10964     | Hose, breather                         | 1    |
| 14   | 291542      | Clamp, hose, 3.25/3.56 in.             | 2    |
| 15   | GM52545     | Bracket, breather tube                 | 1    |
| 16   | GM10579     | Tube, breather, 3.00 in.               | 1    |
| 17   | GM52546     | Bracket, breather tube                 | 1    |
| 18   | 286283      | Clamp, muffler, 3.12 in.               | 2    |
| 19   | X-6014-57   | Hose, radiator, straight, 3 in. ID     | 1    |
| 20   | GM74535     | Terminal, Ground                       | 2    |



# Group 105: Engine, continued

1250-2000 kW



| Item | Part Number | Description                        | Quantity         |   |   |
|------|-------------|------------------------------------|------------------|---|---|
|      |             |                                    | Variation Number |   |   |
|      |             |                                    | 4                | 5 | 6 |
| 1    | GM50464     | Engine assembly, S12RH, 1250 kW    | 1                |   |   |
| 1    | GM50465     | Engine assembly, S16R, 1600 kW     |                  | 1 |   |
| 1    | GM50466     | Engine assembly, S16R, 2000 kW     |                  |   | 1 |
| 2    | X-6014-97   | Hose, radiator, wire inset 1.00 ID | 2                | 2 | 2 |
| 3    | X-426-12    | Clamp, hose, 0.69/1.25 in.         | 2                | 2 | 2 |
| 4    | X-206-9     | Pipe, 3/4 in. NPT x 1.38 in.       | 2                | 2 | 2 |
| 5    | X-268-1     | Cap, pipe, 3/4 in. NPTF            | 2                | 2 | 2 |
| 6    | GM77363     | Terminal, Ground                   | 1                | 1 | 1 |
| 7    | GM62262     | Shield, Heat (not shown)           | 1                | 1 | 1 |

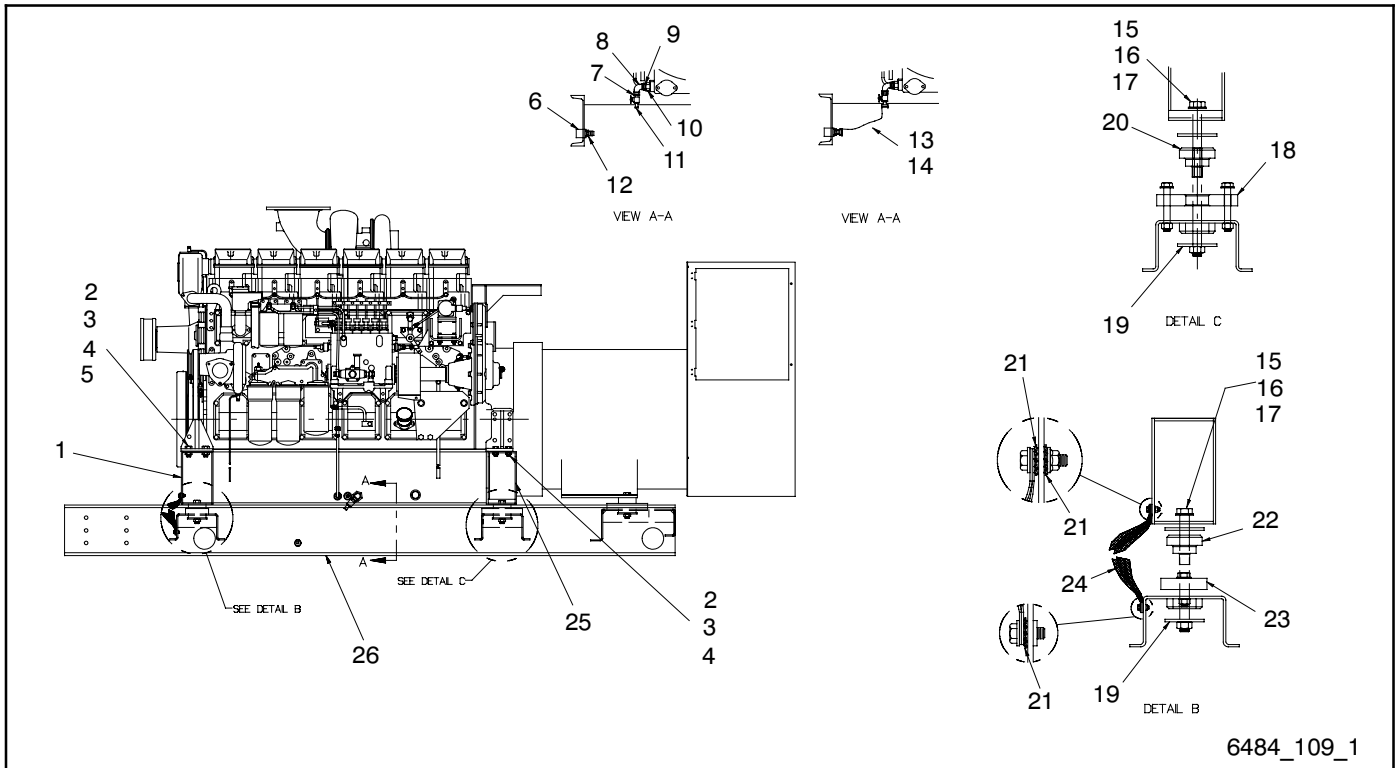
## Group 107: Nameplates and Decals

| Item | Part Number | Description                            | Quantity         |   |   |
|------|-------------|--|------------------|---|---|
|      |             |  | Variation Number |   |   |
|      |             |  | 1                | 2 | 3 |
| 1    | X-6232-3    | Decal, stripes                         | 1                | 1 |   |
| 1    | X-6232-6    | Decal, stripes                         |                  |   | 2 |
| 2    | X-6246-1    | Decal, Kohler Power System             | 1                | 1 | 2 |
| 3    | X-6276-8    | Logo, Kohler                           | 2                | 2 |   |
| 4    | 224233      | Decal, 1-800 number                    | 1                | 1 | 1 |
| 5    | 226917      | Decal, negative battery connection     | 1                | 1 | 1 |
| 6    | 238402      | Decal, caution positive terminal only  | 2                | 2 | 2 |
| 7    | 249808      | Decal, warning rotating parts          | 1                | 1 | 1 |
| 8    | 249809      | Decal, caution hot engine              | 2                | 2 | 2 |
| 9    | 249810      | Decal, warning hot coolant             | 1                | 1 | 1 |
| 10   | 255882      | Decal, caution standby service connect | 1                | 1 | 2 |
| 11   | 257438      | Decal, danger moving rotor             | 1                | 1 | 2 |
| 12   | 294520      | Decal, danger high voltage             | 1                | 1 | 2 |
| 13   | GM60531     | Decal, control height                  | 1                | 1 | 1 |
| 14   | GM13227     | Decal, warning generator fan force     | 1                | 1 |   |
| 15   | GM13228     | Decal, warning lifting support         | 1                | 1 |   |
| 16   | 364116      | Decal, caution welding disconnect      | 2                | 2 | 2 |
| 17   | 279748      | Decal, caution                         | 1                | 1 |   |
| 18   | 258815      | Decal, warning voltage backfeed        | 1                | 1 | 2 |
| 19   | 345211      | Decal, ground                          |                  |   | 1 |
| 20   | GM79042     | Decal, Phasing                         |                  |   | 2 |
| 21   | GM79043     | Decal, Phasing C-B-A                   |                  |   | 2 |

**Note:** Group 107: Nameplates and Decal items are not illustrated.

# Group 109: Skid and Plant Mounting

600 kW

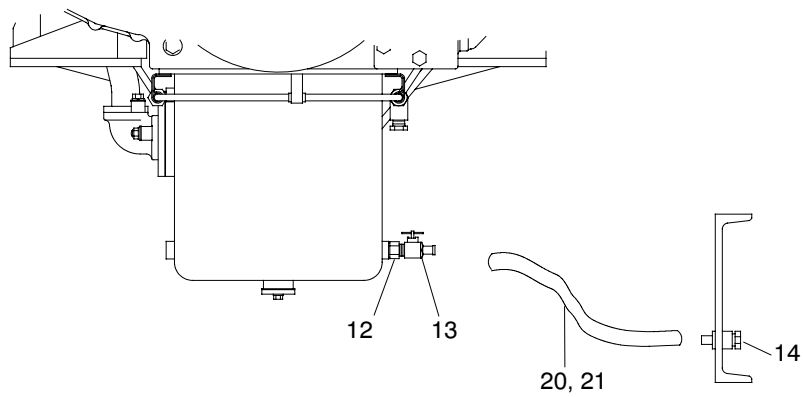
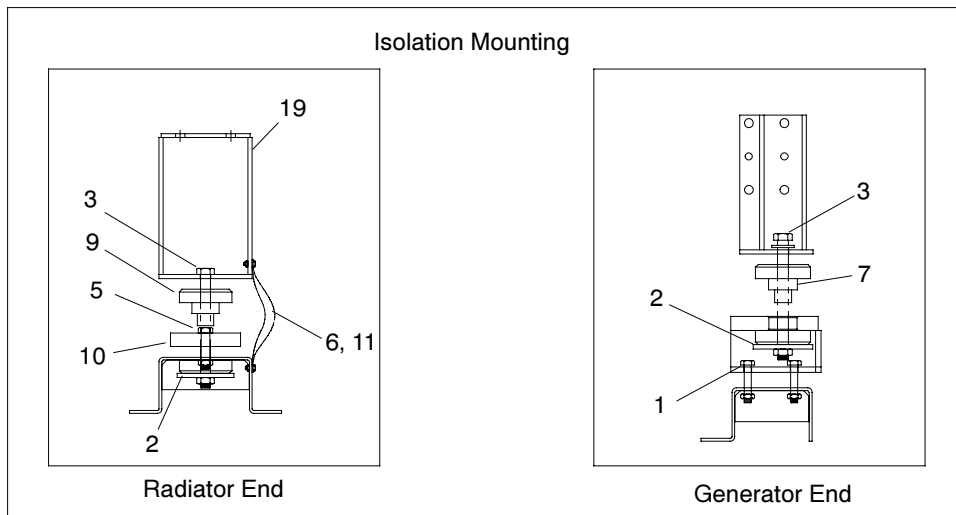
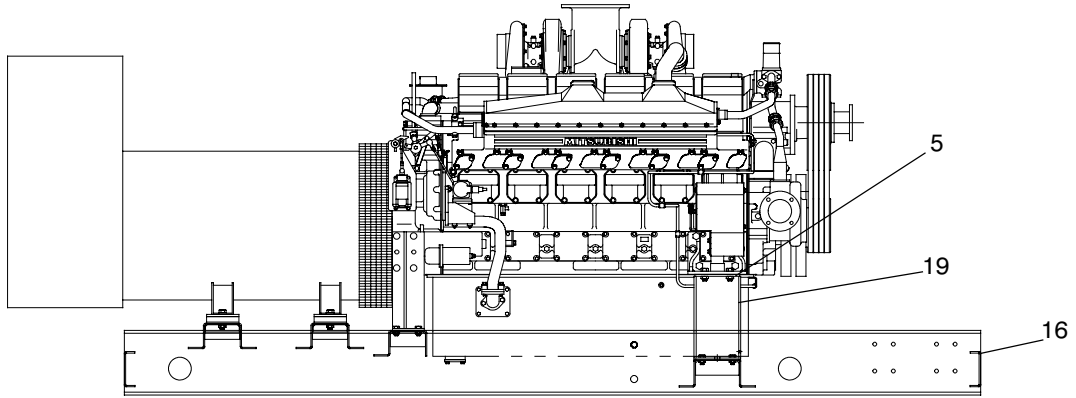


6484\_109\_1

| Item | Part Number   | Description                           | Quantity    |             |
|------|---------------|---------------------------------------|-------------|-------------|
|      |               |                                       | Module      |             |
|      |               |                                       | GM12012-MA3 | GM12012-MA4 |
| 1    | GM49365       | Mount, engine, front                  | 2           | 2           |
| 2    | M933-18050-60 | Screw, hex cap                        | 8           | 8           |
| 3    | M934-18-80    | Nut, hex                              | 8           | 8           |
| 4    | M125A-18-80   | Washer, plain                         | 8           | 8           |
| 5    | M6797A-18-80  | Washer, lock                          | 1           | 1           |
| 6    | X-75-28       | Plug, pipe, 1/2 in.                   | 1           | 1           |
| 7    | X-202-41      | Bushing, reducing, 1/2 x 3/4 in. NPT  | 1           | 1           |
| 8    | X-215-2       | Elbow, pipe, 90° x 3/4 in. NPT        | 1           | 1           |
| 9    | X-206-2       | Pipe, nipple, 3/4 in. NPT x 2 in.     | 1           | 1           |
| 10   | GM10577       | Adapter bushing                       | 1           | 1           |
| 11   | 272701        | Valve, oil drain                      | 1           | 1           |
| 12   | X-582-1       | Coupling, hose                        | 1           | 1           |
| 13   | X-426-3       | Clamp, hose, 0.56/1.06 in.            | 2           | 2           |
| 14   | X-577-48      | Hose, rubber, straight, 0.62 in. ID   | 1           | 1           |
| 15   | M125A-20-80   | Washer, plain                         | 4           | 4           |
| 16   | M982-20-80    | Nut, hex elastic stop                 | 4           | 4           |
| 17   | M931-20120-60 | Screw, hex cap                        | 4           | 4           |
| 18   | 361733        | Plate, engine mounting                | 2           | 2           |
| 19   | X-25-155      | Washer, plain                         | 4           | 4           |
| 20   | 365190        | Vibromount                            | 2           | 2           |
| 21   | X-22-16       | Washer, lock, 0.326 ID x 0.883 in. OD | 3           | 3           |
| 22   | 361734        | Vibromount                            | 2           | 2           |
| 23   | 361733        | Plate, engine mounting                | 2           | 2           |
| 24   | GM21085       | Strap, ground, 16 in.                 | 2           | 2           |
| 25   | GM11972       | Mount, engine, front                  | 2           | 2           |
| 26   | GM50609       | Skid                                  | 1           |             |
| 26   | GM50596       | Skid                                  |             | 1           |

# Group 109: Skid and Plant Mounting, continued

600 kW



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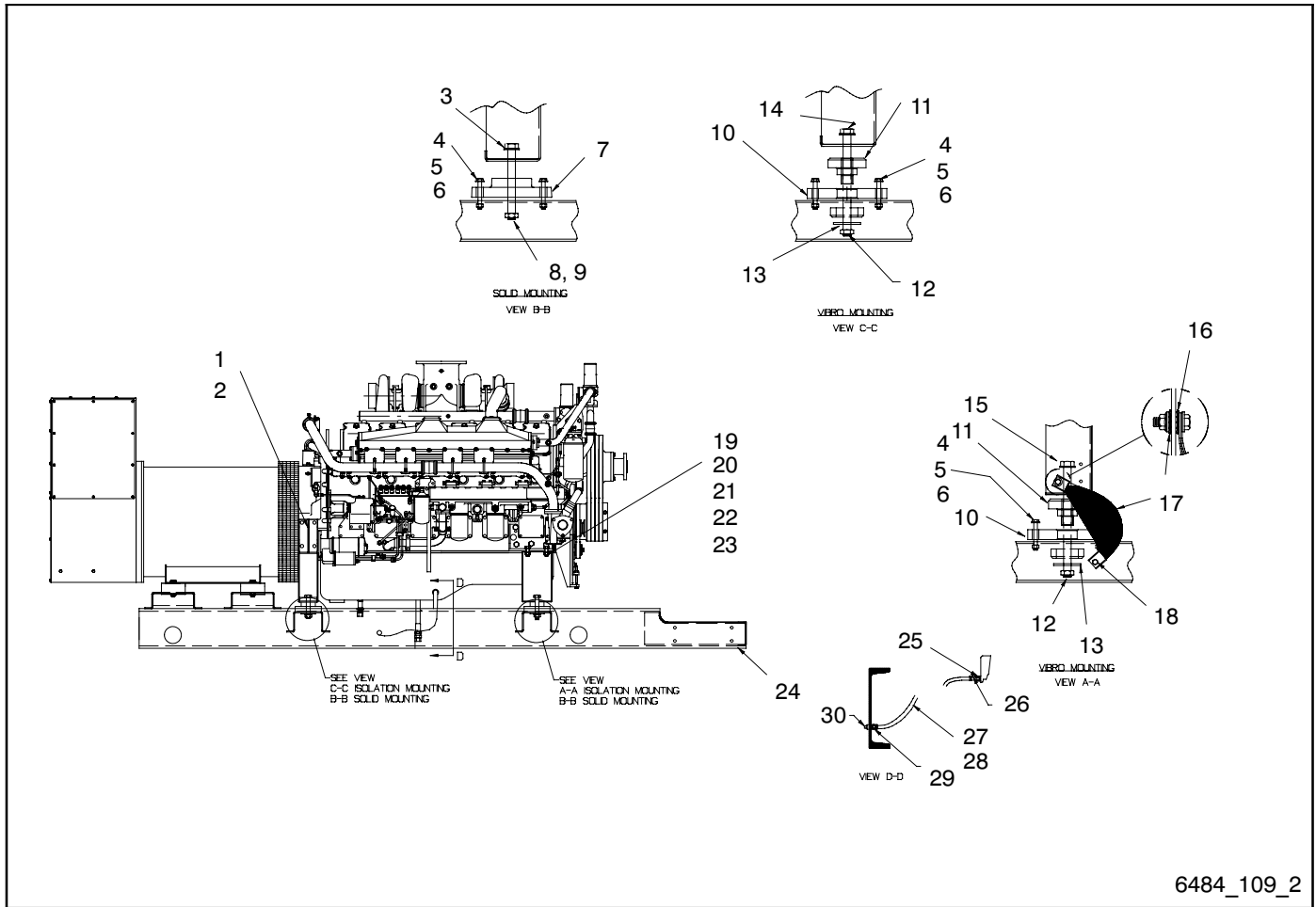
# Group 109: Skid and Plant Mounting, continued

600 kW

| Item | Part Number   | Description                          | Quantity    |             |
|------|---------------|--------------------------------------|-------------|-------------|
|      |               |                                      | Module      |             |
|      |               |                                      | GM77241-MA3 | GM77241-MA4 |
| 2    | X-25-155      | Washer, plain                        | 8           | 8           |
| 3    | M931-20120-60 | Screw, hex cap                       | 4           | 4           |
| 3    | M982-20-80    | Nut, hex elastic stop                | 4           | 4           |
| 5    | M125A-18-80   | Washer, plain                        | 12          | 12          |
| 5    | M6797A-18-80  | Washer, lock                         | 12          | 12          |
| 5    | M933-18050-60 | Screw, hex cap                       | 12          | 12          |
| 5    | M934-18-80    | Nut, hex                             | 12          | 12          |
| 6    | X-22-16       | Washer, lock, .326 ID x .883 in. OD  | 3           | 3           |
| 7    | 365190        | Vibromount                           | 2           | 2           |
| 9    | 361734        | Vibromount                           | 2           | 2           |
| 10   | 361733        | Plate, engine mounting               | 4           | 4           |
| 11   | GM21085       | Strap, ground (16 in.)               | 1           | 1           |
| 12   | X-202-41      | Bushing, reducing, 1/2 x 3/4 in. NPT | 1           | 1           |
| 12   | GM10577       | Adapter bushing                      | 1           | 1           |
| 13   | 272701        | Valve, oil drain                     | 1           | 1           |
| 14   | X-582-1       | Coupling, hose                       | 1           | 1           |
| 14   | X-75-28       | Plug, pipe, 1/2 in.                  | 1           | 1           |
| 16   | GM77254       | Skid                                 | 1           |             |
| 16   | GM77255       | Skid                                 |             | 1           |
| 19   | GM49365       | Mount, engine, front                 | 4           | 4           |
| 20   | X-426-12      | Clamp, hose, .69/1.25 in.            | 2           | 2           |
| 21   | X-577-48      | Hose, rubber, straight, .62 in. ID   | 1           | 1           |

# Group 109: Skid and Plant Mounting, continued

750/800 kW



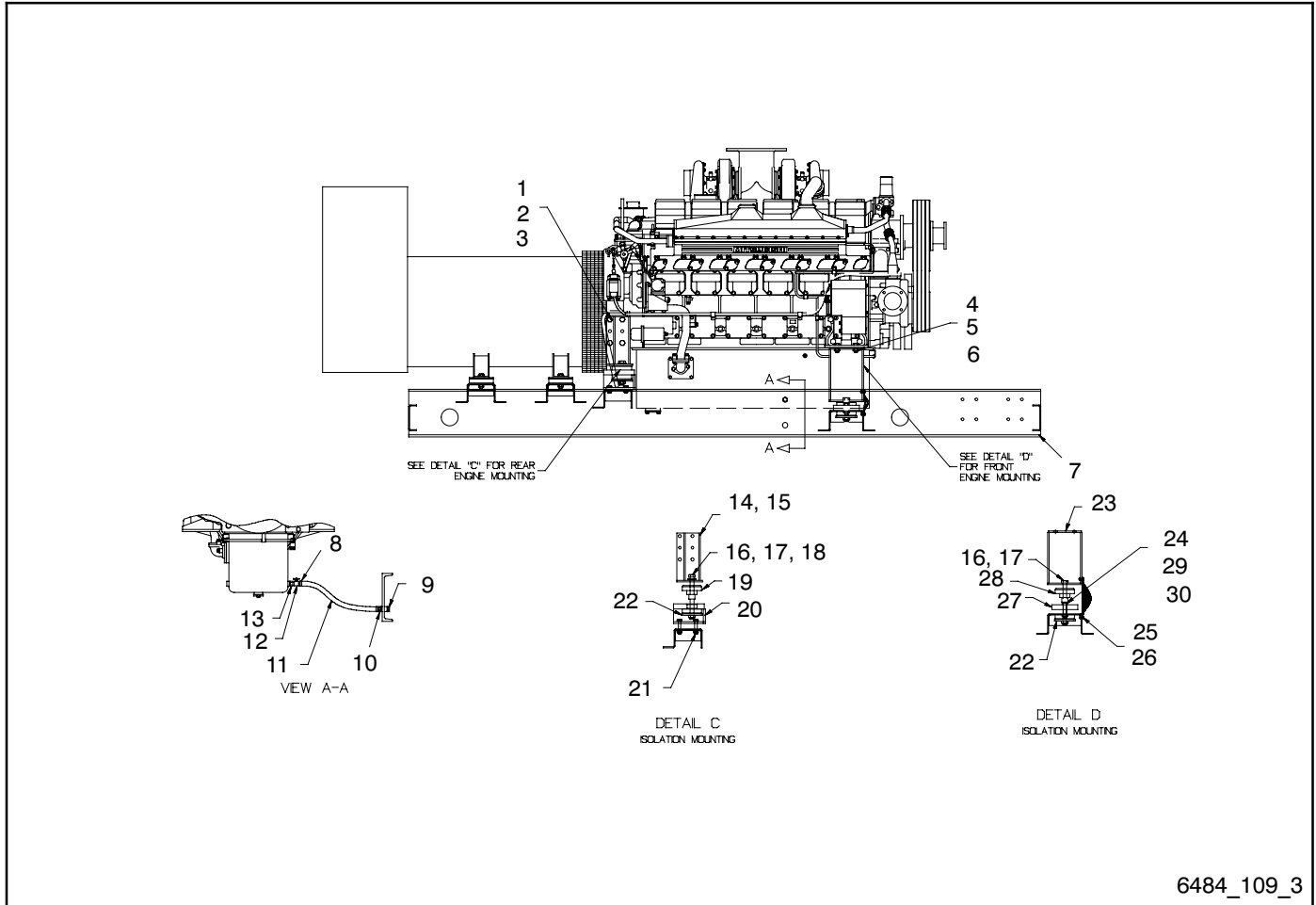
# Group 109: Skid and Plant Mounting, continued

750/800 kW

| Item | Part Number   | Description                            | Quantity<br>Module |             |             |             |             |             |
|------|---------------|--|--------------------|-------------|-------------|-------------|-------------|-------------|
|      |               |  | GM51272-MA1        | GM51272-MA2 | GM77243-MA1 | GM77243-MA2 | GM80793-MA1 | GM80793-MA2 |
| 1    | GM51273       | Mount, rear engine                     | 2                  | 2           | 2           | 2           | 2           | 2           |
| 2    | M933-18035-60 | Screw, hex cap                         | 8                  | 8           | 8           | 8           | 8           | 8           |
| 3    | M931-24120-60 | Screw, hex cap                         | 4                  | 4           | 4           |             |             |             |
| 4    | M931-20065-60 | Screw, hex cap                         | 8                  | 8           | 4           | 8           | 8           | 8           |
| 5    | M934-20-80    | Nut, hex                               | 12                 | 12          | 12          | 12          | 12          | 12          |
| 6    | M125A-20-80   | Washer, plain                          | 8                  | 8           | 8           | 8           | 8           | 8           |
| 7    | 361668        | Plate, spacer mounting                 | 4                  |             | 4           |             |             |             |
| 8    | M934-24-80    | Nut, hex                               | 4                  |             | 4           |             |             |             |
| 9    | M125A-24-80   | Washer, plain                          | 4                  |             | 4           |             |             |             |
| 10   | 361039        | Plate, generator mounting              |                    | 4           |             | 4           | 4           | 4           |
| 11   | 361054        | Vibromount                             |                    | 4           |             | 4           | 4           | 4           |
| 12   | M982-24-60    | Nut, hex elastic stop                  |                    | 4           |             | 4           | 4           | 4           |
| 13   | X-25-152      | Washer, plain, 1.06 ID x 5.25 in. OD   |                    | 4           |             | 4           | 4           | 4           |
| 14   | M931-24160-60 | Screw, hex cap                         |                    | 2           |             | 2           | 2           | 2           |
| 15   | M931-24160-60 | Screw, hex cap                         |                    | 2           |             | 2           | 2           | 2           |
| 16   | X-22-16       | Washer, lock., 0.326 ID x 0.883 in. OD |                    | 2           |             | 2           | 2           | 2           |
| 17   | GM21085       | Strap, ground, 16 in.                  |                    | 2           |             | 2           | 2           | 2           |
| 18   | X-22-26       | Washer, lock, 0.521 ID x 1.24 in. OD   |                    | 2           |             | 2           | 2           | 2           |
| 19   | GM52625       | Mount, front engine right              | 1                  | 1           | 1           | 1           | 1           | 1           |
| 20   | GM51274       | Mount, front engine left               | 1                  | 1           | 1           | 1           | 1           | 1           |
| 21   | M933-20050-60 | Screw, hex cap                         | 4                  | 4           | 4           | 4           | 4           | 4           |
| 22   | M125A-20-80   | Washer, plain                          | 4                  | 4           | 4           | 4           |             |             |
| 23   | M934-20-80    | Nut, hex                               | 4                  | 4           | 4           | 4           |             |             |
| 24   | GM51079       | Skid                                   | 1                  | 1           |             |             |             |             |
| 24   | GM77256       | Skid                                   |                    |             | 1           | 1           |             |             |
| 24   | GM80791       | Skid                                   |                    |             |             |             | 1           |             |
| 24   | GM80831       | Skid                                   |                    |             |             |             |             | 1           |
| 25   | X-202-41      | Bushing, reducing, 1/2 x 3/4 in. NPT   | 1                  | 1           | 1           | 1           | 1           | 1           |
| 26   | 272701        | Valve, oil drain                       | 1                  | 1           | 1           | 1           | 1           | 1           |
| 27   | X-577-28      | Hose, rubber, straight, 0.62 in. ID    | 1                  | 1           | 1           | 1           | 1           | 1           |
| 28   | X-426-12      | Clamp, hose, 0.69/1.25 in.             | 2                  | 2           | 2           | 2           | 2           | 2           |
| 29   | X-582-1       | Connector, hose + vibra seal           | 1                  | 1           | 1           | 1           | 1           | 1           |
| 30   | X-75-28       | Plug, pipe, 1/2 in. NPTF               | 1                  | 1           | 1           | 1           | 1           | 1           |

# Group 109: Skid and Plant Mounting, continued

900/1000 kW





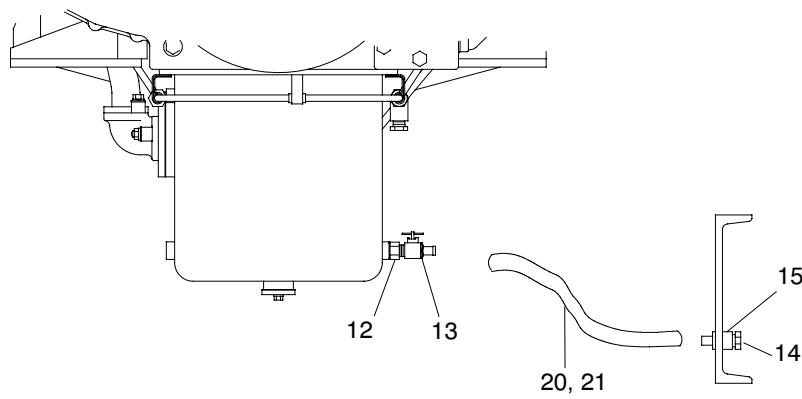
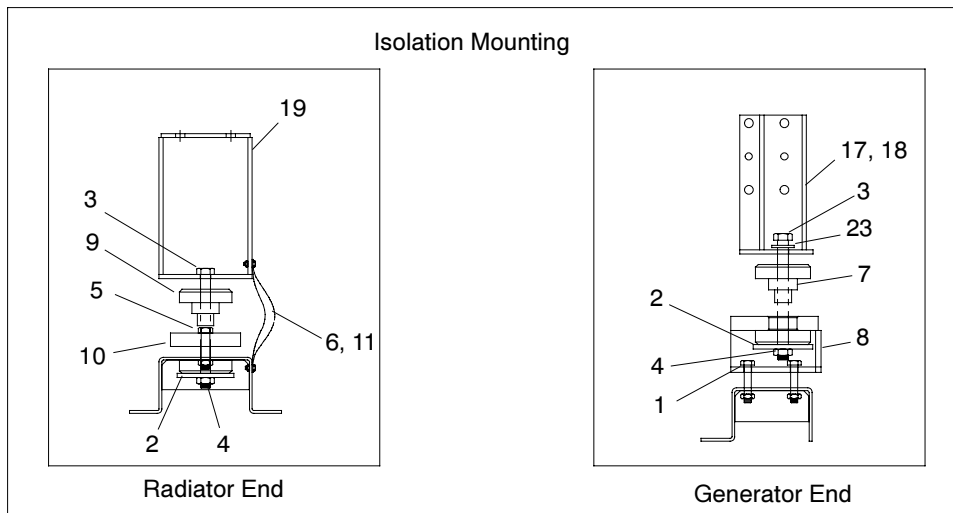
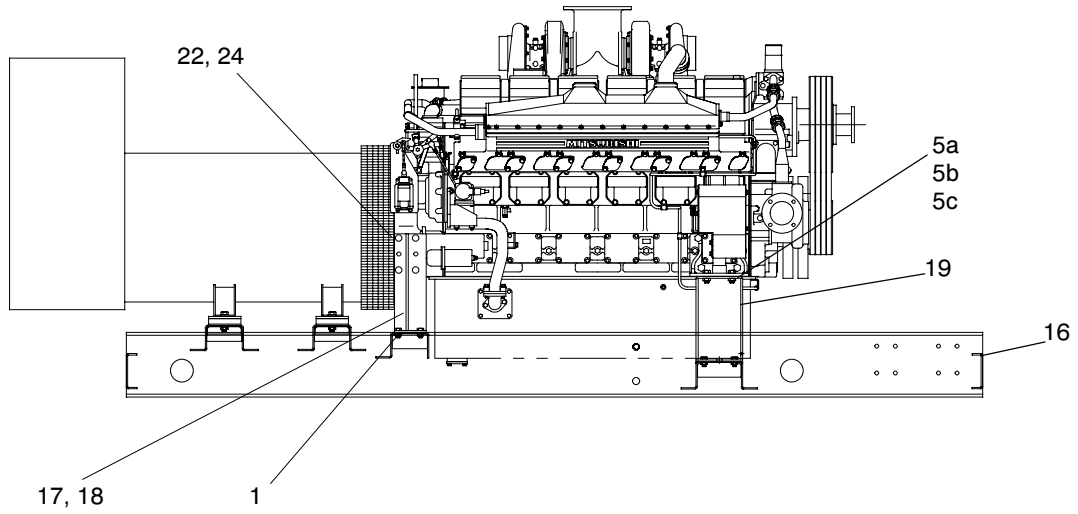
# Group 109: Skid and Plant Mounting, continued

900/1000 kW

| Item | Part Number   | Description                           | Quantity    |             |             |             |
|------|---------------|---------------------------------------|-------------|-------------|-------------|-------------|
|      |               |                                       | Module      |             |             |             |
|      |               |                                       | GM31224-MA3 | GM31224-MA4 | GM31226-MA3 | GM31226-MA4 |
| 1    | M933-18035-60 | Screw, hex cap                        | 8           | 8           | 8           | 8           |
| 2    | M125A-18-80   | Washer, plain                         | 8           | 8           | 8           | 8           |
| 3    | M6797A-18-80  | Washer, lock                          | 1           | 1           | 1           | 1           |
| 4    | M933-20055-60 | Screw, hex cap                        | 8           | 8           | 8           | 8           |
| 5    | M934-20-80    | Nut, hex                              | 8           | 8           | 8           | 8           |
| 6    | M125A-20-80   | Washer, plain                         | 8           | 8           | 8           | 8           |
| 7    | GM50978       | Skid                                  | 1           |             | 1           |             |
| 7    | GM50979       | Skid                                  |             | 1           |             | 1           |
| 8    | X-426-3       | Clamp, hose, 0.56/1.06 in.            | 2           | 2           | 2           | 2           |
| 9    | X-75-28       | Plug, pipe, 1/2 in.                   | 1           | 1           | 1           | 1           |
| 10   | X-582-1       | Coupling, hose                        | 1           | 1           | 1           | 1           |
| 11   | X-577-28      | Hose, rubber, straight, 0.62 in. ID   | 1           | 1           | 1           | 1           |
| 12   | 272701        | Valve, oil drain                      | 1           | 1           | 1           | 1           |
| 13   | X-202-41      | Bushing, reducing, 1/2 x 3/4 in. NPT  | 1           | 1           | 1           | 1           |
| 14   | GM10458       | Support, rear engine, right side      | 1           | 1           |             |             |
| 14   | GM10521       | Support, rear engine, right side      |             |             | 1           | 1           |
| 15   | GM10459       | Support, rear engine, left side       | 1           | 1           |             |             |
| 15   | GM10522       | Support, rear engine, left side       |             |             | 1           | 1           |
| 16   | M931-24160-60 | Screw, hex cap                        | 4           | 4           |             |             |
| 17   | M982-24-60    | Nut, hex elastic stop                 | 4           | 4           |             |             |
| 18   | X-801-10      | Washer, hardened, 1.062 ID x 2 in. OD | 2           | 2           |             |             |
| 19   | 361919        | Vibromount                            | 2           | 2           |             |             |
| 20   | 361024        | Mount, engine                         | 2           | 2           |             |             |
| 21   | X-6011-3      | Washer, beveled, 0.68 ID x 1.5 in. OD | 4           | 4           | 4           | 4           |
| 22   | X-25-152      | Washer, plain, 1.06 ID x 5.25 in. OD  | 4           | 4           |             |             |
| 23   | GM10457       | Support, front engine                 | 2           | 2           |             |             |
| 23   | GM10520       | Support, front engine                 |             |             | 2           | 2           |
| 24   | M931-20065-60 | Screw, hex cap                        | 4           | 4           |             |             |
| 24   | M933-16050-60 | Screw, hex cap                        |             |             | 8           | 8           |
| 25   | GM21085       | Strap, ground, 16 in.                 | 2           | 2           |             |             |
| 26   | X-22-16       | Washer, lock, 0.326 ID x 0.883 in. OD | 3           | 3           |             |             |
| 27   | 361039        | Plate, generator mounting             | 2           | 2           |             |             |
| 28   | 361179        | Vibromount                            | 2           | 2           |             |             |
| 29   | M934-20-80    | Nut, hex                              | 4           | 4           |             |             |
| 29   | M6923-16-80   | Nut, hex                              |             |             | 8           | 8           |
| 30   | M125A-20-80   | Washer, plain                         | 4           | 4           |             |             |
| 30   | M125A-16-80   | Washer, plain                         |             |             | 8           | 8           |

# Group 109: Skid and Plant Mounting, continued

900/1000 kW



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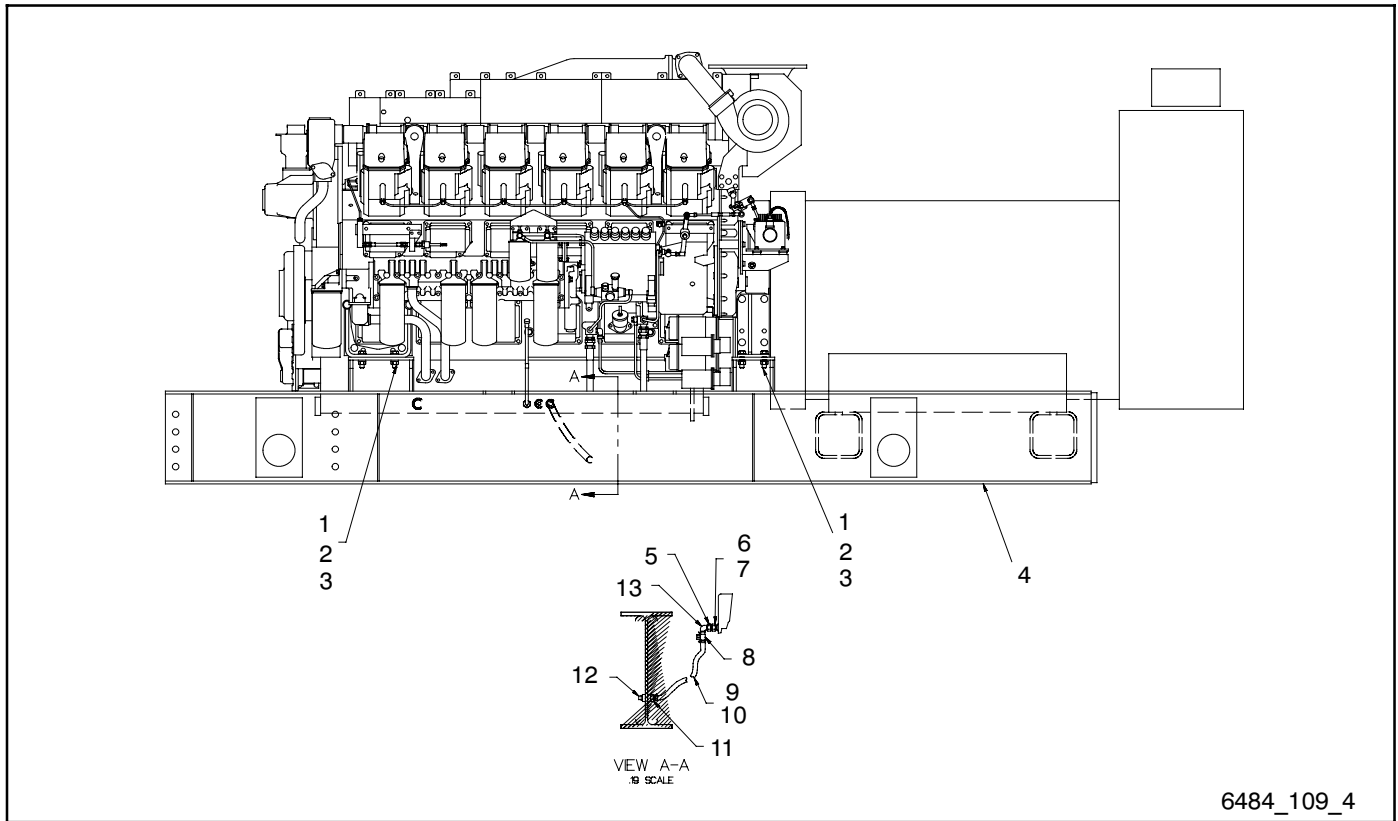
# Group 109: Skid and Plant Mounting, continued

900/1000 kW

| Item | Part Number   | Description                          | Quantity    |             |             |             |             |             |             |             |    |
|------|---------------|--------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|----|
|      |               |                                      | Module      |             |             |             |             |             |             |             |    |
|      |               |                                      | GM80855-MA1 | GM80855-MA2 | GM80855-MA3 | GM80855-MA4 | GM80855-MA5 | GM80855-MA6 | GM80855-MA7 | GM80855-MA8 |    |
| 1    | X-6011-3      | Washer, beveled, .68 ID x 1.5 in. OD | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  |
| 2    | X-25-152      | Washer, plain, 1.06 ID x 5.25 in. OD | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  |
| 3    | M931-24160-60 | Screw, hex cap                       | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  |
| 4    | M982-24-60    | Nut, hex elastic stop                | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  |
| 5a   | M934-20-80    | Nut, hex                             | 12          | 12          | 12          | 12          | 12          | 12          | 12          | 12          | 12 |
| 5b   | M125A-18-80   | Washer, plain                        | 7           | 7           | 7           | 7           | 7           | 7           | 7           | 7           | 7  |
| 5c   | M6797A-18-80  | Washer, lock                         | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |
| 6    | X-22-15       | Washer, lock                         | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |
| 6    | X-22-26       | Washer, lock                         | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |
| 6    | X-25-26       | Washer, plain                        | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |
| 7    | 361919        | Vibromount                           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  |
| 8    | 361024        | Mount, engine                        | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  |
| 9    | 361179        | Vibromount                           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  |
| 10   | 361039        | Plate, generator mounting            | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  |
| 11   | GM21085       | Strap, ground (16 in.)               | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  |
| 12   | X-202-41      | Bushing, reducing, 1/2 x 3/4 in. NPT | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |
| 13   | 272701        | Valve, oil drain                     | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |
| 14   | X-582-1       | Coupling, hose                       | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |
| 14   | X-75-28       | Plug, pipe, 1/2 in.                  | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |
| 16   | GM81140       | Skid                                 | 1           |             |             |             |             |             |             |             |    |
| 16   | GM80849       | Skid                                 |             | 1           |             |             |             |             |             |             |    |
| 16   | GM81144       | Skid                                 |             |             | 1           |             |             |             |             |             |    |
| 16   | GM80853       | Skid                                 |             |             |             | 1           |             |             |             |             |    |
| 16   | GM80847       | Skid                                 |             |             |             |             | 1           |             |             |             |    |
| 16   | GM80859       | Skid                                 |             |             |             |             |             | 1           |             |             |    |
| 16   | GM80851       | Skid                                 |             |             |             |             |             |             | 1           |             |    |
| 16   | GM81142       | Skid                                 |             |             |             |             |             |             |             | 1           |    |
| 17   | GM10458       | Support, rear engine, RS             | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  |
| 18   | GM10459       | Support, rear engine, LS             | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  |
| 19   | GM10457       | Support, front engine                | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  |
| 20   | X-426-12      | Clamp, hose, .69/1.25 in.            | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  |
| 21   | X-577-28      | Hose, rubber, straight, .62 in. ID   | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |
| 22   | M933-18035-60 | Screw, hex cap                       | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8  |
|      |               | Washer, hardened, 1.062 ID x 2 in.   |             |             |             |             |             |             |             |             |    |
| 23   | X-801-10      | OD                                   | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  |
| 24   | M6797A-18-80  | Washer, lock                         | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |

# Group 109: Skid and Plant Mounting, continued

1250-2000 kW



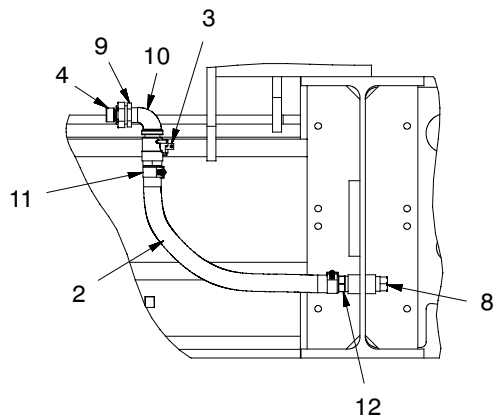
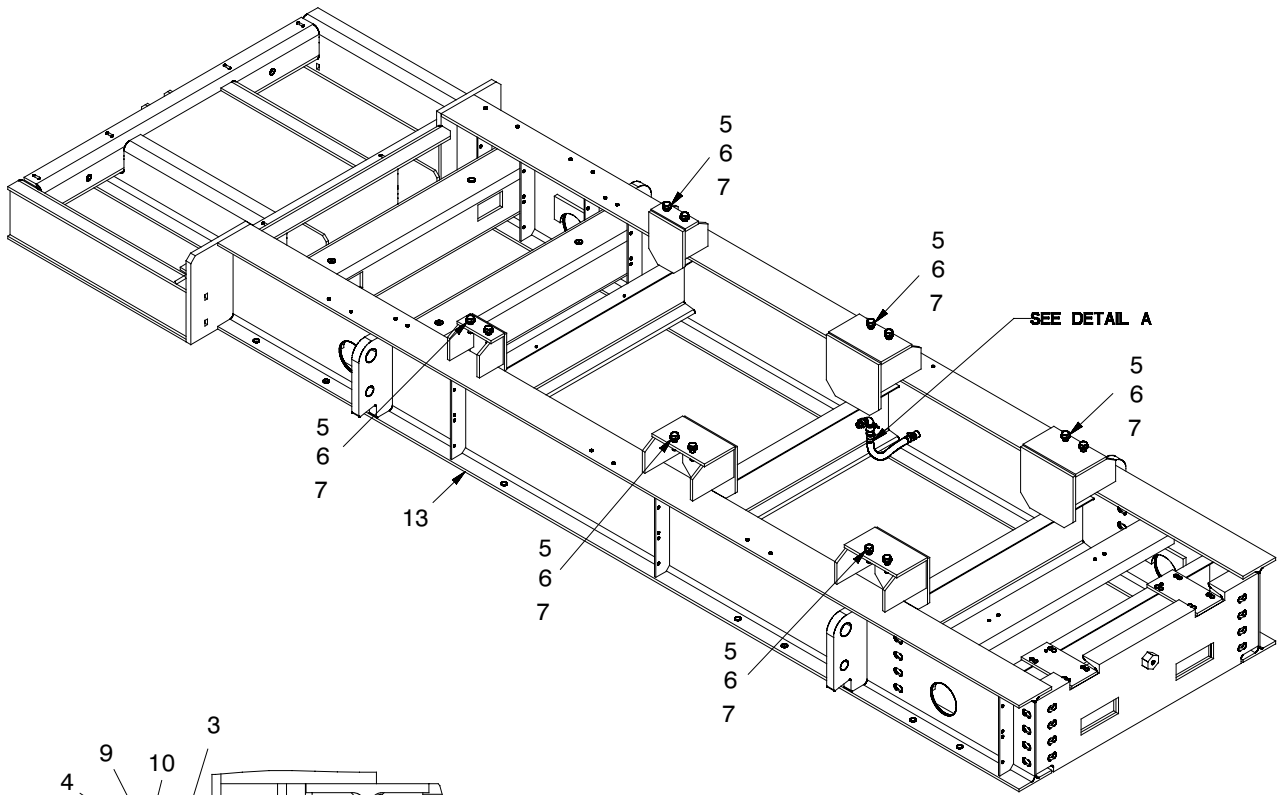
# Group 109: Skid and Plant Mounting, continued

1250-2000 kW

| Item | Part Number   | Description                          | Quantity    |             |             |             |
|------|---------------|--------------------------------------|-------------|-------------|-------------|-------------|
|      |               |                                      | Module      |             |             |             |
|      |               |                                      | GM19377-MA3 | GM19377-MA4 | GM32742-MA3 | GM32742-MA4 |
| 1    | M933-18060-60 | Screw, hex cap                       | 12          | 12          | 8           | 8           |
| 2    | M125A-18-80   | Washer, plain                        | 12          | 12          | 8           | 8           |
| 3    | M934-18-80    | Nut, hex                             | 12          | 12          | 8           | 8           |
| 4    | GM50739       | Skid                                 | 1           |             |             |             |
| 4    | GM50774       | Skid                                 |             | 1           |             |             |
| 4    | GM51411       | Skid                                 |             |             | 1           |             |
| 4    | GM51410       | Skid                                 |             |             |             | 1           |
| 5    | X-202-41      | Bushing, reducing, 1/2 x 3/4 in. NPT | 1           | 1           | 1           | 1           |
| 6    | GM10577       | Adapter bushing                      | 1           | 1           | 1           | 1           |
| 7    | X-6278-4      | Washer, nylon                        |             |             | 1           | 1           |
| 8    | 272701        | Valve, oil drain                     | 1           | 1           | 1           | 1           |
| 9    | X-577-47      | Hose, rubber, straight, 0.62 in. ID  | 1           | 1           | 1           | 1           |
| 10   | X-426-3       | Clamp, hose, 0.56/1.06 in.           | 2           | 2           | 2           | 2           |
| 11   | X-582-1       | Coupling, hose                       | 1           | 1           | 1           | 1           |
| 12   | X-75-28       | Plug, pipe, 1/2 in.                  | 1           | 1           | 1           | 1           |
| 13   | X-211-1       | Elbow, street, 90° x 1/2 in. NPT     | 1           | 1           | 1           | 1           |

# Group 109: Skid and Plant Mounting, continued

1250-2000 kW



**DETAIL A**  
VIEWED FROM FRONT  
OF GENSET

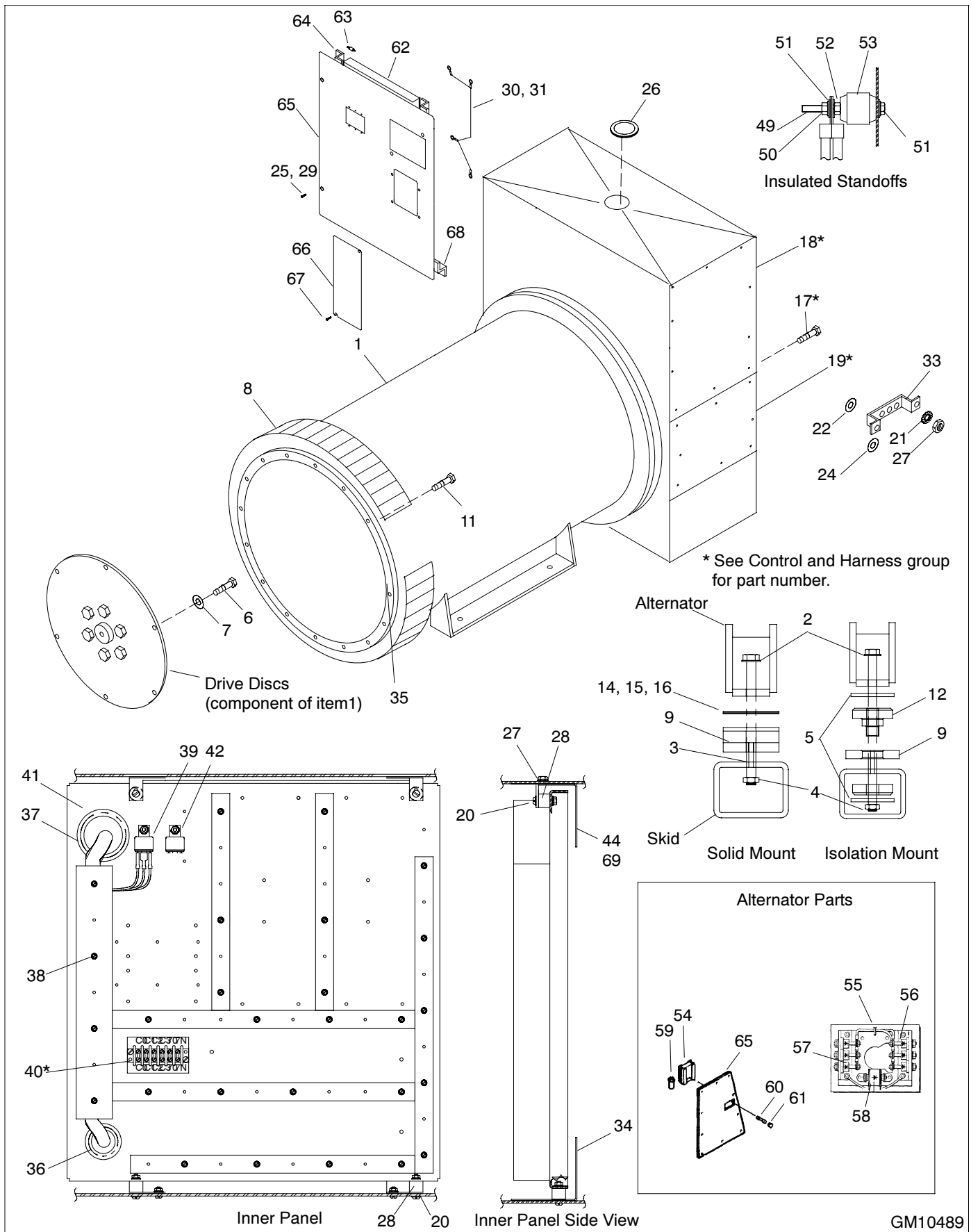
GM80627

# Group 109: Skid and Plant Mounting, continued

1250-2000 kW

| Item | Part Number   | Description                           | Quantity    |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |
|------|---------------|---------------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|----|----|----|----|----|----|----|
|      |               |                                       | Module      |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |
|      |               |                                       | GM80626-MA1 | GM80626-MA2 | GM80626-MA3 | GM80626-MA4 | GM80626-MA5 | GM80626-MA6 | GM79362-MA1 | GM79362-MA2 | GM79362-MA3 |    |    |    |    |    |    |    |
| 2    | X-577-28      | Hose, rubber, straight, .62 in. ID    | 1           | 1           | 1           | 1           | 1           | 1           |             |             |             |    |    |    |    |    |    |    |
| 2    | X-577-47      | Hose, rubber, straight, .62 in. ID    |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |
| 3    | 272701        | Valve, oil drain                      | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 4    | GM10577       | Adapter, bushing                      | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 5    | M125A-18-80   | Washer, plain                         | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 6    | M933-18060-60 | Screw, hex cap                        | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 7    | M934-18-80    | Nut, hex                              | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 12          | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| 8    | X-75-28       | Plug, pipe, 1/2 in.                   | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 9    | X-202-41      | Bushing, reducing, 1/2 x 3/4 in. NPT  | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 10   | X-211-1       | Elbow, Street(90 deg x 1/2"nptf)      | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 11   | X-426-12      | Clamp, hose, .69/1.25 in.             | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| 12   | X-582-1       | Connector, Hose 5/8" x 1/2" MIP Brass | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 13   | GM80611       | Skid                                  | 1           |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |
| 13   | GM80612       | Skid                                  |             | 1           |             |             |             |             |             |             |             |    |    |    |    |    |    |    |
| 13   | GM80613       | Skid                                  |             |             | 1           |             |             |             |             |             |             |    |    |    |    |    |    |    |
| 13   | GM80614       | Skid                                  |             |             |             | 1           |             |             |             |             |             |    |    |    |    |    |    |    |
| 13   | GM80615       | Skid                                  |             |             |             |             | 1           |             |             |             |             |    |    |    |    |    |    |    |
| 13   | GM80616       | Skid                                  |             |             |             |             |             | 1           |             |             |             |    |    |    |    |    |    |    |
| 13   | GM79125       | Skid                                  |             |             |             |             |             |             |             |             |             | 1  |    |    |    |    |    |    |
| 13   | GM80623       | Skid                                  |             |             |             |             |             |             |             |             |             |    | 1  |    |    |    |    |    |
| 13   | GM80620       | Skid                                  |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    | 1  |

# Group 201: Alternator and Mounting





# Group 201: Alternator and Mounting

600-800 kW

| Item | Part Number     | Description                           | Qty. |
|------|-----------------|---------------------------------------|------|
| 1    | See chart below | Alternator assembly                   | 1    |
| 2    | M931-20140-60   | Screw, hex cap (isolation mount)      | 4    |
| 2    | M931-20120-60   | Screw, hex cap (solid mount)          | 4    |
| 3    | M934-20-80      | Nut, hex (isolation mount)            | 8    |
| 4    | M982-20-80      | Nut, hex elastic stop (isolation mt.) | 4    |
| 4    | M934-20-80      | Nut, hex elastic stop (solid mount)   | 4    |
| 5    | X-25-155        | Washer, plain                         | 4    |
| 6    | M961-16030-82   | Screw, hex cap                        | 6    |
| 7    | X-801-5         | Washer, harden., 0.656 ID x 1.06 in.  | 6    |
| 8    | 328903          | Screen                                | 1    |
| 9    | 361733          | Plate, mounting (isolation mount)     | 4    |
| 9    | GM30445         | Plate, mounting (solid mount)         | 4    |
| 10   | X-400-241       | Spacer                                | 4    |
| 11   | M961-12050-82   | Screw, hex cap, 600 kW                | 16   |
| 11   | M931-12050-82   | Screw, hex cap, 750/800 kW            | 16   |
| 11   | M125A-12-80     | Washer, hardened, 600 kW              | 16   |
| 11   | 290945          | Washer, hardened, 750/800 kW          | 16   |
| 12   | 361734          | Vibromount                            | 2    |
| 13   | X-400-239       | Spacer                                | 4    |
| 14   | 365410          | Shim                                  | 4    |
| 15   | 365411          | Shim                                  | 4    |
| 16   | 365412          | Shim                                  | 4    |
| 17   | *               | Screw, hex flange machine             | 12   |
| 18   | *               | Panel, junction box, front            | 1    |
| 19   | *               | Cover, louvered                       | 1    |
| 20   | X-22-12         | Washer, lock, 0.262 ID x 0.743 in.    | 8    |
| 21   | X-22-14         | Washer, lock, 0.391 ID x 0.975 in.    | 4    |
| 22   | X-25-118        | Washer, plain, 0.406 ID x 1 in. OD    | 4    |
| 23   | X-468-9         | Cable tie, NRP                        | 2    |
| 24   | X-6086-6        | Washer, spring, .39 ID x .81 in. OD   | 2    |
| 25   | X-6217-10       | Screw, hex flange machine             | 25   |
| 26   | X-634-23        | Bushing, 1.968 x 2.50 in. NPT         | 2    |
| 27   | X-83-7          | Nut, hex, zinc, 3/8-16                | 2    |
| 28   | 229353          | Mount, controller                     | 4    |
| 29   | 295009          | Retainer                              | 2    |
| 30   | GM21264         | Harness, inner panel ground           | 1    |

| Item | Part Number | Description                         | Qty. |
|------|-------------|-------------------------------------|------|
| 31   | 361567      | Base, tie wrap snapin               | 2    |
| 33   | 361271      | Bus, ground                         | 1    |
| 34   | 361478      | Retainer, inner panel               | 2    |
| 35   | GM10640     | Guard, alternator                   | 1    |
| 36   | X-634-16    | Bushing, 1.312 x 1.50 in. NPT       | 1    |
| 37   | X-634-23    | Bushing, 1.968 x 2.50 in. NPT       | 1    |
| 38   | X-67-43     | Screw, thread-cutting               | 27   |
| 39   | 272684      | Relay                               | 1    |
| 40   | *           | Terminal block                      | 1    |
| 41   | 361186      | Panel, junction box, inner          | 1    |
| 42   | 272684      | Relay                               | 1    |
| 44   | 365476      | Bracket, inner panel                | 1    |
| 49   | X-6274-7    | Rod, threaded                       | 3    |
| 50   | X-6086-6    | Washer, spring, .39 ID x .81 in. OD | 6    |
| 51   | X-25-118    | Washer, plain, .406 ID x 1 in. OD   | 9    |
| 52   | X-83-7      | Nut, hex, 3/8-16, zinc              | 6    |
| 53   | X-6128-29   | Insulator, standoff, 3/8-16 x 2 in. | 3    |
| 54   | GM24876     | Voltage regulator, DVR2000E         | 1    |
| 55   | 347071      | Exciter rectifier assembly          | 1    |
| 56   | 279773      | Diode, standard polarity            | 1    |
| 57   | 279775      | Diode, reversing polarity           | 1    |
| 58   | 279776      | Surge suppressor                    | 1    |
| 59   | 347160      | Capacitor                           | 1    |
| 60   | 279778      | Fuse, 5-amp                         | 1    |
| 61   | 279779      | Fuse cap                            | 1    |
| 62   | GM13563     | Panel, inner door                   | 1    |
| 63   | 282829      | Vibromount                          | 6    |
| 64   | GM13562     | Bracket, door panel mounting, top   | 2    |
| 65   | GM13564     | Door, junction box                  | 1    |
| 66   | GM13565     | Cover, access                       | 1    |
| 67   | X-50-2      | Screw, slotted pan head machine     | 6    |
| 68   | GM13561     | Bracket, door panel mtg, bottom     | 1    |
| 69   | GM15336     | Bracket, inner panel mounting       | 1    |

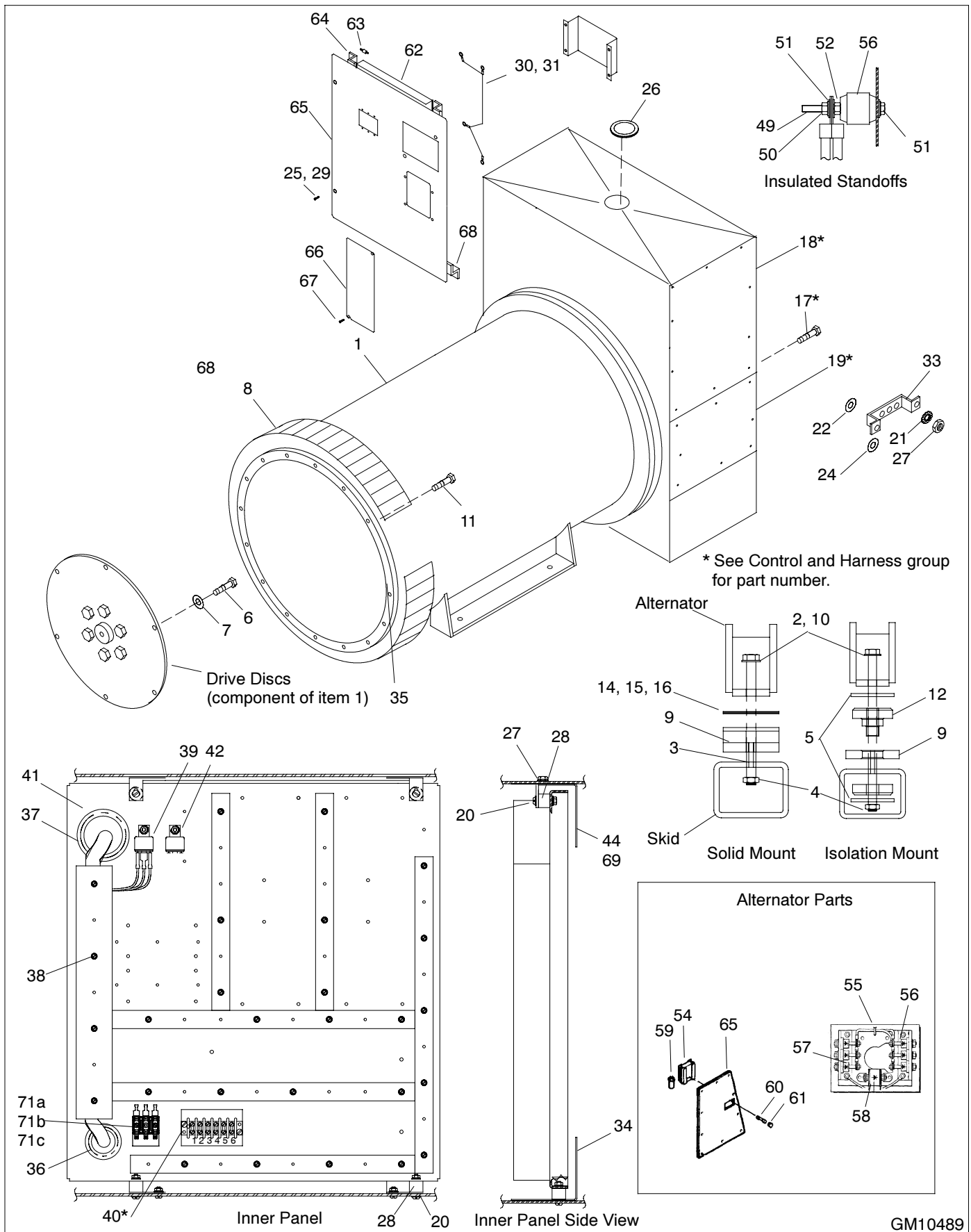
\* See Control and Harness group for part number.

## Alternator Part Number and Mount Type

Use this table to identify the module number's alternator part number (item 1 of the parts illustration on the previous page) and mount type.

| Module Number | Mount Type | Part Number<br>Item 1,<br>Alternator |
|---------------|------------|--------------------------------------|
| GM30678-MA7   | Isolation  | GM11976                              |
| GM30678-MA8   | Isolation  | A-361756                             |
| GM30678-MA9   | Isolation  | GM12022                              |
| GM30678-MA10  | Isolation  | GM12023                              |
| GM30678-MA11  | Isolation  | A-361760                             |
| GM31730-MA1   | Isolation  | A-361756                             |
| GM31730-MA2   | Solid      | A-361756                             |
| GM31730-MA3   | Isolation  | A-361757                             |
| GM31730-MA4   | Solid      | A-361757                             |
| GM31730-MA5   | Isolation  | A-361758                             |
| GM31730-MA6   | Solid      | A-361758                             |
| GM31730-MA7   | Isolation  | A-361762                             |
| GM31730-MA8   | Solid      | A-361762                             |
| GM31730-MA11  | Isolation  | A-361759                             |
| GM31730-MA12  | Solid      | A-361759                             |
| GM31730-MA13  | Isolation  | A-361763                             |
| GM31730-MA14  | Solid      | A-361763                             |
| GM31730-MA15  | Isolation  | A-361760                             |
| GM31730-MA16  | Solid      | A-361760                             |
| GM31730-MA17  | Isolation  | A-361761                             |
| GM31730-MA18  | Solid      | A-361761                             |
| GM31730-MA19  | Isolation  | A-361764                             |
| GM31730-MA20  | Solid      | A-361764                             |

# Group 201: Alternator and Mounting, continued



# Group 201: Alternator and Mounting, continued

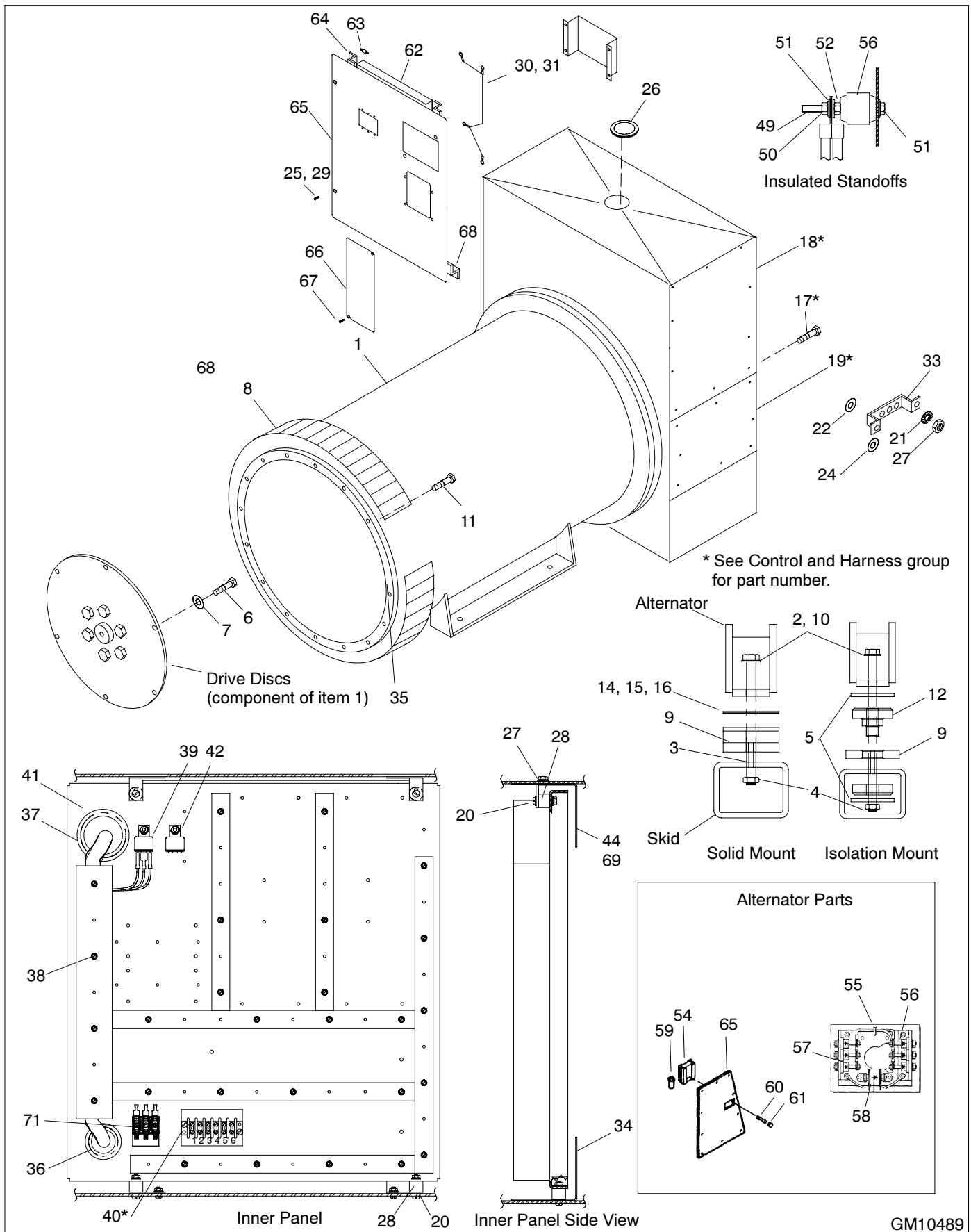
900-2000 kW

| Item | Part Number | Description                                      | Qty. |
|------|-------------|--|------|
| 1    | See chart   | Alternator assembly                              | 1    |
| 2    | See chart   | Screw, hex cap                                   | 4    |
| 3    | M934-20-80  | Nut, hex, 900/1000 kW                            | 8    |
| 4    | See chart   | Nut, hex   | 4    |
| 5    | X-25-152    | Washer, plain, 1.06 ID x 5.25 in. OD             | 8    |
| 6    | See chart   | Screw, hex cap                                   | 6    |
| 7    | X-801-5     | Washer, hardened, 0.656 ID x 1.06 in. OD         | 6    |
| 8    | GM10562     | Screen (7M frames)                               | 1    |
| 8    | 328903      | Screen (5M frames)                               | 1    |
| 8    | 328904      | Screen, 1250-2000 kW                             | 1    |
| 9    | 361039      | Plate, generator mtg. (iso. mt.)                 | 4    |
| 9    | 361061      | Plate, generator mtg., 900/1000 kW (solid mount) | 4    |
| 10   | X-400-241   | Spacer, 900/1000 kW (solid mount)                | 4    |
| 10   | X-801-10    | Washer, hardened, 1250-2000 kW                   | 4    |
| 11   | See chart   | Screw, hex cap                                   | 16   |
| 12   | 361919      | Vibromount, isolation mount                      | 4    |
| 13   | X-400-239   | Spacer   | 4    |
| 14   | 290743      | Shim, 16 gauge                                   | 4    |
| 15   | 290744      | Shim, 7 gauge                                    | 4    |
| 16   | 291191      | Shim, spring                                     | 4    |
| 17   | *           | Screw, hex flange machine                        | 12   |
| 18   | *           | Panel, junction box, front                       | 1    |
| 19   | *           | Cover, louvered                                  | 1    |
| 20   | X-22-12     | Washer, lock, .262 ID x .743 in. OD              | 8    |
| 21   | X-22-14     | Washer, lock, .391 ID x .975 in. OD              | 4    |
| 22   | X-25-118    | Washer, plain, .406 ID x 1 in. OD                | 4    |
| 23   | X-468-9     | Cable tie  | 2    |
| 24   | X-6086-6    | Washer, spring, .39 ID x .81 in. OD              | 2    |
| 25   | X-6214-10   | Screw, hex flange machine                        | 25   |
| 26   | X-634-23    | Bushing, 1.968 x 2.50 in. NPT                    | 2    |
| 27   | X-83-7      | Nut, hex, 3/8-16, zinc                           | 2    |
| 28   | 229353      | Mount, controller                                | 4    |

| Item | Part Number | Description                          | Qty. |
|------|-------------|--------------------------------------|------|
| 29   | 295009      | Retainer                             | 2    |
| 30   | GM21264     | Harness, inner panel ground          | 1    |
| 31   | 361567      | Base, tie wrap snapin                | 2    |
| 33   | 361271      | Bus, ground                          | 1    |
| 34   | 361478      | Retainer, inner panel                | 2    |
| 35   | GM10640     | Guard, alternator                    | 1    |
| 36   | X-634-16    | Bushing, 1.312 x 1.50 in. NPT        | 1    |
| 37   | X-634-23    | Bushing, 1.968 x 2.50 in. NPT        | 1    |
| 38   | X-67-43     | Screw, slotted hex washer            | 27   |
| 39   | 272684      | Relay                                | 1    |
| 39   | GM49747     | Relay (GM58144- only)                | 1    |
| 40   | 295314      | Terminal block                       | 1    |
| 41   | 361186      | Panel, junction box, inner           | 1    |
| 42   | 272684      | Relay                                | 1    |
| 42   | -           | Relay (GM58144- only: see Group 301) | 1    |
| 44   | 365476      | Bracket, inner panel                 | 1    |
| 49   | X-6274-7    | Rod, threaded                        | 3    |
| 50   | X-6086-6    | Washer, spring, .39 ID x .81 in. OD  | 6    |
| 51   | X-25-118    | Washer, plain, .406 ID x 1 in. OD    | 9    |
| 52   | X-83-7      | Nut, hex, 3/8-16, zinc               | 6    |
| 53   | X-6128-29   | Standoff insulator, 3/8-16 x 2 in.   | 3    |
| 54   | GM24876     | Voltage regulator, DVR2000E          | 1    |
| 55   | 347070      | Exciter rectifier assembly           | 1    |
| 56   | 279773      | Diode, standard polarity             | 1    |
| 57   | 279775      | Diode, reversing polarity            | 1    |
| 58   | 279777      | Surge suppressor                     | 1    |
| 59   | 347160      | Capacitor                            | 1    |
| 60   | 279778      | Fuse, 5-amp                          | 1    |
| 61   | 279779      | Fuse cap                             | 1    |
| 62   | GM13563     | Panel, inner door                    | 1    |
| 63   | 282829      | Vibromount                           | 6    |
| 64   | GM13562     | Bracket, door panel mounting, top    | 2    |
| 65   | GM13564     | Door, junction box                   | 1    |
| 66   | GM13565     | Cover, access                        | 1    |
| 67   | X-50-2      | Screw, slotted pan head machine      | 6    |
| 68   | GM13561     | Bracket, door panel mtg., bottom     | 1    |
| 69   | GM15336     | Bracket, inner panel mounting        | 1    |
| 70   | GM57630     | Bracket, Mounting (GM58144- only)    | 1    |
| 71a  | 292821      | Fuse holder (GM58144- only)          | 1    |
| 71b  | GM58321     | Strip, Marker (GM58144- only)        | 1    |
| 71c  | 358337      | Fuse, 10 A, 250 V (GM58144- only)    | 2    |

\* See Control and Harness group for part number.

# Group 201: Alternator and Mounting, continued



GM10489

# Group 201: Alternator and Mounting, continued

900-2000 kW, continued

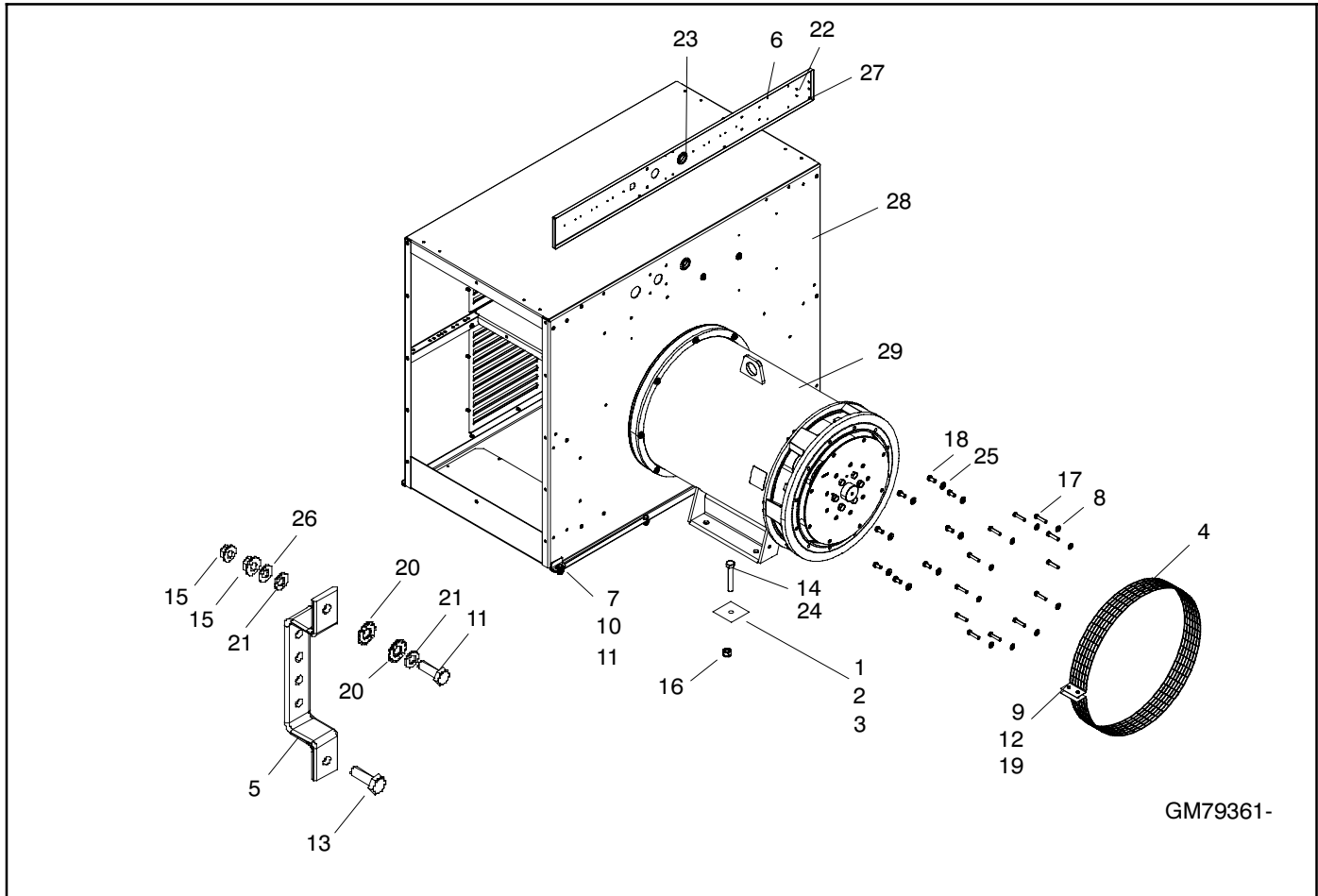
## Alternator Part Number and Mount Type

Use this table to identify the module number's alternator part number (item 1), mount type and items 2, 4, 6, and 11.

| Module Number | Alternator Part Number | Mount Type | Item 2, Screw, HC | Item 4, Nut, Hex | Item 6, Screw, HC | Item 11, Screw, HC |
|---------------|------------------------|------------|-------------------|------------------|-------------------|--------------------|
| GM16900-MA1   | F-361007               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA2   | F-361008               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA3   | F-361011               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA4   | F-361014               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA5   | F-361018               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA6   | B-361005               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA7   | B-361006               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA8   | B-361010               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA9   | B-361013               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA10  | F-361016               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA11  | F-361017               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA12  | A-361003               | Solid      | M933-24065-60     | M934-24-80       | M961-16030-82     | M961-14050-82      |
| GM16900-MA13  | B-361004               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA14  | B-361009               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA15  | B-361012               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA16  | B-361015               | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA17  | GM41659                | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM16900-MA18  | GM47964                | Solid      | M933-24065-60     | M934-24-80       | M961-16045-82     | M961-14050-82      |
| GM31617-MA1   | A-361758               | Isolation  | M931-20160-60     | M982-20-80       | M933-16030-82     | M961-12050-82      |
| GM31617-MA2   | A-361758               | Solid      | M931-20120-60     | M934-20-80       | M933-16030-82     | M961-12050-82      |
| GM31617-MA3   | A-361762               | Isolation  | M931-20160-60     | M982-20-80       | M933-16030-82     | M961-12050-82      |
| GM31617-MA4   | A-361762               | Solid      | M931-20120-60     | M934-20-80       | M933-16030-82     | M961-12050-82      |
| GM31617-MA5   | A-361765               | Isolation  | M931-20160-60     | M982-20-80       | M933-16030-82     | M961-12050-82      |
| GM31617-MA6   | A-361765               | Solid      | M931-20120-60     | M934-20-80       | M933-16030-82     | M961-12050-82      |
| GM31617-MA7   | GM10490                | Isolation  | M931-24160-60     | M982-24-60       | M933-16030-82     | M961-12040-82      |
| GM31617-MA8   | GM10490                | Solid      | M931-24120-60     | M934-24-80       | M933-16030-82     | M961-12040-82      |
| GM31617-MA9   | A-361763               | Isolation  | M931-20160-60     | M982-20-80       | M933-16030-82     | M961-12050-82      |
| GM31617-MA10  | A-361763               | Solid      | M931-20120-60     | M934-20-80       | M933-16030-82     | M961-12050-82      |
| GM31617-MA11  | GM10549                | Isolation  | M931-24160-60     | M982-24-60       | M933-16045-82     | M961-12040-82      |
| GM31617-MA12  | GM10549                | Solid      | M931-24120-60     | M934-24-80       | M933-16045-82     | M961-12040-82      |
| GM31617-MA13  | A-361764               | Isolation  | M931-20160-60     | M982-20-80       | M933-16030-82     | M961-12050-82      |
| GM31617-MA14  | A-361764               | Solid      | M931-20120-60     | M934-20-80       | M933-16030-82     | M961-12050-82      |
| GM31617-MA15  | GM10550                | Isolation  | M931-24160-60     | M982-24-60       | M933-16045-82     | M961-12040-82      |
| GM31617-MA16  | GM10550                | Solid      | M931-24120-60     | M934-24-80       | M933-16045-82     | M961-12040-82      |
| GM31617-MA17  | GM10551                | Isolation  | M931-24160-60     | M982-24-60       | M933-16045-82     | M961-12040-82      |
| GM31617-MA18  | GM10551                | Solid      | M931-24120-60     | M934-24-80       | M933-16045-82     | M961-12040-82      |
| GM58144-MA1   | A-361758               | Isolation  | M931-20160-60     | M982-20-80       | M933-16030-82     | M961-12050-82      |
| GM58144-MA2   | A-361758               | Solid      | M931-20120-60     | M934-20-80       | M933-16030-82     | M961-12050-82      |
| GM58144-MA3   | A-361762               | Isolation  | M931-20160-60     | M982-20-80       | M933-16030-82     | M961-12050-82      |
| GM58144-MA4   | A-361762               | Solid      | M931-20120-60     | M934-20-80       | M933-16030-82     | M961-12050-82      |
| GM58144-MA5   | A-361765               | Isolation  | M931-20160-60     | M982-20-80       | M933-16030-82     | M961-12050-82      |
| GM58144-MA6   | A-361765               | Solid      | M931-20120-60     | M934-20-80       | M933-16030-82     | M961-12050-82      |
| GM58144-MA7   | GM10490                | Isolation  | M931-24160-60     | M982-24-60       | M933-16030-82     | M961-12040-82      |
| GM58144-MA8   | GM10490                | Solid      | M931-24120-60     | M934-24-80       | M933-16030-82     | M961-12040-82      |
| GM58144-MA9   | A-361763               | Isolation  | M931-20160-60     | M982-20-80       | M933-16030-82     | M961-12050-82      |
| GM58144-MA10  | A-361763               | Solid      | M931-20120-60     | M934-20-80       | M933-16030-82     | M961-12050-82      |
| GM58144-MA11  | GM10549                | Isolation  | M931-24160-60     | M982-24-60       | M933-16045-82     | M961-12040-82      |
| GM58144-MA12  | GM10549                | Solid      | M931-24120-60     | M934-24-80       | M933-16045-82     | M961-12040-82      |
| GM58144-MA13  | A-361764               | Isolation  | M931-20160-60     | M982-20-80       | M933-16030-82     | M961-12050-82      |
| GM58144-MA14  | A-361764               | Solid      | M931-20120-60     | M934-20-80       | M933-16030-82     | M961-12050-82      |
| GM58144-MA15  | GM10550                | Isolation  | M931-24160-60     | M982-24-60       | M933-16045-82     | M961-12040-82      |
| GM58144-MA16  | GM10550                | Solid      | M931-24120-60     | M934-24-80       | M933-16045-82     | M961-12040-82      |
| GM58144-MA17  | GM10551                | Isolation  | M931-24160-60     | M982-24-60       | M933-16045-82     | M961-12040-82      |
| GM58144-MA18  | GM10551                | Solid      | M931-24120-60     | M934-24-80       | M933-16045-82     | M961-12040-82      |

# Group 201: Alternator and Mounting, continued

GM79361-



| Item | Part No.      | Description                             | Qty. |
|------|---------------|---|------|
| 1    | 290743        | Shim                                    | AR   |
| 2    | 290744        | Shim                                    | AR   |
| 3    | 291191        | Shim                                    | AR   |
| 4    | 328904        | Screen                                  | 1    |
| 5    | 361271        | Bus, ground                             | 1    |
| 6    | GM75910       | Panel, Component Mtg.                   | 1    |
| 7    | M125A-10-80   | Washer, Plain                           | 7    |
| 8    | M125A-14-80   | Washer, Plain                           | 16   |
| 9    | M6923-06-80   | Nut, Hex 6mm                            | 2    |
| 10   | M6923-10-80   | Nut, Hex 10mm                           | 8    |
| 11   | M931-10040-60 | Screw, Hex Head                         | 9    |
| 12   | M933-06040-60 | Screw, Hex Cap                          | 2    |
| 13   | M933-10030-60 | Screw, Hex Cap                          | 1    |
| 14   | M933-24065-60 | Screw, Hex Cap                          | 4    |
| 15   | M934-10-60    | Nut, hex                                | 3    |
| 16   | M934-24-80    | Nut, hex                                | 4    |
| 17   | M961-14050-82 | Screw, Hex Head                         | 16   |
| 18   | M961-16045-82 | Screw, Hex Head                         | 12   |
| 19   | X-22-12       | Washer, lock                            | 2    |
| 20   | X-22-15       | Washer, lock                            | 6    |
| 21   | X-25-118      | Washer, plain, .406 ID x 1 in. OD       | 4    |
| 22   | X-67-59       | Screw, hex washer, thread-forming       | 4    |
| 23   | X-284-23      | Grommet                                 | 1    |
| 24   | X-801-10      | Washer, hardened, 1.062 ID x 2 in. OD   | 4    |
| 25   | X-801-5       | Washer, hardened, .656 ID x 1.06 in. OD | 12   |
| 26   | X-6086-6      | Washer, spring                          | 2    |
| 27   | X-6210-2      | Nut, flange spirallock, 1/4-20          | 8    |
| 28   | See chart     | Junction Box Assembly                   | 1    |
| 29   | See chart     | Alternator Assy                         | 1    |

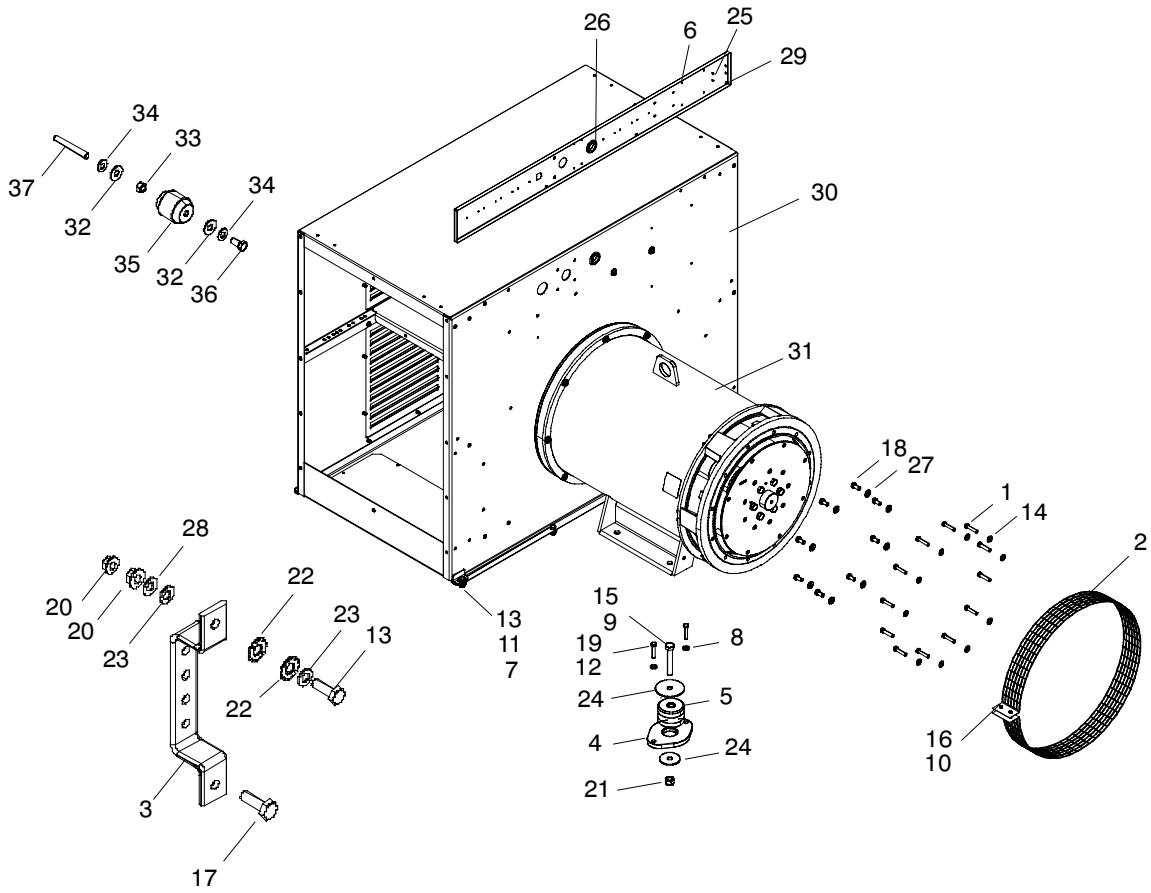
## Group 201: Alternator and Mounting, continued

Use this table to identify the module number's alternator part number and junction box part number.

| <b>Module No.</b> | <b>Alternator Description</b> | <b>Item 28, Junction Box Assembly</b> | <b>Item 29, Alternator Assembly</b> |
|-------------------|-------------------------------|---------------------------------------|-------------------------------------|
| GM79361-MA1       | 7M4046                        | GM75930-2                             | GM77510-1                           |
| GM79361-MA2       | 7M4048                        | GM75930-3                             | GM77510-2                           |
| GM79361-MA3       | 7M4050                        | GM75930-3                             | GM77510-3                           |
| GM79361-MA4       | 7M4172                        | GM75930-3                             | GM77510-4                           |
| GM79361-MA5       | 7M4366                        | GM75930-3                             | GM77510-5                           |
| GM79361-MA6       | 7M4052                        | GM75930-3                             | GM77511-1                           |
| GM79361-MA7       | 7M4054                        | GM75930-3                             | GM77511-2                           |
| GM79361-MA8       | 7M4056                        | GM75930-3                             | GM77511-3                           |
| GM79361-MA9       | 7M4058                        | GM75930-3                             | GM77511-4                           |
| GM79361-MA10      | 7M4174                        | GM75930-3                             | GM77511-5                           |
| GM79361-MA11      | 7M4176                        | GM75930-3                             | GM77511-6                           |
| GM79361-MA12      | 7M4288                        | GM75930-3                             | GM77511-7                           |
| GM79361-MA13      | 7M4290                        | GM75930-3                             | GM77511-8                           |
| GM79361-MA14      | 7M4292                        | GM75930-3                             | GM77511-9                           |
| GM79361-MA15      | 7M4368                        | GM75930-3                             | GM77511-10                          |
| GM79361-MA16      | 7M4370                        | GM75930-3                             | GM77511-11                          |
| GM79361-MA17      | 7M4374                        | GM75930-3                             | GM77511-12                          |
| GM79361-MA18      | 7M4376                        | GM75930-3                             | GM77511-13                          |

# Group 201: Alternator and Mounting, continued

GM80796-



GM80796-

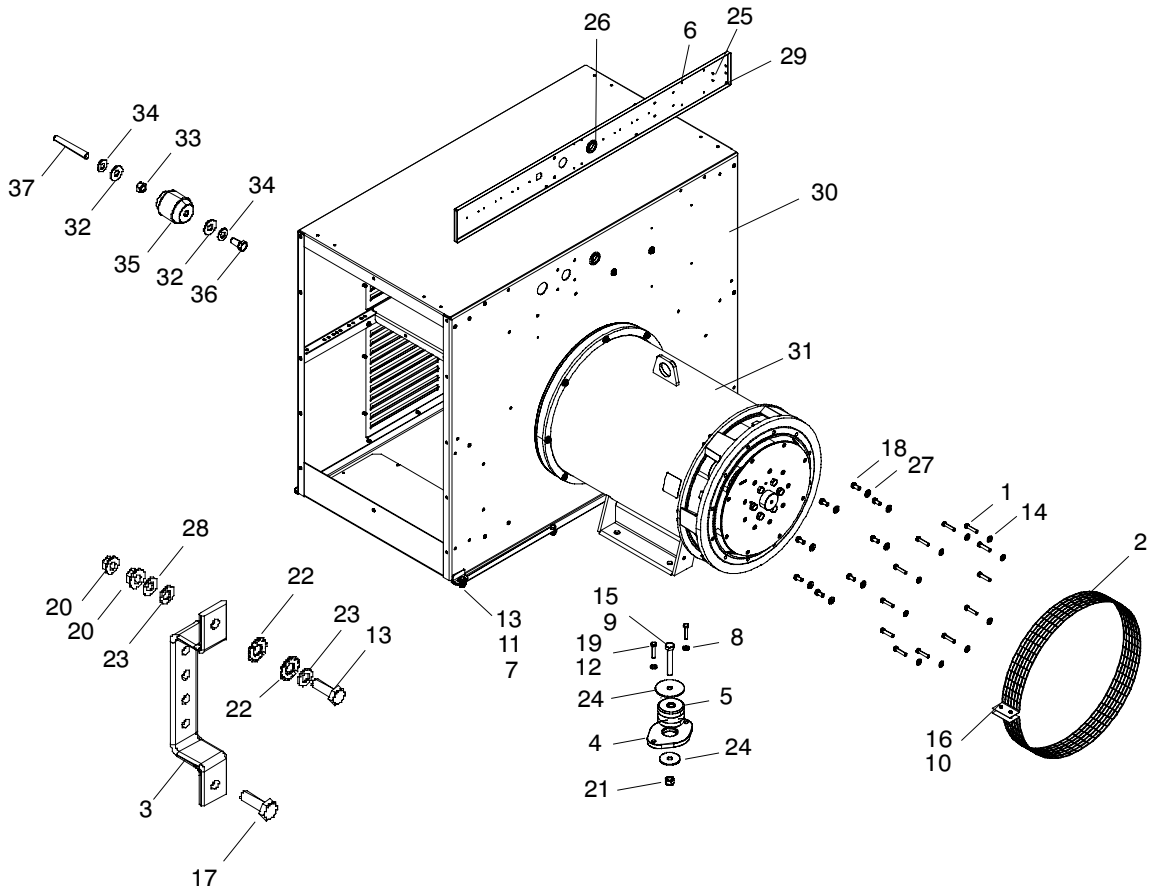


## Group 201: Alternator and Mounting, continued

| Item | Part Number   | Description                            | Quantity    |             |             |
|------|---------------|--|-------------|-------------|-------------|
|      |               |  | Module      |             |             |
|      |               |  | GM80796-MA1 | GM80796-MA2 | GM80796-MA3 |
| 1    | 290945        | Washer, hardened, .531 IDx1.06 in.OD   | 16          | 16          | 16          |
| 2    | 328903        | Screen                                 | 1           | 1           | 1           |
| 3    | 361271        | Bus, ground                            | 1           | 1           | 1           |
| 4    | 361733        | Plate, generator mounting              | 4           | 4           | 4           |
| 5    | 361734        | Vibromount                             | 4           | 4           | 4           |
| 6    | GM75910       | Panel, Component Mtg.                  | 1           | 1           | 1           |
| 7    | M125A-10-80   | Washer, Plain                          | 7           | 7           | 7           |
| 8    | M125A-16-80   | Washer, Plain                          | 8           | 8           | 8           |
| 9    | M125A-20-80   | Washer, Plain                          | 4           | 4           | 4           |
| 10   | M6923-06-80   | Nut, Hex 6mm                           | 2           | 2           | 2           |
| 11   | M6923-10-80   | Nut, Hex                               | 8           | 8           | 8           |
| 12   | M6923-16-80   | Nut, hex                               | 8           | 8           | 8           |
| 13   | M931-10040-60 | Screw, Hex Head                        | 9           | 9           | 9           |
| 14   | M931-12050-82 | Screw, Hex Cap                         | 16          | 16          | 16          |
| 15   | M931-20140-60 | Screw, Hex Head                        | 4           | 4           | 4           |
| 16   | M933-06050-60 | Screw, Hex Cap                         | 2           | 2           | 2           |
| 17   | M933-10030-60 | Screw, Hex Cap                         | 1           | 1           | 1           |
| 18   | M933-16030-82 | Screw, Hex Cap                         | 6           | 6           | 6           |
| 19   | M933-16060-60 | Screw, Hex Head                        | 8           | 8           | 8           |
| 20   | M934-10-60    | Nut, hex                               | 3           | 3           | 3           |
| 21   | M982-20-80    | Nut, hex elastic stop                  | 4           | 4           | 4           |
| 22   | X-22-15       | Washer, lock                           | 6           | 6           | 6           |
| 23   | X-25-118      | Washer, plain, .406 ID x 1 in. OD      | 4           | 4           | 4           |
| 24   | X-25-155      | Washer, plain                          | 8           | 8           | 8           |
| 25   | X-67-59       | Screw, hex washer, thread-forming      | 4           | 4           | 4           |
| 26   | X-284-23      | Grommet                                | 1           | 1           | 1           |
| 27   | X-801-5       | Washer,hardened, .656 ID x 1.06 in. OD | 6           | 6           | 6           |
| 28   | X-6086-6      | Washer,spring                          | 2           | 2           | 2           |
| 29   | X-6210-2      | Nut, flange spirallock, 1/4-20         | 8           | 8           | 8           |
| 30   | GM75930-2     | Junction Box Assembly 5M (See page 60) | 1           | 1           | 1           |
| 31   | GM77507-2     | Alternator Assy, 5M4032                | 1           |             |             |
| 31   | GM77507-3     | Alternator Assy, 5M4034                |             | 1           |             |
| 31   | GM77507-11    | Alternator Assy, 5M4276                |             |             | 1           |
| 32   | X-25-118      | Washer, plain, .406 ID x 1 in. OD      | 6           | 6           |             |
| 33   | X-83-7        | Nut, hex, 3/8-16, zinc                 | 3           | 3           |             |
| 34   | X-6086-6      | Washer,spring, .39 ID x .81 in. OD     | 6           | 6           |             |
| 35   | X-6128-29     | Standoff insulator, 3/8-16 x 2 in.     | 3           | 3           |             |
| 36   | X-6238-10     | Bolt, Hex Cap                          | 3           | 3           |             |
| 37   | X-6274-7      | Stud                                   | 3           | 3           |             |

# Group 201: Alternator and Mounting, continued

GM81167-



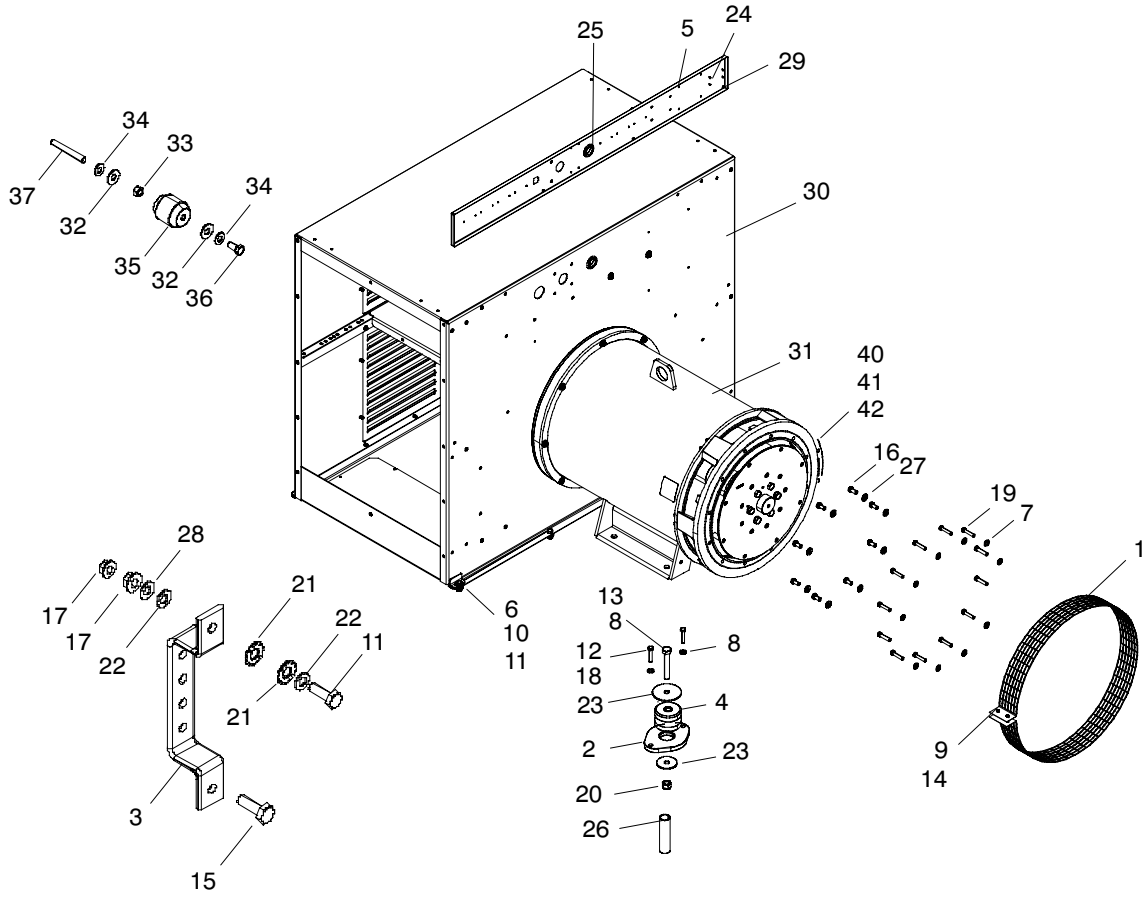
GM81167-

## Group 201: Alternator and Mounting, continued

| Item | Part Number   | Description                            | Quantity    |             |             |             |             |             |
|------|---------------|--|-------------|-------------|-------------|-------------|-------------|-------------|
|      |               |  | Module      |             |             |             |             |             |
|      |               |  | GM81167-MA1 | GM81167-MA2 | GM81167-MA3 | GM81167-MA4 | GM81167-MA5 | GM81167-MA6 |
| 1    | 290945        | Washer, hardened, .531 IDx1.06 in.OD   | 16          | 16          | 16          | 16          | 16          | 16          |
| 2    | 328903        | Screen                                 | 1           | 1           | 1           | 1           | 1           | 1           |
| 3    | 361271        | Bus, ground                            | 1           | 1           | 1           | 1           | 1           | 1           |
| 4    | 361733        | Plate, generator mounting              | 4           | 4           | 4           | 4           | 4           | 4           |
| 5    | 361734        | Vibromount                             | 4           | 4           | 4           | 4           | 4           | 4           |
| 6    | GM75910       | Panel, Component Mtg.                  | 1           | 1           | 1           | 1           | 1           | 1           |
| 7    | M125A-10-80   | Washer, Plain                          | 7           | 7           | 7           | 7           | 7           | 7           |
| 8    | M125A-16-80   | Washer, Plain                          | 8           | 8           | 8           | 8           | 8           | 8           |
| 9    | M125A-20-80   | Washer, Plain                          | 4           | 4           | 4           | 4           | 4           | 4           |
| 10   | M6923-06-80   | Nut, Hex 6mm                           | 2           | 2           | 2           | 2           | 2           | 2           |
| 11   | M6923-10-80   | Nut, Hex                               | 8           | 8           | 8           | 8           | 8           | 8           |
| 12   | M6923-16-80   | Nut, hex                               | 8           | 8           | 8           | 8           | 8           | 8           |
| 13   | M931-10040-60 | Screw, Hex Head                        | 9           | 9           | 9           | 9           | 9           | 9           |
| 14   | M931-12050-82 | Screw, Hex Cap                         | 16          | 16          | 16          | 16          | 16          | 16          |
| 15   | M931-20140-60 | Screw, Hex Head                        | 4           | 4           | 4           | 4           | 4           | 4           |
| 16   | M933-06050-60 | Screw, Hex Cap                         | 2           | 2           | 2           | 2           | 2           | 2           |
| 17   | M933-10030-60 | Screw, Hex Cap                         | 1           | 1           | 1           | 1           | 1           | 1           |
| 18   | M933-16030-82 | Screw, Hex Cap                         | 6           | 6           | 6           | 6           | 6           | 6           |
| 19   | M933-16060-60 | Screw, Hex Head                        | 8           | 8           | 8           | 8           | 8           | 8           |
| 20   | M934-10-60    | Nut, hex                               | 3           | 3           | 3           | 3           | 3           | 3           |
| 21   | M982-20-80    | Nut, hex elastic stop                  | 4           | 4           | 4           | 4           | 4           | 4           |
| 22   | X-22-15       | Washer, lock                           | 6           | 6           | 6           | 6           | 6           | 6           |
| 23   | X-25-118      | Washer, plain, .406 ID x 1 in. OD      | 4           | 4           | 4           | 4           | 4           | 4           |
| 24   | X-25-155      | Washer, plain                          | 8           | 8           | 8           | 8           | 8           | 8           |
| 25   | X-67-59       | Screw, hex washer, thread-forming      | 4           | 4           | 4           | 4           | 4           | 4           |
| 26   | X-284-25      | Grommet                                | 1           | 1           | 1           | 1           | 1           | 1           |
| 27   | X-801-5       | Washer,hardened, .656 ID x 1.06 in. OD | 6           | 6           | 6           | 6           | 6           | 6           |
| 28   | X-6086-6      | Washer,spring                          | 2           | 2           | 2           | 2           | 2           | 2           |
| 29   | X-6210-2      | Nut, flange spirallock, 1/4-20         | 8           | 8           | 8           | 8           | 8           | 8           |
| 30   | GM75930-2     | Junction Box Assembly 5M (See page 60) | 1           | 1           | 1           | 1           | 1           | 1           |
| 31   | GM77507-4     | Alternator Assy, 5M4036                | 1           |             |             |             |             |             |
| 31   | GM77507-5     | Alternator Assy, 5M4038                |             | 1           |             |             |             |             |
| 31   | GM77507-8     | Alternator Assy, 5M4166                |             |             | 1           |             |             |             |
| 31   | GM77507-9     | Alternator Assy, 5M4168                |             |             |             | 1           |             |             |
| 31   | GM77507-12    | Alternator Assy, 5M4278                |             |             |             |             | 1           |             |
| 31   | GM77507-13    | Alternator Assy, 5M4280                |             |             |             |             |             | 1           |
| 32   | X-25-118      | Washer, plain, .406 ID x 1 in. OD      | 6           |             |             |             |             |             |
| 33   | X-83-7        | Nut, hex, 3/8-16, zinc                 | 3           |             |             |             |             |             |
| 34   | X-6086-6      | Washer,spring, .39 ID x .81 in. OD     | 6           |             |             |             |             |             |
| 35   | X-6128-29     | Standoff insulator, 3/8-16 x 2 in.     | 3           |             |             |             |             |             |
| 36   | X-6238-10     | Bolt, Hex Cap                          | 3           |             |             |             |             |             |
| 37   | X-6274-7      | Stud                                   | 3           |             |             |             |             |             |

# Group 201: Alternator and Mounting, continued

GM81156-, GM81157-



GM81157-

# Group 201: Alternator and Mounting, continued

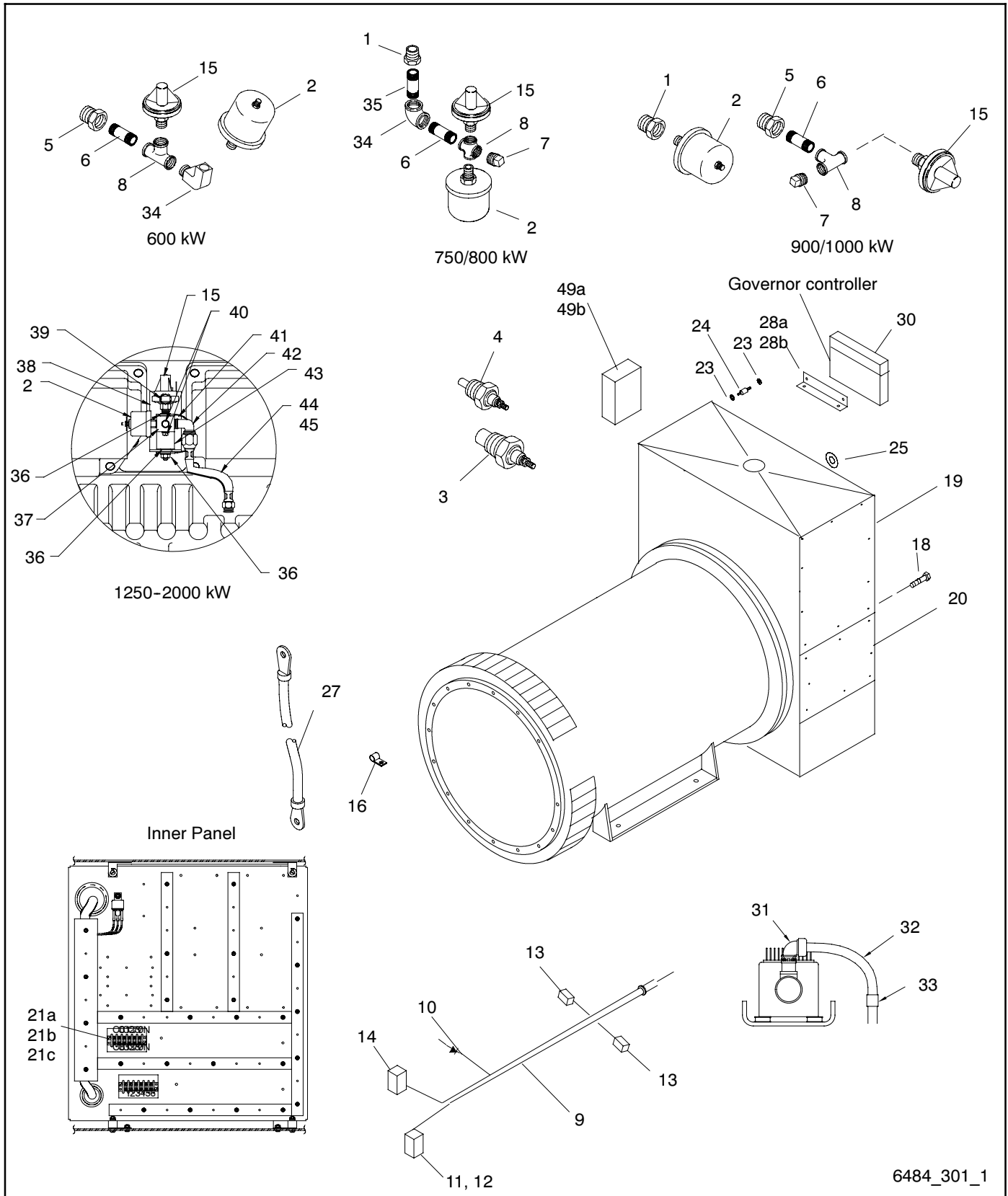
| Item | Part Number   | Description                            | Quantity    |             |             |             |             |             |             |             |             |    |   |
|------|---------------|--|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|----|---|
|      |               |  | Module      |             |             |             |             |             |             |             |             |    |   |
|      |               |  | GM81156-MA1 | GM81156-MA2 | GM81156-MA3 | GM81156-MA4 | GM81156-MA5 | GM81157-MA1 | GM81157-MA2 | GM81157-MA3 | GM81157-MA4 |    |   |
| 1    | 328903        | Screen                                 | 1           | 1           | 1           | 1           | 1           |             |             |             |             |    |   |
| 1    | GM10562       | Screen                                 |             |             |             |             |             |             | 1           | 1           | 1           | 1  |   |
| 2    | 361039        | Plate, generator mounting              | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  |   |
| 3    | 361271        | Bus, ground                            | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |   |
| 4    | 361919        | Vibromount                             | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  |   |
| 5    | GM75910       | Panel, Component Mtg.                  | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |   |
| 6    | M125A-10-80   | Washer, Plain                          | 7           | 7           | 7           | 7           | 7           | 7           | 7           | 7           | 7           | 7  |   |
| 7    | M125A-12-80   | Washer, Plain                          | 16          | 16          | 16          | 16          | 16          | 16          | 16          | 16          | 16          | 16 |   |
| 8    | M125A-20-80   | Washer, Plain                          | 12          | 12          | 12          | 12          | 12          | 12          | 8           | 8           | 8           | 8  |   |
| 8    | M125A-24-80   | Washer, Plain                          |             |             |             |             |             |             | 4           | 4           | 4           | 4  |   |
| 9    | M6923-06-80   | Nut, Hex 6mm                           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  |   |
| 10   | M6923-10-80   | Nut, Hex 10mm                          | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8  |   |
| 11   | M931-10040-60 | Screw, Hex Head                        | 9           | 9           | 9           | 9           | 9           | 9           | 9           | 9           | 9           | 9  |   |
| 12   | M931-20065-60 | Screw, Hex Cap                         | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8  |   |
| 13   | M931-20160-60 | Screw, Hex Head                        | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  |   |
| 13   | M931-24160-60 | Screw, Hex Head                        |             |             |             |             |             |             | 4           | 4           | 4           | 4  |   |
| 14   | M933-06050-60 | Screw, Hex Cap                         | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  |   |
| 15   | M933-10030-60 | Screw, Hex Cap                         | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |   |
| 16   | M933-16030-82 | Screw, Hex Cap                         | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6  |   |
| 16   | M933-16045-82 | Screw, Hex Cap                         |             |             |             |             |             |             |             | 6           | 6           | 6  |   |
| 17   | M934-10-60    | Nut, hex                               | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3  |   |
| 18   | M934-20-80    | Nut, hex                               | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8  |   |
| 19   | M961-12050-82 | Screw, Hex Head                        | 16          | 16          | 16          | 16          | 16          | 16          | 16          | 16          | 16          | 16 |   |
| 19   | M933-12040-82 | Screw, Hex Head                        |             |             |             |             |             |             |             |             |             |    |   |
| 20   | M982-20-80    | Nut, hex                               | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  |   |
| 20   | M982-24-60    | Nut, hex                               |             |             |             |             |             |             | 4           | 4           | 4           | 4  |   |
| 21   | X-22-15       | Washer, lock                           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6  |   |
| 22   | X-25-118      | Washer, plain, .406 ID x 1 in. OD      | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  |   |
| 23   | X-25-152      | Washer, plain                          | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8  |   |
| 24   | X-67-59       | Screw, hex washer, thread-forming      | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  |   |
| 25   | X-284-23      | Grommet                                | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |   |
| 26   | X-400-239     | Spacer                                 | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  |   |
| 27   | X-801-5       | Washer,hardened, .656 ID x 1.06 in. OD | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6  |   |
| 28   | X-6086-6      | Washer,spring                          | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  |   |
| 29   | X-6210-2      | Nut, flange spirallock, 1/4-20         | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8  |   |
| 30   | GM75930-2     | Junction Box Assembly 5M (See page 60) | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  |   |
| 30   | GM75930-3     | Junction Box Assembly 7M (See page 60) |             |             |             |             |             |             |             |             | 1           | 1  | 1 |
| 31   | GM77507-4     | Alternator Assy, 5M4036                | 1           |             |             |             |             |             |             |             |             |    |   |
| 31   | GM77507-5     | Alternator Assy, 5M4038                |             | 1           |             |             |             |             |             |             |             |    |   |
| 31   | GM77507-9     | Alternator Assy, 5M4168                |             |             | 1           |             |             |             |             |             |             |    |   |
| 31   | GM77507-13    | Alternator Assy, 5M4280                |             |             |             | 1           |             |             |             |             |             |    |   |
| 31   | GM77507-6     | Alternator Assy, 5M4044                |             |             |             |             | 1           |             |             |             |             |    |   |
| 31   | GM77509-2     | Alternator Assy, 7M4046                |             |             |             |             |             | 1           |             |             |             |    |   |
| 31   | GM77509-4     | Alternator Assy, 7M4170                |             |             |             |             |             |             | 1           |             |             |    |   |
| 31   | GM77509-6     | Alternator Assy, 7M4282                |             |             |             |             |             |             |             |             | 1           |    |   |
| 31   | GM77509-8     | Alternator Assy, 7M4284                |             |             |             |             |             |             |             |             |             |    | 1 |
| 32   | X-25-118      | Washer, plain, .406 ID x 1 in. OD      | 6           |             |             |             |             |             |             |             |             |    |   |
| 33   | X-83-7        | Nut, hex, 3/8-16, zinc                 | 3           |             |             |             |             |             |             |             |             |    |   |
| 34   | X-6086-6      | Washer,spring, .39 ID x .81 in. OD     | 6           |             |             |             |             |             |             |             |             |    |   |
| 35   | X-6128-29     | Standoff insulator, 3/8-16 x 2 in.     | 3           |             |             |             |             |             |             |             |             |    |   |
| 36   | X-6238-10     | Bolt, Hex Cap                          | 3           |             |             |             |             |             |             |             |             |    |   |
| 37   | X-6274-7      | Stud                                   | 3           |             |             |             |             |             |             |             |             |    |   |
| 40   | GM10640       | Guard, alternator                      |             |             |             |             |             |             | 1           | 1           | 1           | 1  |   |
| 41   | X-6210-7      | Nut, flange spirallock, 5/16-28        |             |             |             |             |             |             | 2           | 2           | 2           | 2  |   |
| 42   | X-6238-1      | Bolt, Hex Cap                          |             |             |             |             |             |             | 2           | 2           | 2           | 2  |   |



# Notes

# Group 301: Control and Harness

3+ Controller



6484\_301\_1



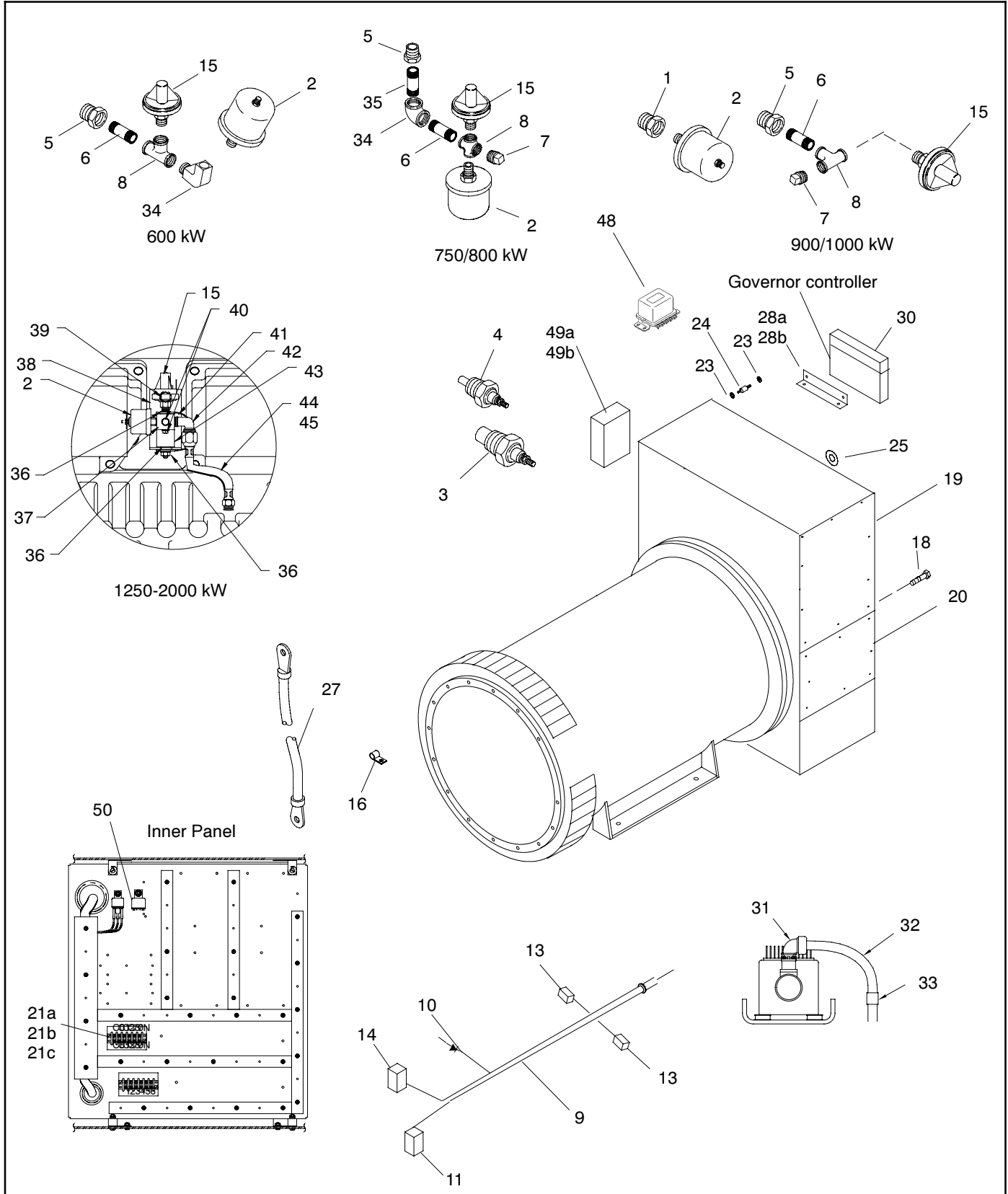
# Group 301: Control and Harness

3+ Controller

| Item | Part Number | Description                                 | Quantity    |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
|------|-------------|---|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|----|----|----|----|----|----|----|----|
|      |             |   | Module      |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
|      |             |   | GM31736-MA1 | GM50801-MA1 | GM31503-MA1 | GM31503-MA2 | GM16933-MA1 | GM16933-MA2 | GM54815-MA1 | GM54815-MA2 | GM60168-MA1 | GM60168-MA2 |    |    |    |    |    |    |    |    |
| 1    | GM10576     | Adapter bushing                             |             |             | 1           | 1           |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 2    | 343474      | Sender, oil pressure                        | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 3    | 241481      | Switch, high temperature shutoff            | 1           |             | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 3    | GM50832     | Switch-sender                               |             | 1           |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 4    | 268298      | Sender, water temperature                   | 1           |             | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 5    | GM12035     | Adapter bushing                             | 1           | 1           |             |             |             |             |             |             |             | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 5    | GM10576     | Adapter bushing                             |             |             | 1           | 1           |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 6    | X-217-6     | Nipple, pipe, 1/8 x 3/4 in.                 | 1           | 1           | 1           | 1           |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 7    | X-75-1      | Plug, pipe, 1/8                             | 1           |             | 1           | 1           |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 8    | X-203-16    | Fitting, tee, 1/8 x 1/8 x 1/8 in., pipe     |             | 1           | 1           | 1           | 1           |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 8    | 164037      | Cross pipe, 1/8 in.                         | 1           |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 9    | GM50744     | Harness, engine                             |             | 1           |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 9    | GM31234     | Harness, engine                             |             |             | 1           | 1           |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 9    | GM31852     | Harness, engine                             | 1           |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 9    | GM16935     | Harness, engine                             |             |             |             |             |             | 1           | 1           |             |             |             |    |    |    |    |    |    |    |    |
| 9    | GM51493     | Harness, engine                             |             |             |             |             |             |             |             |             |             | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 10   | 233959      | Diode, 6 A                                  | 7           | 5           | 7           | 7           | 7           | 7           | 7           | 7           | 7           | 7           | 7  | 7  | 7  | 7  | 7  | 7  | 7  | 7  |
| 11   | 292800      | Connector, cable                            | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 12   | 295145      | Connector, 24-position                      | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 13   | GM11422     | Connector                                   | 3           | 1           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| 14   | GM11423     | Connector                                   |             | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 15   | GM10574     | Switch, pressure, LOP                       | 1           | 1           | 1           | 1           |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 15   | GM10575     | Switch, pressure                            |             |             |             |             |             | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 16   | X-672-31    | Clamp, insulated, 0.75 in.                  |             |             |             |             |             | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 18   | X-6217-10   | Screw, hex flange machine                   | 12          | 10          | 22          | 24          | 38          | 38          | 24          | 24          | 24          | 24          | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| 19   | 361184-BLK  | Panel, junction box, front                  | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 20   | 361826-BLK  | Panel, junction box (5M and 7M4046 alt.)    | 1           | 1           | 1           |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 20   | 328901-BLK  | Panel, junction box (7M alt. except 7M4046) |             |             |             | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 21a  | X-49-6      | Screw, cross recess                         | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| 21b  | 255080      | Marker, strip                               | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 21c  | 295314      | Terminal block                              | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 23   | X-22-11     | Washer, lock                                | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8  | 8  | 8  | 8  | 8  | 8  | 8  | 8  |
| 24   | 229353      | Vibromount                                  | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4  | 4  | 4  | 4  | 4  | 4  | 4  | 4  |
| 25   | X-284-3     | Grommet, round                              | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| 27   | X-545-149   | Cable, battery                              |             |             |             |             |             | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 28a  | GM30658     | Bracket, governor mounting                  | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  |
| 28b  | GM46823     | Bracket, governor mounting                  | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 30   | GM46824     | Cover, governor                             | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 31   | X-6027-5    | Connector, conduit                          | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 32   | X-6026-30   | Conduit, flexible                           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 33   | GM51521     | Conduit, inner sleeve                       | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 34   | X-215-19    | Elbow, pipe, 90° x 1/8 in. NPT              | 1           |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 34   | 267428      | Fitting, 45° street elbow                   |             | 1           |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 35   | X-217-2     | Pipe, nipple, 1/8 in. NPT x 1.50 in.        | 1           |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 36   | X-22-12     | Washer, lock, 0.262 ID x 0.743 in. OD       |             |             |             |             |             |             |             |             |             |             |    |    |    |    |    |    |    |    |
| 37   | 267548      | Block, oil gauge                            |             |             |             |             |             | 3           | 3           | 3           | 3           | 3           | 3  | 3  | 3  | 3  | 3  | 3  | 3  | 3  |
| 38   | GM35184     | Bracket, sender                             |             |             |             |             |             | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 39   | X-22-26     | Washer, lock, 0.521 ID x 1.24 in. OD        |             |             |             |             |             | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 40   | X-75-4      | Plug, pipe, 1/8 in. NPT                     |             |             |             |             |             | 2           | 2           | 2           | 2           | 2           | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| 41   | 223033      | Strap, ground, 5 in.                        |             |             |             |             |             | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 42   | X-447-10    | Elbow, male tube, 90°                       |             |             |             |             |             | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 43   | 259632      | Bumper                                      |             |             |             |             |             | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 44   | 270727      | Fuel line, flexible                         |             |             |             |             |             | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 45   | GM12035     | Adapter, bushing                            |             |             |             |             |             | 1           | 1           |             |             |             |    |    |    |    |    |    |    |    |
| 46   | GM10669     | Shield, heat, 32 mm ID x 305 mm (not shown) |             |             |             |             |             |             |             |             |             | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 47   | GM54825     | Shield, heat, 20 mm ID x 103 mm (not shown) |             |             |             |             |             |             |             |             |             | 2           | 2  | 2  | 2  | 2  | 2  | 2  | 2  | 2  |
| 49a  | GM24876-S   | Regulator, Voltage (Digital)                | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |
| 49b  | GM66039     | Screw, Plastic Tapping, 6-19 x 0.625        | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6  | 6  | 6  | 6  | 6  | 6  | 6  | 6  |

# Group 301: Control and Harness, continued

3+ Controller



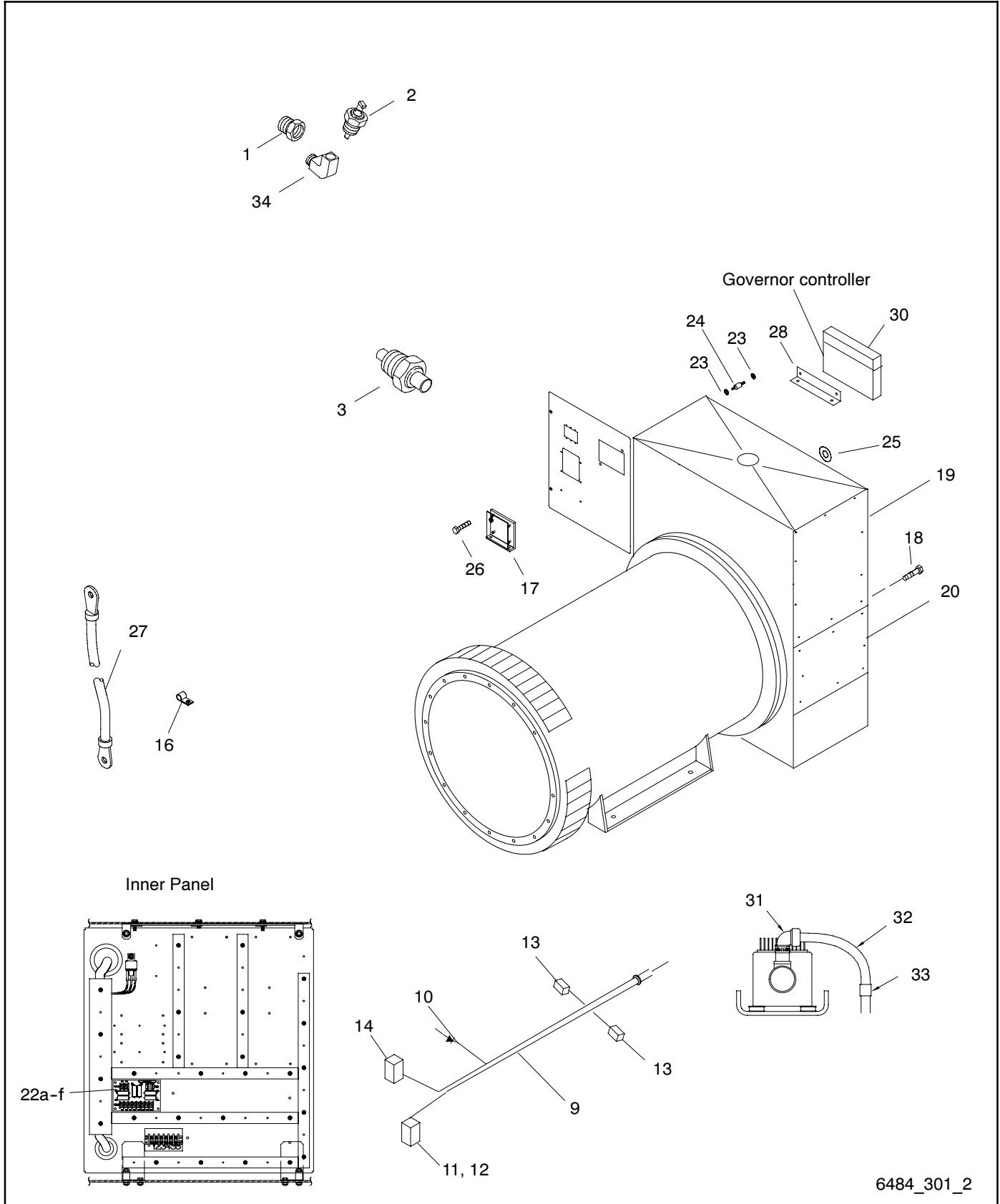
# Group 301: Control and Harness, continued

3+ Controller

| Item | Part Number | Description                                   | Quantity    |             |             |             |             |             |             |             |
|------|-------------|---|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|      |             |   | Module      |             |             |             |             |             |             |             |
|      |             |   | GM74826-MA1 | GM74828-MA1 | GM74829-MA1 | GM74829-MA2 | GM74831-MA1 | GM74831-MA2 | GM74833-MA1 | GM74833-MA2 |
| 1    | GM10576     | Adapter bushing                               |             |             |             | 1           |             |             |             |             |
| 2    | 343474      | Sender, oil pressure                          | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 3    | 241481      | Switch, high temperature shutoff              |             | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 3    | GM50832     | Switch-Sensor                                 | 1           |             |             |             |             |             |             |             |
| 4    | 268298      | Sender, water temperature                     |             | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 4    | GM10669     | Shield, Heat (32mm ID x 305 mm L) (not shown) |             |             |             |             | 1           | 1           | 1           | 1           |
| 4    | GM54825     | Shield, Heat (not shown)                      |             |             |             |             | 2           | 2           | 2           | 2           |
| 5    | GM12035     | Adapter bushing                               | 1           | 1           |             |             |             |             |             |             |
| 5    | GM10576     | Adapter bushing                               |             |             | 1           | 1           |             |             |             |             |
| 6    | X-217-6     | Nipple, pipe, 1/8 x 3/4 in.                   | 1           | 1           | 1           | 1           |             |             |             |             |
| 7    | X-75-1      | Plug, pipe, 1/8                               |             | 1           | 1           | 1           |             |             |             |             |
| 8    | X-203-16    | Fitting, tee, 1/8 x 1/8 x 1/8 in., pipe       | 1           |             | 1           | 1           |             |             |             |             |
| 8    | 164037      | Cross pipe, 1/8 in.                           |             | 1           |             |             |             |             |             |             |
| 9    | GM74812     | Harness, Eng Mits T2 600kW Dec 3+             | 1           |             |             |             |             |             |             |             |
| 9    | GM74814     | Harness, Eng Mits 750-800kW Dec3+             |             | 1           |             |             |             |             |             |             |
| 9    | GM74815     | Harness, Eng Mits T2 900-1000kW Dec3+         |             |             | 1           | 1           |             |             |             |             |
| 9    | GM74817     | Harness, Eng Mits T1 1250-1600kW Dec3+        |             |             |             |             | 1           | 1           | 1           | 1           |
| 10   | 233959      | Diode, 6 A                                    | 5           | 3           | 7           | 7           | 7           | 7           | 7           | 7           |
| 11   | 295145      | Connector, 24-position                        | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 13   | GM11422     | Connector                                     | 1           | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 14   | GM11423     | Connector                                     | 1           |             | 1           | 1           | 1           | 1           | 1           | 1           |
| 15   | GM10574     | Switch, pressure, LOP                         | 1           | 1           | 1           | 1           |             |             |             |             |
| 15   | GM10575     | Switch, pressure                              |             |             |             |             | 1           | 1           | 1           | 1           |
| 16   | X-672-31    | Clamp, insulated, 0.75 in.                    |             |             |             |             |             |             |             |             |
| 18   | X-6217-10   | Screw, hex flange machine                     | 28          | 12          | 22          | 24          | 24          | 24          | 24          | 24          |
| 19   | 361184-BLK  | Panel, junction box, front                    | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 20   | 361826-BLK  | Panel, junction box                           | 1           | 1           | 1           |             |             |             |             |             |
| 20   | 328901-BLK  | Panel, junction box                           |             |             |             | 1           | 1           | 1           | 1           | 1           |
| 21a  | X-49-6      | Screw, cross recess                           | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 21b  | 255080      | Marker, strip                                 | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 21c  | 295314      | Terminal block                                | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 23   | X-22-11     | Washer, lock                                  | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           |
| 24   | 229353      | Vibromount                                    | 4           | 4           |             |             | 4           | 4           | 4           | 4           |
| 25   | X-284-3     | Grommet, round                                | 2           | 2           |             |             | 2           | 2           | 2           | 2           |
| 27   | X-545-149   | Cable, battery                                |             |             |             |             | 1           | 1           | 1           | 1           |
| 28a  | GM30658     | Bracket, governor mounting                    | 3           | 3           |             |             | 3           | 3           | 3           | 3           |
| 28b  | GM46823     | Bracket, governor mounting                    | 1           | 1           |             |             | 1           | 1           | 1           | 1           |
| 30   | GM46824     | Cover, governor                               | 1           | 1           |             |             | 1           | 1           | 1           | 1           |
| 31   | X-6027-5    | Connector, conduit                            | 1           | 1           |             |             | 1           | 1           | 1           | 1           |
| 32   | X-6026-30   | Conduit, flexible                             | 1           | 1           |             |             | 1           | 1           | 1           | 1           |
| 33   | GM51521     | Conduit, inner sleeve                         | 1           | 1           |             | 1           | 1           | 1           | 1           | 1           |
| 34   | X-215-19    | Elbow, pipe, 90° x 1/8 in. NPT                |             | 1           |             |             |             |             |             |             |
| 34   | 267428      | Fitting, 45° street elbow                     | 1           |             |             |             |             |             |             |             |
| 35   | X-217-2     | Pipe, nipple, 1/8 in. NPT x 1.50 in.          |             | 1           |             |             |             |             |             |             |
| 36   | X-22-12     | Washer, lock, 0.262 ID x 0.743 in. OD         |             |             |             |             | 3           | 3           | 3           | 3           |
| 37   | 267548      | Block, oil gauge                              |             |             |             |             | 1           | 1           | 1           | 1           |
| 38   | GM35184     | Bracket, sender                               |             |             |             |             | 1           | 1           | 1           | 1           |
| 39   | X-22-26     | Washer, lock, 0.521 ID x 1.24 in. OD          |             |             |             |             | 1           | 1           | 1           | 1           |
| 40   | X-75-4      | Plug, pipe, 1/8 in. NPT                       |             |             |             |             | 2           | 2           | 1           | 1           |
| 41   | 223033      | Strap, ground, 5 in.                          |             |             |             |             | 1           | 1           | 1           | 1           |
| 42   | X-447-10    | Elbow, male tube, 90°                         |             |             |             |             | 1           | 1           | 1           | 1           |
| 43   | 259632      | Bumper  |             |             |             |             | 1           | 1           | 1           | 1           |
| 44   | 265462      | Fuel line, flexible                           |             |             |             |             | 1           | 1           |             |             |
| 44   | 270727      | Fuel line, flexible                           |             |             |             |             |             |             | 1           | 1           |
| 45   | GM12035     | Adapter, bushing                              |             |             |             |             | 1           | 1           | 1           | 1           |
| 48   | GM74810     | Chattering Relay (supplied with engine)       | 1           |             |             |             |             |             |             |             |
| 48   | GM74811     | Synchronizing Relay (supplied with engine)    |             | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 49a  | GM24876-S   | Regulator, Voltage (Digital)                  | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 49b  | GM66039     | Screw, Plastic Tapping, 6-19 x 0.625          | 6           | 6           | 6           | 6           | 6           | 6           | 6           | 6           |
| 50   | GM49747     | Relay, 24V DC                                 |             |             | 1           | 1           |             |             |             |             |

# Group 301: Control and Harness, continued

550 Controller



6484\_301\_2

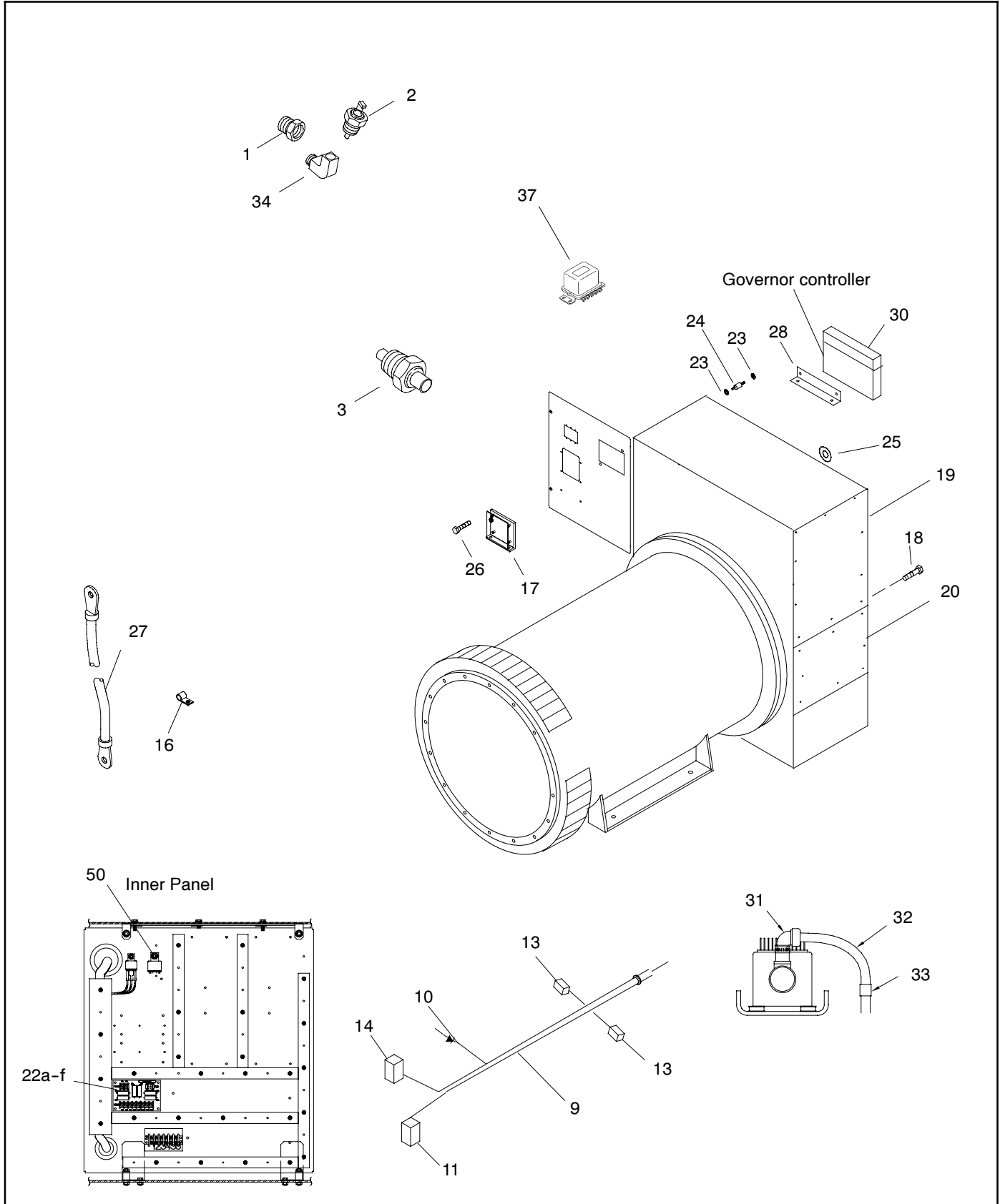
# Group 301: Control and Harness, continued

550 Controller

| Item | Part Number    | Description                                 | Quantity    |             |             |             |             |             |             |             |
|------|----------------|---|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|      |                |   | Module      |             |             |             |             |             |             |             |
|      |                |   | GM50802-MA1 | GM31851-MA1 | GM31504-MA1 | GM31504-MA2 | GM30952-MA1 | GM30952-MA2 | GM52968-MA1 | GM52968-MA2 |
| 1    | GM12035        | Adapter bushing                             | 1           | 1           |             |             |             |             |             |             |
| 1    | GM10576        | Adapter bushing                             |             |             | 1           | 1           | 1           | 1           | 1           | 1           |
| 2    | GM70917-1      | Sensor, pressure, 1/8-27 NPT                | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 3    | GM31990        | Kit, Sensor, temp.                          | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 9    | GM50743        | Harness, engine                             | 1           |             |             |             |             |             |             |             |
| 9    | GM31233        | Harness, engine                             |             |             | 1           | 1           |             |             |             |             |
| 9    | GM31853        | Harness, engine                             |             | 1           |             |             |             |             |             |             |
| 9    | GM17434        | Harness, engine                             |             |             |             |             | 1           | 1           |             |             |
| 9    | GM46930        | Harness, 5 ft.                              |             |             |             |             | 1           | 1           |             |             |
| 9    | GM51492        | Harness, engine                             |             |             |             |             |             |             | 1           | 1           |
| 10   | 233959         | Diode, 6 A                                  | 7           | 7           | 7           | 7           | 7           | 7           | 7           | 7           |
| 11   | 292800         | Connector, cable                            | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 12   | 295145         | Connector, 24-position                      | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 13   | GM11422        | Connector                                   | 1           | 1           | 1           | 1           | 1           | 1           | 2           | 2           |
| 14   | GM11423        | Connector                                   | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 16   | X-672-31       | Clamp, insulated, 0.75 in.                  |             |             |             |             | 1           | 1           |             |             |
| 17   | GM11718        | PCB assy., Marathon excitation interface    | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 18   | X-6217-10      | Screw, hex flange machine                   | 28          | 12          | 20          | 22          | 24          | 24          | 24          | 24          |
| 19   | 361184-BLK     | Panel, junction box, front                  | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 20   | 361826-BLK     | Panel, junction box (5M and 7M4046 alt.)    | 1           | 1           | 1           |             |             |             |             |             |
| 20   | 328901-BLK     | Panel, junction box (7M alt. except 7M4046) |             |             |             | 1           | 1           | 1           | 1           | 1           |
| 22a  | X-49-6         | Screw, cross recess                         |             |             |             |             |             | 2           |             | 2           |
| 22b  | 254127         | Marker, strip                               |             |             |             |             |             | 1           |             | 1           |
| 22c  | X-405-2        | Terminal block                              |             |             |             |             |             | 1           |             | 1           |
| 22d  | GM13980        | PCB assy., CT burden resistor               | 1           | 1           | 1           | 1           | 1           |             | 1           |             |
| 22e  | X-70-12        | Nut, hex machine screw, 8-32                | 4           | 4           | 4           | 4           | 4           |             | 4           |             |
| 22f  | X-712-9        | Spacer, 0.25 OD, 0.5 in.                    | 4           | 4           | 4           | 4           | 4           |             | 4           |             |
| 23   | X-22-11        | Washer, lock                                | 8           | 8           | 8           | 8           | 8           | 8           | 8           | 8           |
| 24   | 229353         | Vibromount                                  | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           |
| 25   | X-284-3        | Grommet, round                              | 2           | 2           | 2           | 2           | 2           | 2           | 2           | 2           |
| 26   | M965A-06012-20 | Screw, pan head machine                     | 4           | 4           | 4           | 4           | 4           | 4           | 4           | 4           |
| 27   | X-545-149      | Cable, battery                              |             |             |             |             | 1           | 1           | 1           | 1           |
| 28a  | GM30658        | Bracket, governor mounting                  | 3           | 3           | 3           | 3           | 3           | 3           | 3           | 3           |
| 28b  | GM46823        | Bracket, governor mounting                  | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 30   | GM46824        | Cover, governor                             | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 31   | X-6027-5       | Connector, conduit                          | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 32   | X-6026-30      | Conduit, flexible                           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 33   | GM51521        | Conduit, inner sleeve                       | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 34   | X-555-2        | Elbow, street, 90° x 1/8 in. NPTF           |             | 1           | 1           | 1           |             |             |             |             |
| 34   | 267428         | Fitting, 45° street elbow                   | 1           |             |             |             |             |             |             |             |
| 35   | GM10669        | Shield, heat, 32 mm ID x 305 mm (not shown) |             |             |             |             |             |             | 1           | 1           |

# Group 301: Control and Harness, continued

550/6000 Controller



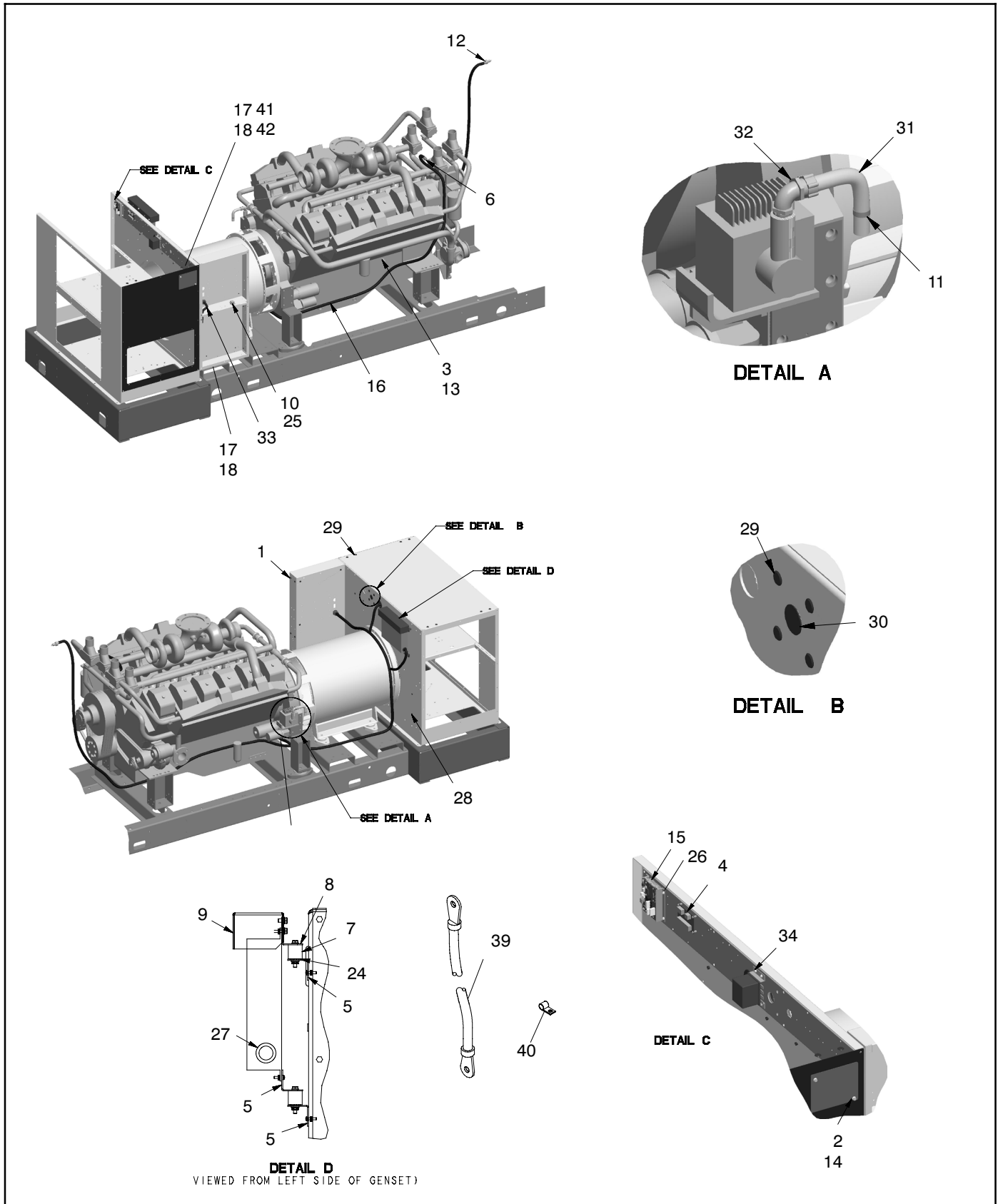
# Group 301: Control and Harness, continued

550/6000 Controller

| Item | Part Number    | Description                                | Quantity    |             |             |             |             |             |
|------|----------------|--|-------------|-------------|-------------|-------------|-------------|-------------|
|      |                |  | Module      |             |             |             |             |             |
|      |                |  | GM74835-MA1 | GM74837-MA1 | GM74838-MA1 | GM74838-MA2 | GM74841-MA1 | GM74841-MA2 |
| 1    | GM12035        | Adapter bushing                            | 1           | 1           | 1           | 1           | 1           | 1           |
| 2    | GM70917-1      | Sender, Pressure, 0-150psi, 1/8-27 NPTF    | 1           | 1           | 1           | 1           | 1           | 1           |
| 3    | GM31990        | Kit, Temperature Sensor                    | 1           | 1           | 1           | 1           | 1           | 1           |
| 3    | GM10669        | Shield, heat (32mm id x 305mm length)      |             |             |             |             | 1           | 1           |
| 9    | GM74819        | Harness, Eng Mits T2 600kW DEC550/6000     | 1           |             |             |             |             |             |
| 9    | GM74821        | Harness, Eng Mits 750-800kW DEC550/6000    |             | 1           |             |             |             |             |
| 9    | GM74822        | Harness, Eng MitsT2 900-1000kW DEC550/6000 |             |             | 1           | 1           |             |             |
| 9    | GM74824        | Harness, EngMitsT2 1250-2000kW DEC550/6000 |             |             |             |             | 1           | 1           |
| 10   | 233959         | Diode, 6 A                                 | 2           | 7           | 7           | 7           | 7           | 7           |
| 11   | 295145         | Connector, 24-position                     | 1           | 1           | 1           | 1           | 1           | 1           |
| 13   | GM11422        | Connector                                  | 1           | 3           | 2           | 2           | 2           | 2           |
| 16   | X-672-31       | Clamp, insulated, 0.75 in.                 |             |             |             |             | 1           | 1           |
| 17   | GM11718        | PCB assy., Marathon excitation interface   | 1           | 1           | 1           | 1           | 1           | 1           |
| 18   | X-6217-10      | Screw, hex flange machine                  | 28          | 12          | 22          | 24          | 24          | 24          |
| 19   | 361184-BLK     | Panel, junction box, front                 | 1           | 1           | 1           | 1           | 1           | 1           |
| 20   | 361826-BLK     | Panel, junction box                        | 1           | 1           | 1           |             |             |             |
| 20   | 328901-BLK     | Panel, junction box                        |             |             |             | 1           | 1           | 1           |
| 22a  | X-49-6         | Screw, cross recess                        |             |             |             |             |             | 1           |
| 22b  | 254127         | Marker, strip                              |             |             |             |             |             | 1           |
| 22c  | X-405-2        | Terminal block                             |             |             |             |             |             | 1           |
| 22d  | GM13980        | PCB assy., CT burden resistor              | 1           | 1           | 1           | 1           | 1           |             |
| 22e  | X-70-12        | Nut, hex machine screw, 8-32               | 4           | 4           | 4           | 4           | 4           |             |
| 22f  | X-712-9        | Spacer, 0.25 OD, 0.5 in.                   | 4           | 4           | 4           | 4           | 4           |             |
| 23   | X-22-11        | Washer, lock                               | 8           | 8           |             |             | 8           | 8           |
| 24   | 229353         | Vibromount                                 | 4           | 4           |             |             | 4           | 4           |
| 25   | X-284-3        | Grommet, round                             | 2           | 2           |             |             | 2           | 2           |
| 26   | M965A-06012-20 | Screw, pan head machine                    | 4           | 4           | 4           | 4           | 4           | 4           |
| 27   | X-545-149      | Cable, battery                             |             |             |             |             | 1           | 1           |
| 28   | GM30658        | Bracket, governor mounting                 | 3           | 3           |             |             | 3           | 3           |
| 28   | GM46823        | Bracket, governor mounting                 | 1           | 1           |             |             | 1           | 1           |
| 30   | GM46824        | Cover, governor                            | 1           | 1           |             |             | 1           | 1           |
| 31   | X-6027-5       | Connector, conduit                         | 1           | 1           |             |             | 1           | 1           |
| 32   | X-6026-30      | Conduit, flexible                          | 1           | 1           |             |             | 1           | 1           |
| 33   | GM51521        | Conduit, inner sleeve                      | 1           | 1           |             |             | 1           | 1           |
| 34   | X-555-2        | Elbow, street, 90° x 1/8 in. NPTF          |             | 1           | 1           | 1           |             |             |
| 34   | 267428         | Fitting, 45° street elbow                  | 1           |             |             |             |             |             |
| 37   | GM74810        | Chattering Relay (supplied with engine)    | 1           |             |             |             |             |             |
| 37   | GM74811        | Synchronizing Relay (supplied with engine) |             | 1           | 1           | 1           | 1           | 1           |
| 50   | GM49747        | Relay, 24V DC                              |             |             | 1           | 1           |             |             |

# Group 301: Control and Harness, continued

550/3000/6000 Controller





# Group 301: Control and Harness, continued

550/3000/6000 Controller

| Item | Part Number | Description                                | Quantity    |             |             |             |             |             |             |             |             |
|------|-------------|--|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|      |             |  | Module      |             |             |             |             |             |             |             |             |
|      |             |  | GM79363-MA1 | GM79363-MA2 | GM79363-MA3 | GM80794-MA1 | GM80794-MA2 | GM80795-MA1 | GM81544-MA1 | GM81544-MA2 | GM81545-MA1 |
| 1    | 324861      | Coupling, black plastic                    | 12          | 12          | 12          | 12          | 12          | 12          | 12          | 12          | 12          |
| 2    | GM11040-7   | Insert, Threaded (M6 x 1.0 Hex)            | 2           | 2           | 2           | 2           | 2           | 2           | 4           | 4           | 4           |
| 3    | GM12035     | Adapter bushing                            | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 4    | GM13980     | PCB assy., CT burden resistor              | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 5    | GM30658     | Bracket, governor mounting                 | 3           | 3           | 3           | 3           | 3           | 3           |             |             |             |
| 6    | GM31990     | Kit, Temperature Sensor                    | 1           | 1           | 1           | 1           | 1           |             | 1           | 1           |             |
| 6    | GM39458     | Sender, Temperature                        |             |             |             |             |             | 1           |             |             | 1           |
| 7    | GM38784-3   | Vibromount                                 | 4           | 4           | 4           | 4           | 4           | 4           |             |             |             |
| 8    | GM46823     | Bracket, governor mounting                 | 1           | 1           | 1           | 1           | 1           | 1           |             |             |             |
| 9    | GM46824     | Cover, governor                            | 1           | 1           | 1           | 1           | 1           | 1           |             |             |             |
| 10   | GM49747     | Relay, 24V DC                              | 1           | 1           | 1           | 1           | 1           | 1           | 2           | 2           | 2           |
| 11   | GM51521     | Conduit, inner sleeve                      | 1           | 1           | 1           | 1           | 1           | 1           |             |             |             |
| 12   | GM66270     | Sensor, Low Coolant Level                  |             |             |             | 1           | 1           | 1           | 1           | 1           | 1           |
| 13   | GM70917-1   | Sender, Pressure, 0-150psi, 1/8-27 NPTF    | 1           | 1           | 1           | 1           | 1           |             | 1           | 1           | 1           |
| 13   | 343474      | Sender, oil pressure                       |             |             |             |             |             | 1           |             |             | 1           |
| 14   | GM77908     | Cover, Diagnostic                          | 1           | 1           | 1           | 1           | 1           | 1           |             |             |             |
| 14   | GM77909     | Cover, Diagnostic                          |             |             |             |             |             |             | 1           | 1           | 1           |
| 15   | GM79677     | Board, Assy Marathon Interface             | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 16   | GM81299     | Harness, Engine 750/800 kW Mitsubishi      |             |             |             | 1           | 1           |             |             |             |             |
| 16   | GM81315     | Harness, Engine 750/800 kW Mitsubishi      |             |             |             |             |             | 1           |             |             |             |
| 16   | GM81602     | Harness, Engine 900/1000 kW Mitsubishi     |             |             |             |             |             |             | 1           | 1           |             |
| 16   | GM81603     | Harness, Engine 900/1000 kW Mitsubishi     |             |             |             |             |             |             |             |             | 1           |
| 16   | GM79392     | Harness, Engine 2000 kW Mitsubishi         | 1           | 1           | 1           |             |             |             |             |             |             |
| 17   | GM79448     | Bracket, Controller                        | 1           | 1           | 1           |             |             |             |             |             |             |
| 18   | GM38784-2   | Vibromount                                 | 4           | 4           | 4           |             |             |             |             |             |             |
| 24   | X-22-12     | Washer, lock.262 IDx.743 in.OD             | 8           | 8           | 8           | 4           | 4           | 4           |             |             |             |
| 25   | X-67-155    | Screw, Tapping                             | 1           | 1           | 1           | 1           | 1           | 1           | 2           | 2           | 2           |
| 26   | X-67-156    | Screw, Tapping                             |             |             |             | 8           | 8           | 8           |             |             |             |
| 26   | X-67-59     | Screw, Tapping                             |             |             |             |             |             |             | 8           | 8           | 8           |
| 26   | GM38784-1   | Vibromount                                 | 4           | 4           | 4           |             |             |             |             |             |             |
| 27   | X-284-3     | Grommet, round                             | 1           | 1           | 1           | 1           | 1           | 1           |             |             |             |
| 28   | X-301-34    | Plug, Button                               | 7           | 7           | 7           | 7           | 7           | 7           | 7           | 7           | 7           |
| 29   | X-301-47    | Plug, Button                               | 12          | 12          | 12          | 12          | 12          | 12          | 10          | 10          | 10          |
| 30   | X-301-48    | Plug, Button                               | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 31   | X-6026-30   | Conduit, flexible                          | 1           | 1           | 1           | 1           | 1           | 1           |             |             |             |
| 32   | X-6027-5    | Connector, conduit                         | 1           | 1           | 1           | 1           | 1           | 1           |             |             |             |
| 33   | GM79393     | Harness, Control Box, DEC550               | 1           |             | 1           | 1           |             |             |             |             |             |
| 33   | GM79394     | Harness, Control Box, DEC6000              |             | 1           |             |             | 1           |             |             |             |             |
| 33   | GM81317     | Harness, Control Box, DEC3000              |             |             |             |             |             | 1           |             |             |             |
| 33   | GM81606     | Harness, Control Box, DEC550               |             |             |             |             |             |             | 1           |             |             |
| 33   | GM81608     | Harness, Control Box, DEC6000              |             |             |             |             |             |             |             | 1           |             |
| 33   | GM81607     | Harness, Control Box, DEC3000              |             |             |             |             |             |             |             |             | 1           |
| 34   | GM74811     | Synchronizing Relay (supplied with engine) | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           | 1           |
| 39   | X-545-149   | Cable, battery (No.0 x 6.1") red+          | 1           | 1           | 1           |             |             |             |             |             |             |
| 40   | X-672-30    | Clamp, insulated, 1.06 in.                 | 1           | 1           | 1           |             |             |             |             |             |             |
| 41   | GM77902     | Bracket, Mtg (Diagnostic)                  |             |             |             |             |             |             | 1           | 1           | 1           |
| 42   | GM81747     | Harness, Diagnostic Mits                   |             |             |             |             |             |             | 1           | 1           | 1           |

# Group 701: Literature

| Item | Part Number | Description                                      | Quantity         |     |     |     |     |     |     |     |     |   |
|------|-------------|--|------------------|-----|-----|-----|-----|-----|-----|-----|-----|---|
|      |             |  | Variation Number |     |     |     |     |     |     |     |     |   |
|      |             |  | 241              | 242 | 243 | 244 | 245 | 246 | 247 | 248 | 249 |   |
| 1    | TP-5578     | O/I/S/M Marathon Alternator, MMAX DVR            | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 2    | TP-5700     | I/M Industrial                                   | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 3    | TP-6009     | P/C Controllers                                  | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 5    | TP-6140     | O/I/M Controller Setup & App. Decision-Maker 550 | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 6    | TP-6161     | O/M 20-2250 kW, Industrial                       | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 7    | TP-6199     | O/I/S/M Marathon voltage regulator DVR2000E      | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 8    | TP-6200     | O/M Decision-Maker 550 Controller V 2.10         | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 9    | TP-6257     | P/C Kohler D600 Engine, 600REOZM                 | 1                |     |     |     |     |     |     |     |     |   |
| 9    | TP-6282     | P/C Kohler D750/D800 Engine, 750/800REOZM/B      |                  | 1   | 1   |     |     |     |     |     |     |   |
| 9    | TP-6258     | P/C Kohler D1000 37.1A Eng, 900/100REOZM/B       |                  |     |     | 1   | 1   |     |     |     |     |   |
| 9    | TP-6283     | P/C Kohler D1250 Engine, 1250REOZM/B             |                  |     |     |     |     | 1   |     |     |     |   |
| 9    | TP-6259     | P/C Kohler D1600-2000Eng, 1600-2000REOZM/B       |                  |     |     |     |     |     | 1   | 1   | 1   | 1 |
| 10   | TP-6556     | O/M MHI 600REOZMB                                | 1                |     |     |     |     |     |     |     |     |   |
| 10   | TP-6557     | O/M MHI 750/800REOZMB                            |                  | 1   | 1   |     |     |     |     |     |     |   |
| 10   | TP-6558     | O/M MHI 900/1000REOZMB                           |                  |     |     | 1   | 1   |     |     |     |     |   |
| 10   | TP-6644     | O/M MHI ECM3, 900/1000REOZMB                     |                  |     |     | 1   | 1   |     |     |     |     |   |
| 10   | TP-6559     | O/M MHI 1250REOZMB                               |                  |     |     |     |     | 1   |     |     |     |   |
| 10   | TP-6560     | O/M MHI 1600REOZMB                               |                  |     |     |     |     |     | 1   |     |     |   |
| 10   | TP-6561     | O/M MHI 1750/2000REOZMB                          |                  |     |     |     |     |     |     | 1   | 1   | 1 |
| 11   | TP-6289     | W/D 600-2000REOZM, Industrial                    | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 12   | TP-6330     | O/I/M Woodward ProAct I/II Governor              | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 13   | TP-6356     | S/M Controllers, 20-2800 kW                      | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 14   | TP-6373     | S/M Pilot-Excited PM Alternator, 350-2800 kW     | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 15   | TP-6484     | P/C 600-2000REOZMB                               | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 16   | TP-6562     | S/M MHI 600REOZM/B                               | 1                |     |     |     |     |     |     |     |     |   |
| 16   | TP-6563     | S/M MHI 750/800REOZM/B                           |                  | 1   | 1   |     |     |     |     |     |     |   |
| 16   | TP-6564     | S/M MHI 900-1000REOZM/B                          |                  |     |     | 1   | 1   |     |     |     |     |   |
| 16   | TP-6565     | S/M MHI 1250REOZM/B                              |                  |     |     |     |     | 1   |     |     |     |   |
| 16   | TP-6566     | S/M MHI 1600REOZM/B                              |                  |     |     |     |     |     | 1   |     |     |   |
| 16   | TP-6567     | S/M MHI 1820-2000REOZM/B                         |                  |     |     |     |     |     |     | 1   | 1   | 1 |
| 17   | TP-6746     | P/C DEC6000 AND DPS System                       | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 18   | TP-6747     | O/I/M DPS System Installation and Setup          | 1                | 1   |     |     |     |     |     |     |     |   |
| 19   | TP-6750     | O/M DEC 6000 Controller                          | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |

# Group 701: Literature

| Item | Part Number | Description                                      | Quantity         |     |     |     |     |     |     |     |   |
|------|-------------|--|------------------|-----|-----|-----|-----|-----|-----|-----|---|
|      |             |  | Variation Number |     |     |     |     |     |     |     |   |
|      |             |  | 297              | 298 | 299 | 300 | 287 | 288 | 289 | 290 |   |
| 1    | TP-5374     | Warranty 1-Year Limited, Industrial              | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 2    | TP-5578     | O/I/S/M Marathon Alternator, MMAX DVR            | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 3    | TP-5700     | I/M 20-3250kW, Industrial                        | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 4    | TP-6140     | O/I/M Controller Setup & App. Decision-Maker 550 | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 5    | TP-6694     | O/M DEC3000 Controller                           | 1                | 1   | 1   | 1   |     |     |     |     |   |
| 6    | TP-6200     | O/M Decision-Maker 550 Controller V 2.10         | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 7    | TP-6282     | P/C Kohler D750/D800 Engine, 750/800REOZM/B      | 1                | 1   |     |     |     |     |     |     |   |
| 7    | TP-6258     | P/C Kohler D1000 37.1A Eng, 900/100REOZM/B       |                  |     | 1   | 1   |     |     |     |     |   |
| 7    | TP-6283     | P/C Kohler D1250 Engine, 1250REOZM/B             |                  |     |     |     | 1   |     |     |     |   |
| 7    | TP-6259     | P/C Kohler D1600-2000Eng, 1600-2000REOZM/B       |                  |     |     |     |     |     | 1   | 1   | 1 |
| 8    | TP-6557     | O/M MHI 750/800REOZMB                            | 1                | 1   |     |     |     |     |     |     |   |
| 8    | TP-6558     | O/M MHI 900/1000REOZMB                           |                  |     | 1   | 1   |     |     |     |     |   |
| 8    | TP-6644     | O/M MHI ECM3, 900/1000REOZMB, Industrial         |                  |     | 1   | 1   |     |     |     |     |   |
| 8    | TP-6559     | O/M MHI 1250REOZMB                               |                  |     |     |     | 1   |     |     |     |   |
| 8    | TP-6560     | O/M MHI 1600REOZMB                               |                  |     |     |     |     |     | 1   |     |   |
| 8    | TP-6561     | O/M MHI 1750/2000REOZMB                          |                  |     |     |     |     |     |     | 1   | 1 |
| 9    | TP-6318     | W/D 750-2000REOZMD, 750-2000ROZMC                | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 10   | TP-6330     | O/I/M Woodward ProAct I/II Governor              | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 11   | TP-6356     | S/M Controllers, 20-2800 kW                      | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 12   | TP-6373     | S/M Pilot-Excited PM Alternator, 350-2800 kW     | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 13   | TP-6484     | P/C 600-2000REOZMB                               | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 14   | TP-6563     | S/M MHI 750/800REOZM/B                           | 1                | 1   |     |     |     |     |     |     |   |
| 14   | TP-6564     | S/M MHI 900-1000REOZM/B                          |                  |     | 1   | 1   |     |     |     |     |   |
| 14   | TP-6565     | S/M MHI 1250REOZM/B                              |                  |     |     |     | 1   |     |     |     |   |
| 14   | TP-6566     | S/M MHI 1600REOZM/B                              |                  |     |     |     |     |     | 1   |     |   |
| 14   | TP-6567     | S/M MHI 1820-2000REOZM/B                         |                  |     |     |     |     |     |     | 1   | 1 |
| 15   | TP-6746     | P/C DEC6000 AND DPS System                       | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 15   | TP-6780     | P/C DEC 550 Controller (J-Box Panel Mt)          | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 15   | TP-6781     | P/C DEC 3000 Controller                          | 1                | 1   | 1   | 1   |     |     |     |     |   |
| 16   | TP-6747     | O/I/M DPS System Installation and Setup          | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |
| 17   | TP-6750     | O/M DEC 6000 Controller                          | 1                | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 1 |

# Kit List

This section lists the part numbers of modules/kits not listed in the Group Parts Lists on the previous pages. Refer to the generator set nameplate or the list below to identify the module/kit number installed on your generator set. See the sections following this page for the parts list of the module/kit.

|  | 600 kW               | 750/800 kW           | 900/1000 kW |
|--|----------------------|----------------------|-------------|
| <b>Cooling Systems</b>                   |                      |                      |             |
| Radiator drain valve                     | GM33830-KA1          | GM33830-KA1          | GM33830-KA1 |
| Remote radiator setup                    | GM50923-MA1          | GM51078-MA1          | GM51433-MA1 |
| Remote radiator flex kit                 | —                    | GM51591-KP1          | GM51674-KP1 |
| Heater, block including isolation valves |                      | (Obsolete CSS Style) |             |
| 190/208 V, 1-phase                       | GM21100-KA1          | GM53095-KA6          | GM19409-KA6 |
| 210/240 V, 1-phase                       | GM21100-KA2          | GM53095-KA2          | GM19409-KA1 |
| 240 V, 3-phase                           | —                    | GM53095-KA4          | GM19409-KA3 |
| 380 V, 3-phase                           | —                    | GM53095-KA5          | GM19409-KA4 |
| 380/480 V, 1-phase                       | GM21100-KA3          | GM53095-KA3          | GM19409-KA2 |
| 480 V, 3-phase                           | —                    | GM53095-KA1          | GM19409-KA5 |
| Heater, block including isolation valves |                      | (CMS Style)          |             |
| 190/208 V, 1-phase                       | GM21100-KA1          | GM64395-KA6          | GM64396-KA6 |
| 210/240 V, 1-phase                       | GM21100-KA2          | GM64395-KA2          | GM64396-KA2 |
| 240 V, 3-phase                           | —                    | GM64395-KA4          | GM64396-KA4 |
| 380 V, 3-phase                           | —                    | GM64395-KA5          | GM64396-KA5 |
| 380/480 V, 1-phase                       | GM21100-KA3          | GM64395-KA3          | GM64396-KA3 |
| 480 V, 3-phase                           | —                    | GM64395-KA1          | GM64396-KA1 |
| <hr/>                                    |                      |                      |             |
|  | 1250 kW              | 1600-2000 kW         |             |
| <b>Cooling Systems</b>                   |                      |                      |             |
| Radiator drain valve                     | GM33830-MA1          | GM33830-MA1          |             |
| Remote radiator setup                    | GM51551-MA1          | GM51551-MA1          |             |
| Heater, block including isolation valves | (Obsolete CSS Style) |                      |             |
| 208 V, 1-phase                           | GM51438-KA6          | GM51266-KA6          |             |
| 240 V, 1-phase                           | GM51438-KA1          | GM51266-KA1          |             |
| 240 V, 3-phase                           | GM51438-KA2          | GM51266-KA2          |             |
| 380 V, 3-phase                           | GM51438-KA3          | GM51266-KA3          |             |
| 480 V, 1-phase                           | GM51438-KA5          | GM51266-KA5          |             |
| 480 V, 3-phase                           | GM51438-KA4          | GM51266-KA4          |             |
| Heater, block including isolation valves | (CMS Style)          |                      |             |
| 208 V, 1-phase                           | GM64397-KA6          | GM64399-KA6          |             |
| 240 V, 1-phase                           | GM64397-KA1          | GM64399-KA1          |             |
| 240 V, 3-phase                           | GM64397-KA2          | GM64399-KA2          |             |
| 380 V, 3-phase                           | GM64397-KA3          | GM64399-KA3          |             |
| 480 V, 1-phase                           | GM64397-KA5          | GM64399-KA5          |             |
| 480 V, 3-phase                           | GM64397-KA4          | GM64399-KA4          |             |

# Kit List

|  | 600 kW      | 750/800 kW  |
|--|-------------|-------------|
| <b>Cooling Systems</b>                   |             |             |
| Heater, block including isolation valves |             |             |
| 208 V, 1-Phase                           | GM79185-KA1 | GM77395-KA6 |
| 240 V, 1-Phase                           | GM79185-KA2 | GM77395-KA2 |
| 240 V, 3-Phase                           | —           | GM77395-KA4 |
| 380 V, 3-Phase                           | —           | GM77395-KA5 |
| 480 V, 1-Phase                           | GM79185-KA3 | GM77395-KA3 |
| 480 V, 3-Phase                           | —           | GM77395-KA1 |

## Touch-Up Paint

Gloss and textured paint is available from Aftermarket Parts.

| Description                            | Part Number |
|--|-------------|
| Paint, Gloss KCB, 12oz spray can       | GM71383     |
| Paint, Gloss KCB, 1 gallon can         | GM71387     |
| Paint, Textured KCB, 12oz spray can    | GM82834     |
| Paint, Textured KCB, 1 gallon can      | GM82835     |
| Paint, Textured Black, 12 oz spray can | GM82836     |
| Paint, Tank touch up                   | GM82837     |

# Cooling System Kits

| Qty. | Description | Part No. |
|------|-------------|----------|
|------|-------------|----------|

| <b>Radiator Drain Valve</b> |                                      | <b>GM33820-KA1</b> |
|-----------------------------|--------------------------------------|--------------------|
| 1                           | Valve, drain, 3/8 in. NPTF           | 278788             |
| 1                           | Bushing, reducing, 3/8 x 1/2 in. NPT | X-202-28           |

| <b>Remote Radiator Setup</b> |  | <b>GM50923-MA1</b> |
|------------------------------|--|--------------------|
| 1                            | Clamp, hose, 2.81/3.12 in.             | 275527             |
| 1                            | Clamp, hose, 3.25/3.56 in.             | 291542             |
| 1                            | Clamp, hose, 2.63/2.94 in.             | 336228             |
| 1                            | Clamp, hose, 3.88/4.19 in.             | 336229             |
| 1                            | Flange, water connection, outlet       | GM11962            |
| 1                            | Flange, water connection, inlet        | GM11963            |
| 1                            | Guard, belt guard mounting             | GM12351            |
| 1                            | Flange, water connection, inlet        | GM50752            |
| 1                            | Guard, Belt (RS)                       | GM50754            |
| 1                            | Guard, Belt (Bottom)                   | GM50755            |
| 1                            | Guard, Belt (LS)                       | GM50757            |
| 1                            | Guard, Belt (Top)                      | GM50758            |
| 1                            | Guard, pulley, right side              | GM51038            |
| 1                            | Cover, pulley                          | GM51039            |
| 1                            | Guard, Belt (LS)                       | GM51583            |
| 1                            | Bracket, belt guard mtg.               | GM51724            |
| 1                            | Bracket, belt guard mtg.               | GM51725            |
| 1                            | Guard, Belt (LS) Rear                  | GM51850            |
| 1                            | Bracket, Belt Guard Mtg                | GM55038            |
| 1                            | Hose, radiator, straight, 2.5 in. ID   | X-424-10           |
| 1                            | Hose, radiator, straight, 3 in. ID     | X-507-7            |
| 1                            | Hose, radiator, wire inset, 2.5 in. ID | X-6014-69          |
| 1                            | Hose, radiator, wire inset, 3.5 in. ID | X-6014-70          |

| <b>Remote Radiator Setup</b> |                                    | <b>GM51078-MA1</b> |
|------------------------------|------------------------------------|--------------------|
| 1                            | Clamp, muffler, 3.62 in.           | 286286             |
| 4                            | Clamp, muffler, 4.12 in.           | 289372             |
| 8                            | Clamp, hose, 3.25/3.56 in.         | 291542             |
| 1                            | Bracket, hose                      | GM32394            |
| 1                            | Tube, lower remote radiator        | GM32395            |
| 2                            | Bracket, hose                      | GM32398            |
| 1                            | Guard, belt (chg. alt.), right     | GM51037            |
| 1                            | Guard, Belt (Top)                  | GM51285            |
| 1                            | Guard, belt, right side            | GM51286            |
| 1                            | Bracket, guard, right side         | GM51287            |
| 1                            | Guard, Belt (Bottom)               | GM51288            |
| 1                            | Bracket, guard, left side          | GM51289            |
| 1                            | Guard, belt (chg. alt.), left      | GM51290            |
| 1                            | Guard, belt (chg. alt.), left      | GM51291            |
| 1                            | Guard, Belt (LS)                   | GM51292            |
| 2                            | Guard, chg. alt.                   | GM51338            |
| 1                            | Guard, belt (chg. alt.), right     | GM51363            |
| 1                            | Tube, outlet                       | GM51375            |
| 1                            | Tube, outlet                       | GM51376            |
| 1                            | Bracket, guard                     | GM51391            |
| 1                            | Bracket, guard                     | GM51392            |
| 1                            | Tube, lower remote radiator        | GM51435            |
| 1                            | Bracket, hose                      | GM51436            |
| 1                            | Bracket, Guard (LS)                | GM52139            |
| 1                            | Bracket, Guard (RS)                | GM52138            |
| 1                            | Guard, Belt LH (BCA)               | GM52270            |
| 1                            | Guard, Belt Front                  | GM66362            |
| 1                            | Bracket, Support                   | GM66573            |
| 3                            | Cover, Coolant Connection          | GM74080            |
| 1                            | Cover, Coolant Connection          | GM74081            |
| 2                            | Spacer, 0.531 ID x 1 OD x 1 in.    | X-400-230          |
| 2                            | Hose, radiator, straight, 3 in. ID | X-507-10           |
| 2                            | Hose, radiator, straight, 3 in. ID | X-507-7            |
| 1                            | Clamp, muffler, 2.62 in.           | X-722-2            |

| Qty. | Description | Part No. |
|------|-------------|----------|
|------|-------------|----------|

| <b>Remote Radiator Setup</b> |  | <b>GM51433-MA1</b> |
|------------------------------|--|--------------------|
| 1                            | Clamp, muffler, 3.12 in.               | 286283             |
| 2                            | Clamp, muffler, 4.12 in.               | 289372             |
| 4                            | Clamp, hose, 3.25/3.56 in.             | 291542             |
| 1                            | Bracket, belt guard                    | GM10544            |
| 1                            | Bracket, belt guard                    | GM10545            |
| 1                            | Bracket, belt guard                    | GM10546            |
| 1                            | Bracket, belt guard                    | GM10547            |
| 1                            | Bracket, guard                         | GM10948            |
| 1                            | Guard, pulley top                      | GM10949            |
| 1                            | Guard, pulley left side                | GM10950            |
| 1                            | Guard, pulley bottom                   | GM10951            |
| 1                            | Guard, pulley right side               | GM10952            |
| 1                            | Tube, water inlet                      | GM10953            |
| 1                            | Guard, pulley front                    | GM10955            |
| 1                            | Ball, bearing                          | GM10996            |
| 1                            | Tube, outlet                           | GM51464            |
| 1                            | Tube, water inlet                      | GM51465            |
| 1                            | Bracket, hose                          | GM51466            |
| 1                            | Bracket, guard                         | GM51467            |
| 1                            | Tube, lower                            | GM51505            |
| 1                            | Bracket, tube                          | GM51522            |
| 3                            | Cover, Coolant Connection              | GM74080            |
| 1                            | Cover, Coolant Connection              | GM74081            |
| 2                            | Hose, radiator, straight, 3 in. ID     | X-507-10           |
| 1                            | Hose, radiator, straight, 3 in. ID     | X-507-4            |
| 2                            | Washer, beveled, 0.44 ID x 1.25 in. OD | X-6011-4           |
| 1                            | Clamp, muffler, 2.62 in.               | X-722-2            |
| 1                            | Plug, pipe, 1/2                        | X-75-3             |

| <b>Remote Radiator Setup</b> |  | <b>GM51551-MA1</b> |
|------------------------------|--|--------------------|
| 2                            | Clamp, muffler, 3.12 in.               | 286283             |
| 1                            | Clamp, muffler, 3.62 in.               | 286286             |
| 1                            | Clamp, muffler, 4.12 in.               | 289372             |
| 4                            | Clamp, hose, 3.25/3.56 in.             | 291542             |
| 1                            | Tube, water inlet, 4 in. OD steel      | GM10953            |
| 2                            | Support, radiator tube                 | GM19607            |
| 1                            | Tube, water inlet                      | GM51552            |
| 1                            | Tube, outlet                           | GM51553            |
| 1                            | Bracket, support                       | GM51554            |
| 1                            | Guard, pulley, right side              | GM51555            |
| 1                            | Guard, pulley, left side               | GM51556            |
| 1                            | Guard, pulley top                      | GM51557            |
| 1                            | Guard, pulley front                    | GM51558            |
| 1                            | Tube, Water Inlet                      | GM52986            |
| 1                            | Guard, Belt Lower                      | GM60790            |
| 1                            | Cover, Coolant Connection              | GM74080            |
| 2                            | Hose, radiator, straight, 3 in. ID     | X-507-7            |
| 1                            | Hose, radiator, straight, 3.5 in. ID   | X-6006-3           |
| 2                            | Washer, beveled, 0.44 ID x 1.25 in. OD | X-6011-4           |

| <b>Remote Radiator Flex Kit</b> |                             | <b>GM51591-KP1</b> |
|---------------------------------|-----------------------------|--------------------|
| 32                              | Screw, hex head machine     | X-6021-1           |
| 32                              | Nut, hex, 5/8-11, zinc      | X-85-3             |
| 3                               | Adapter, flexible, radiator | 354044             |
| 1                               | Adapter, flexible, radiator | 354281             |

| <b>Remote Radiator Flex Kit</b> |                             | <b>GM51674-KP1</b> |
|---------------------------------|-----------------------------|--------------------|
| 32                              | Screw, hex head machine     | X-6021-1           |
| 32                              | Nut, hex, 5/8-11, zinc      | X-85-3             |
| 2                               | Adapter, flexible, radiator | 354044             |
| 2                               | Adapter, flexible, radiator | 354281             |

# Cooling System Kits

## Block Heater Kits: GM21100-KA1 to GM21100-KA3

| Qty. | Description                         | Common Parts | Unique Parts |             |             |
|------|-------------------------------------|--------------|--------------|-------------|-------------|
|      |                                     |              | GM21100-KA1  | GM21100-KA2 | GM21100-KA3 |
| 1    | Heater, block                       |              | GM19667      | GM19668     | GM19669     |
| 1    | Block heater service element        |              | GM29480      | GM29481     | GM29482     |
| 1    | Thermostat                          |              | GM29529      | GM29529     |             |
| 1    | Bushing, reducing, 1/2 x 3/4 in NPT | 153659       |              |             |             |
| 1    | Strap, ground, 5 in.                | 223033       |              |             |             |
| 1    | Tag, hang                           | 279047       |              |             |             |
| 1    | Thermostat, block heater            | 279813       |              |             |             |
| 4    | Gasket, washer                      | 297001       |              |             |             |
| 1    | Box, block heater control           | 354316       |              |             |             |
| 1    | Cover, block heater control         | 354317       |              |             |             |
| 1    | Gasket, control box                 | 354318       |              |             |             |
| 1    | Decal, warning                      | 354325       |              |             |             |
| 1    | Label, wiring diagram               | 354328       |              |             |             |
| 1    | Bushing, adapter                    | GM10577      |              |             |             |
| 2    | Valve, shutoff                      | GM19670      |              |             |             |
| 4    | Vibromount                          | GM38784-2    |              |             |             |
| 1    | Bracket, block heater               | GM38834      |              |             |             |
| 1    | Busing, reducing, 1/4 x 1/2 in. NPT | X-202-47     |              |             |             |
| 1    | Tee, pipe, 1/2 x 1/2 x 1/2 in.      | X-203-13     |              |             |             |
| 2    | Pipe, 1/2 NPT x 1.19 in.            | X-209-2      |              |             |             |
| 1    | Pipe, 1/2 NPT x 3 in.               | X-209-11     |              |             |             |
| 1    | Fitting, elbow, street 1/2 in.      | X-211-1      |              |             |             |
| 1    | Valve, drain, 1/4 in. NPT           | X-256-3      |              |             |             |
| 3    | Elbow, street, 45° x 1/2 in. NPT    | X-274-13     |              |             |             |
| 1    | Elbow, street, 45° x 3/4 in. NPT    | X-274-15     |              |             |             |
| 4    | Clamp, hose, 0.69/1.25 in.          | X-426-12     |              |             |             |
| 2    | Connector, hose                     | X-582-7      |              |             |             |
| 2    | Hose, coolant 40 in.                | X-6367-7     |              |             |             |
| 4    | Screw, slotted hex washer head      | X-97-13      |              |             |             |

## Block Heater Kits: GM19409-KA1-GM19409-KA5

| Qty. | Description                                | Common Parts | Unique Parts |             |             |
|------|--|--------------|--------------|-------------|-------------|
|      |  |              | GM19409-KA1  | GM19409-KA2 | GM19409-KA3 |
| 1    | Heater, block (CSS Style; use service kit) |              | 361246       | 361247      | 361248      |
| 1    | Element, replacement                       |              | GM29666      | GM29667     | GM29668     |
| 1    | Block Heater Service Kit                   |              | GM66014-1    | GM66014-2   | GM66014-3   |
| 1    | Block Heater (CSM Style)                   |              | GM62499      | GM62500     | GM62501     |
| 1    | Block Heater replacement element           |              | GM62639      | GM62640     | GM62641     |
| 2    | Washer, nylon, .878 ID x .132 in OD        | X-6278-4     |              |             |             |
| 1    | Tag, hang                                  | 279047       |              |             |             |
| 1    | Harness, wiring                            | 279956       |              |             |             |
| 1    | Tag, instruction                           | 299896       |              |             |             |
| 4    | Vibromount                                 | 328645       |              |             |             |
| 2    | Bushing, adapter                           | GM10577      |              |             |             |
| 2    | Valve, shutoff (3/4-14 NPT)                | GM19666      |              |             |             |
| 1    | Valve, shutoff (1/2-14 NPT)                | GM19670      |              |             |             |
| 1    | Bracket, block heater                      | GM30921      |              |             |             |
| 1    | Bracket, block heater                      | GM30922      |              |             |             |
| 1    | Pipe (3/4 in. NPT x 1.38 in.)              | X-206-9      |              |             |             |
| 1    | Pipe (3/4 in. NPT x 2.50 in.)              | X-206-4      |              |             |             |
| 1    | Pipe, cross (1 in. NPT)                    | X-207-1      |              |             |             |
| 1    | Pipe (1/2 in. NPT x 1.19 in.)              | X-209-2      |              |             |             |
| 1    | Fitting, elbow, street 1/2 in.             | X-211-1      |              |             |             |
| 2    | Nipple, pipe, 1 x 1 1/2 in.                | X-218-24     |              |             |             |
| 2    | Elbow, street (45 deg. x 3/4 in. NPT)      | X-274-2      |              |             |             |
| 4    | Stud, 5/15-18 x 1.5 in.                    | X-352-65     |              |             |             |
| 6    | Clamp, hose, .69/1.25 in.                  | X-426-12     |              |             |             |
| 3    | Connector, hose                            | X-582-15     |              |             |             |
| 1    | Connector, hose                            | X-582-7      |              |             |             |
| 2    | Connector, hose                            | X-582-8      |              |             |             |
| 2    | Washer, beveled, .44 ID x 1.25 in. OD      | X-6011-4     |              |             |             |
| 1    | Hose, coolant 70 in.                       | X-6367-3     |              |             |             |
| 1    | Hose, coolant 56 in.                       | X-6367-5     |              |             |             |
| 2    | Clamp, insulated, 1.06 in.                 | X-672-32     |              |             |             |
| 1    | Elbow, pipe (45 deg x 1"npt)               | X-225-9      |              |             |             |
| 1    | Pipe (1"npt x 6.50")                       | X-218-9      |              |             |             |
| 2    | Pipe, Nipple (1" NPT x 3.00")              | X-218-22     |              |             |             |
| 3    | Elbow, pipe (90 deg x 1"npt)               | X-215-15     |              |             |             |

# Cooling System Kits, continued

## Block Heater Kits: GM19409-KA4-GM19409-KA6

| Qty. | Description                                | Common Parts | Unique Parts |             |             |
|------|--|--------------|--------------|-------------|-------------|
|      |  |              | GM19409-KA4  | GM19409-KA5 | GM19409-KA6 |
| 1    | Heater, block (CSS Style; use service kit) |              | 361249       | 361240      | GM42088     |
| 1    | Element, replacement                       |              | GM29669      | GM29665     | GM42089     |
| 1    | Block Heater Service Kit                   |              | GM66014-4    | GM66014-5   | GM66014-6   |
| 1    | Block Heater (CSM Style)                   |              | GM62502      | GM62498     | GM62509     |
| 1    | Block Heater replacement element           |              | GM62642      | GM62638     | GM62649     |
| 2    | Washer, nylon, .878 ID x .132 in OD        | X-6278-4     |              |             |             |
| 1    | Tag, hang                                  | 279047       |              |             |             |
| 1    | Harness, wiring                            | 279956       |              |             |             |
| 1    | Tag, instruction                           | 299896       |              |             |             |
| 4    | Vibromount                                 | 328645       |              |             |             |
| 2    | Bushing, adapter                           | GM10577      |              |             |             |
| 2    | Valve, shutoff (3/4-14 NPT)                | GM19666      |              |             |             |
| 1    | Valve, shutoff (1/2-14 NPT)                | GM19670      |              |             |             |
| 1    | Bracket, block heater                      | GM30921      |              |             |             |
| 1    | Bracket, block heater                      | GM30922      |              |             |             |
| 1    | Fitting, tee, pipe, 1 x 1 x 1 in.          | X-203-2      |              |             |             |
| 1    | Pipe (3/4 in. NPT x 1.38 in.)              | X-206-9      |              |             |             |
| 1    | Pipe (3/4 in. NPT x 2.50 in.)              | X-206-4      |              |             |             |
| 1    | Pipe, cross (1 in. NPT)                    | X-207-1      |              |             |             |
| 1    | Pipe (1/2 in. NPT x 1.19 in.)              | X-209-2      |              |             |             |
| 1    | Fitting, elbow, street 1/2 in.             | X-211-1      |              |             |             |
| 1    | Nipple, pipe, 1 x 1 1/2 in.                | X-218-24     |              |             |             |
| 2    | Elbow, street (45 deg. x 3/4 in. NPT)      | X-274-2      |              |             |             |
| 4    | Stud, 5/15-18 x 1.5 in.                    | X-352-65     |              |             |             |
| 4    | Clamp, hose, .69/1.25 in.                  | X-426-12     |              |             |             |
| 3    | Connector, hose                            | X-582-15     |              |             |             |
| 1    | Connector, hose                            | X-582-7      |              |             |             |
| 2    | Connector, hose                            | X-582-8      |              |             |             |
| 2    | Washer, beveled, .44 ID x 1.25 in. OD      | X-6011-4     |              |             |             |
| 1    | Hose, coolant 70 in.                       | X-6367-3     |              |             |             |
| 1    | Hose, coolant 56 in.                       | X-6367-5     |              |             |             |
| 2    | Clamp, insulated, 1.06 in.                 | X-672-32     |              |             |             |
| 1    | Elbow, pipe (45 deg x 1"npt)               | X-225-9      |              |             |             |
| 1    | Pipe (1"npt x 6.50")                       | X-218-9      |              |             |             |
| 2    | Pipe, Nipple (1" NPT x 3.00")              | X-218-22     |              |             |             |
| 3    | Elbow, pipe (90 deg x 1"npt)               | X-215-15     |              |             |             |



# Cooling System Kits, continued

## Block Heater Kits: GM53095-KA1 to GM53095-KA3

| Qty. | Description                                | Common Parts | Unique Parts |             |             |
|------|--|--------------|--------------|-------------|-------------|
|      |  |              | GM53095-KA1  | GM53095-KA2 | GM53095-KA3 |
| 1    | Heater, block (CSS Style; use service kit) |              | 361240       | 361246      | 361247      |
| 1    | Contactator                                |              |              | 328217      |             |
| 1    | Element, replacement                       |              | GM29665      | GM29666     | GM29667     |
| 1    | Block Heater Service Kit                   |              | GM66014-55   | GM66014-56  | GM66014-57  |
| 1    | Block Heater (CSM Style)                   |              | GM62498      | GM62499     | GM62500     |
| 1    | Block Heater replacement element           |              | GM62638      | GM62639     | GM62640     |
| 1    | Tag, hang                                  | 279047       |              |             |             |
| 1    | Tag, instruction                           | 299896       |              |             |             |
| 4    | Vibromount                                 | 328645       |              |             |             |
| 1    | Valve, shutoff, 3/4-14 NPT                 | GM19666      |              |             |             |
| 2    | Valve, shutoff, 1/2-14 NPT                 | GM19670      |              |             |             |
| 1    | Bracket, block heater                      | GM30921      |              |             |             |
| 1    | Bracket, block heater                      | GM30922      |              |             |             |
| 2    | Fitting, tee, pipe, 1 x 1 x 1 in.          | X-203-2      |              |             |             |
| 1    | Pipe, 3/4 in. NPT x 2 in.                  | X-206-2      |              |             |             |
| 2    | Pipe, 1/2 in. NPT x 1.50 in.               | X-209-5      |              |             |             |
| 2    | Elbow, street, 90° x 1/2 in. NPT           | X-211-3      |              |             |             |
| 1    | Elbow, street, 45° x 3/4 in. NPT           | X-274-2      |              |             |             |
| 1    | Nipple, pipe, 1 x 3 in.                    | X-218-22     |              |             |             |
| 1    | Nipple, pipe, 1 x 1 1/2 in.                | X-218-24     |              |             |             |
| 1    | Elbow, street, 45° x 1/2 in. NPT           | X-274-13     |              |             |             |
| 4    | Stud, 5/15-18 x 1.5 in.                    | X-352-65     |              |             |             |
| 6    | Clamp, hose, 0.69/1.25 in.                 | X-426-12     |              |             |             |
| 3    | Connector, hose                            | X-582-15     |              |             |             |
| 2    | Connector, hose                            | X-582-7      |              |             |             |
| 1    | Connector, hose                            | X-582-8      |              |             |             |
| 2    | Washer, beveled, 0.44 ID x 1.25 in. OD     | X-6011-4     |              |             |             |
| 1    | Hose, coolant                              | X-6367-15    |              |             |             |
| 1    | Hose, coolant, 52 in.                      | X-6367-2     |              |             |             |
| 1    | Hose, coolant, 70 in.                      | X-6367-3     |              |             |             |
| 1    | Plug, pipe, 1 in. NPT                      | X-75-13      |              |             |             |

# Cooling System Kits, continued

## Block Heater Kits: GM53095-KA4 to GM53095-KA6

| Qty. | Description                                | Common Parts | Unique Parts |             |             |
|------|--|--------------|--------------|-------------|-------------|
|      |  |              | GM53095-KA4  | GM53095-KA5 | GM53095-KA6 |
| 1    | Heater, block (CSS Style; use service kit) |              | 361248       | 361249      | GM42088     |
| 1    | Element, replacement                       |              | GM29668      | GM29669     | GM42089     |
| 1    | Block Heater Service Kit                   |              | GM66014-58   | GM66014-59  | GM66014-60  |
| 1    | Block Heater (CSM Style)                   |              | GM62501      | GM62502     | GM62509     |
| 1    | Block Heater replacement element           |              | GM62641      | GM62642     | GM62649     |
| 1    | Tag, hang                                  | 279047       |              |             |             |
| 1    | Tag, instruction                           | 299896       |              |             |             |
| 4    | Vibromount                                 | 328645       |              |             |             |
| 1    | Valve, shutoff, 3/4-14 NPT                 | GM19666      |              |             |             |
| 2    | Valve, shutoff, 1/2-14 NPT                 | GM19670      |              |             |             |
| 1    | Bracket, block heater                      | GM30921      |              |             |             |
| 1    | Bracket, block heater                      | GM30922      |              |             |             |
| 2    | Fitting, tee, pipe, 1 x 1 x 1 in.          | X-203-2      |              |             |             |
| 1    | Pipe, 3/4 in. NPT x 2 in.                  | X-206-2      |              |             |             |
| 2    | Pipe, 1/2 in. NPT x 1.50 in.               | X-209-5      |              |             |             |
| 2    | Elbow, street, 90° x 1/2 in. NPT           | X-211-3      |              |             |             |
| 1    | Elbow, street, 45° x 3/4 in. NPT           | X-274-2      |              |             |             |
| 1    | Nipple, pipe, 1 x 3 in.                    | X-218-22     |              |             |             |
| 1    | Nipple, pipe, 1 x 1 1/2 in.                | X-218-24     |              |             |             |
| 1    | Elbow, street, 45° x 1/2 in. NPT           | X-274-13     |              |             |             |
| 4    | Stud, 5/15-18 x 1.5 in.                    | X-352-65     |              |             |             |
| 6    | Clamp, hose, 0.69/1.25 in.                 | X-426-12     |              |             |             |
| 3    | Connector, hose                            | X-582-15     |              |             |             |
| 2    | Connector, hose                            | X-582-7      |              |             |             |
| 1    | Connector, hose                            | X-582-8      |              |             |             |
| 2    | Washer, beveled, 0.44 ID x 1.25 in. OD     | X-6011-4     |              |             |             |
| 1    | Hose, coolant                              | X-6367-15    |              |             |             |
| 1    | Hose, coolant, 52 in.                      | X-6367-2     |              |             |             |
| 1    | Hose, coolant, 70 in.                      | X-6367-3     |              |             |             |
| 1    | Plug, pipe, 1 in. NPT                      | X-75-13      |              |             |             |

## Block Heater Kits: GM51266-KA1 to GM51266-KA3

| Qty. | Description                                | Common Parts | Unique Parts |             |             |
|------|--|--------------|--------------|-------------|-------------|
|      |  |              | GM51266-KA1  | GM51266-KA2 | GM51266-KA3 |
| 1    | Heater, block (CSS Style; use service kit) |              | 361246       | 361248      | 361249      |
| 1    | Contacto                                   |              | 328217       |             |             |
| 1    | Block heater service element               |              | GM29666      | GM29668     | GM29669     |
| 1    | Block Heater Service Kit                   |              | GM66014-25   | GM66014-26  | GM66014-27  |
| 1    | Block Heater (CSM Style)                   |              | GM62499      | GM62501     | GM62502     |
| 1    | Block Heater replacement element           |              | GM62639      | GM62641     | GM62642     |
| 1    | Tag, hang                                  | 279047       |              |             |             |
| 1    | Tag, instruction                           | 299896       |              |             |             |
| 4    | Vibromount                                 | 328645       |              |             |             |
| 6    | Valve, shutoff                             | GM19670      |              |             |             |
| 1    | Bracket, block heater                      | GM30921      |              |             |             |
| 1    | Bracket, block heater                      | GM30922      |              |             |             |
| 2    | Tee, pipe, 1 x 1 x 1 in. NPT               | X-203-2      |              |             |             |
| 1    | Cross, pipe (1" npt)                       | X-207-1      |              |             |             |
| 1    | Pipe (1/2"npt x 1.19")                     | X-209-2      |              |             |             |
| 2    | Pipe (1/2"npt x 4.50")                     | X-209-21     |              |             |             |
| 5    | Pipe, 1/2 in. NPT x 1.5 in.                | X-209-5      |              |             |             |
| 1    | Elbow, pipe, 90° x 1/2 in. NPT             | X-215-1      |              |             |             |
| 1    | Elbow, Street(90 deg x 1/2"nptf)           | X-211-1      |              |             |             |
| 2    | Elbow, Street(90 deg x 1/2"npt)            | X-211-3      |              |             |             |
| 1    | Pipe, 1 in. NPT x 1.5 in.                  | X-218-24     |              |             |             |
| 1    | Elbow, street, 45° x 1 in. NPT             | X-274-10     |              |             |             |
| 8    | Stud, 5/16-18 x 1.5 in.                    | X-352-65     |              |             |             |
| 12   | Clamp, hose, 0.69/1.25 in.                 | X-426-12     |              |             |             |
| 6    | Connector, hose                            | X-582-15     |              |             |             |
| 6    | Connector, hose                            | X-582-7      |              |             |             |
| 1    | Hose, coolant                              | X-6367-15    |              |             |             |
| 2    | Hose, coolant                              | X-6367-16    |              |             |             |
| 1    | Hose, coolant                              | X-6367-17    |              |             |             |
| 1    | Hose, coolant                              | X-6367-18    |              |             |             |
| 1    | Hose, coolant, 56 in.                      | X-6367-5     |              |             |             |
| 1    | Clamp, insulated, 0.75 in.                 | X-672-31     |              |             |             |
| 2    | Plug, pipe, 1 in. NPT                      | X-75-13      |              |             |             |

# Cooling System Kits, continued

## Block Heater Kits: GM51266-KA4 to GM51266-KA6

| Qty. | Description                               | Common Parts | Unique Parts |             |             |
|------|---|--------------|--------------|-------------|-------------|
|      |   |              | GM51266-KA4  | GM51266-KA5 | GM51266-KA6 |
| 1    | Heater, block(CSS Style; use service kit) |              | 361240       | 361247      | GM42088     |
| 1    | Block heater service element              |              | GM29665      | GM29667     | GM42089     |
| 1    | Block Heater Service Kit                  |              | GM66014-28   | GM66014-29  | GM66014-30  |
| 1    | Block Heater (CSM Style)                  |              | GM62498      | GM62500     | GM62509     |
| 1    | Block Heater replacement element          |              | GM62638      | GM62640     | GM62649     |
| 1    | Tag, hang                                 | 279047       |              |             |             |
| 1    | Tag, instruction                          | 299896       |              |             |             |
| 4    | Vibromount                                | 328645       |              |             |             |
| 6    | Valve, shutoff                            | GM19670      |              |             |             |
| 1    | Bracket, block heater                     | GM30921      |              |             |             |
| 1    | Bracket, block heater                     | GM30922      |              |             |             |
| 2    | Tee, pipe, 1 x 1 x 1 in. NPT              | X-203-2      |              |             |             |
| 1    | Cross, pipe (1" npt)                      | X-207-1      |              |             |             |
| 1    | Pipe (1/2"npt x 1.19")                    | X-209-2      |              |             |             |
| 2    | Pipe (1/2"npt x 4.50")                    | X-209-21     |              |             |             |
| 5    | Pipe, 1/2 in. NPT x 1.5 in.               | X-209-5      |              |             |             |
| 1    | Elbow, pipe, 90° x 1/2 in. NPT            | X-215-1      |              |             |             |
| 1    | Elbow, Street(90 deg x 1/2"nptf)          | X-211-1      |              |             |             |
| 2    | Elbow, Street(90 deg x 1/2"npt)           | X-211-3      |              |             |             |
| 1    | Pipe, 1 in. NPT x 1.5 in.                 | X-218-24     |              |             |             |
| 1    | Elbow, street, 45° x 1 in. NPT            | X-274-10     |              |             |             |
| 8    | Stud, 5/16-18 x 1.5 in.                   | X-352-65     |              |             |             |
| 12   | Clamp, hose, 0.69/1.25 in.                | X-426-12     |              |             |             |
| 6    | Connector, hose                           | X-582-15     |              |             |             |
| 6    | Connector, hose                           | X-582-7      |              |             |             |
| 1    | Hose, coolant                             | X-6367-15    |              |             |             |
| 2    | Hose, coolant                             | X-6367-16    |              |             |             |
| 1    | Hose, coolant                             | X-6367-17    |              |             |             |
| 1    | Hose, coolant                             | X-6367-18    |              |             |             |
| 1    | Hose, coolant, 56 in.                     | X-6367-5     |              |             |             |
| 1    | Clamp, insulated, 0.75 in.                | X-672-31     |              |             |             |
| 2    | Plug, pipe, 1 in. NPT                     | X-75-13      |              |             |             |

## Block Heater Kits: GM51438-KA1 to GM51438-KA3

| Qty. | Description                                | Common Parts | Unique Parts |             |             |
|------|--|--------------|--------------|-------------|-------------|
|      |  |              | GM51438-KA1  | GM51438-KA2 | GM51438-KA3 |
| 2    | Heater, block (CSS Style; use service kit) |              | 361246       | 361248      | 361249      |
| 2    | Contactora                                 |              | 328217       |             |             |
| 2    | Block heater service element               |              | GM29666      | GM29668     | GM29669     |
| 2    | Block Heater Service Kit                   |              | GM66014-7    | GM66014-8   | GM66014-9   |
| 2    | Block Heater (CSM Style)                   |              | GM62499      | GM62501     | GM62502     |
| 2    | Block Heater replacement element           |              | GM62639      | GM62641     | GM62642     |
| 2    | Tag, hang                                  | 279047       |              |             |             |
| 2    | Tag, instruction                           | 299896       |              |             |             |
| 8    | Vibromount                                 | 328645       |              |             |             |
| 4    | Valve, shutoff                             | GM19670      |              |             |             |
| 1    | Bracket, block heater                      | GM30921      |              |             |             |
| 2    | Bracket, block heater                      | GM30922      |              |             |             |
| 2    | Tee, pipe, 1 x 1 x 1 in. NPT               | X-203-2      |              |             |             |
| 1    | Pipe, 1/2 in. NPT x 3.5 in.                | X-209-20     |              |             |             |
| 3    | Pipe, 1/2 in. NPT x 1.5 in.                | X-209-5      |              |             |             |
| 1    | Elbow, pipe, 90° x 1/2 in. NPT             | X-211-1      |              |             |             |
| 2    | Pipe, 1 in. NPT x 1.5 in.                  | X-218-24     |              |             |             |
| 2    | Elbow, street, 45° x 1 in. NPT             | X-274-10     |              |             |             |
| 1    | Elbow, street, 45° x 1/2 in. NPT           | X-274-13     |              |             |             |
| 8    | Stud, 5/16-18 x 1.5 in.                    | X-352-65     |              |             |             |
| 8    | Clamp, hose, 0.69/1.25 in.                 | X-426-12     |              |             |             |
| 4    | Connector, hose                            | X-582-15     |              |             |             |
| 4    | Connector, hose                            | X-582-7      |              |             |             |
| 2    | Hose, coolant                              | X-6367-15    |              |             |             |
| 1    | Hose, coolant                              | X-6367-17    |              |             |             |
| 1    | Hose, coolant, 56 in.                      | X-6367-5     |              |             |             |
| 1    | Clamp, insulated, 1.25 in.                 | X-672-20     |              |             |             |
| 2    | Clamp, insulated, 0.75 in.                 | X-672-31     |              |             |             |
| 2    | Plug, pipe, 1 in. NPT                      | X-75-13      |              |             |             |

# Cooling System Kits, continued

## Block Heater Kits: GM51438-KA4 to GM51438-KA6

| Qty. | Description                                | Common Parts | Unique Parts |             |             |
|------|--|--------------|--------------|-------------|-------------|
|      |  |              | GM51438-KA4  | GM51438-KA5 | GM51438-KA6 |
| 2    | Heater, block (CSS Style; use service kit) |              | 361240       | 361247      | GM42088     |
| 2    | Block heater service element               |              | GM29665      | GM29667     | GM42089     |
| 2    | Block Heater Service Kit                   |              | GM66014-10   | GM66014-11  | GM66014-12  |
| 2    | Block Heater (CSM Style)                   |              | GM62498      | GM62500     | GM62509     |
| 2    | Block Heater replacement element           |              | GM62638      | GM62640     | GM62649     |
| 2    | Tag, hang                                  | 279047       |              |             |             |
| 2    | Tag, instruction                           | 299896       |              |             |             |
| 8    | Vibromount                                 | 328645       |              |             |             |
| 4    | Valve, shutoff                             | GM19670      |              |             |             |
| 1    | Bracket, block heater                      | GM30921      |              |             |             |
| 2    | Bracket, block heater                      | GM30922      |              |             |             |
| 2    | Tee, pipe, 1 x 1 x 1 in. NPT               | X-203-2      |              |             |             |
| 1    | Pipe, 1/2 in. NPT x 3.5 in.                | X-209-20     |              |             |             |
| 3    | Pipe, 1/2 in. NPT x 1.5 in.                | X-209-5      |              |             |             |
| 1    | Elbow, pipe, 90° x 1/2 in. NPT             | X-211-1      |              |             |             |
| 2    | Pipe, 1 in. NPT x 1.5 in.                  | X-218-24     |              |             |             |
| 2    | Elbow, street, 45° x 1 in. NPT             | X-274-10     |              |             |             |
| 1    | Elbow, street, 45° x 1/2 in. NPT           | X-274-13     |              |             |             |
| 8    | Stud, 5/16-18 x 1.5 in.                    | X-352-65     |              |             |             |
| 8    | Clamp, hose, 0.69/1.25 in.                 | X-426-12     |              |             |             |
| 4    | Connector, hose                            | X-582-15     |              |             |             |
| 4    | Connector, hose                            | X-582-7      |              |             |             |
| 2    | Hose, coolant                              | X-6367-15    |              |             |             |
| 1    | Hose, coolant                              | X-6367-17    |              |             |             |
| 1    | Hose, coolant, 56 in.                      | X-6367-5     |              |             |             |
| 1    | Clamp, insulated, 1.25 in.                 | X-672-20     |              |             |             |
| 2    | Clamp, insulated, 0.75 in.                 | X-672-31     |              |             |             |
| 2    | Plug, pipe, 1 in. NPT                      | X-75-13      |              |             |             |

# Cooling System Kits, continued

## Block Heater Kits: GM64395-KA1-GM64395-KA6

| Qty. | Description                           | Common Parts | Unique Parts |             |            |
|------|---------------------------------------|--------------|--------------|-------------|------------|
|      |                                       |              | GM64395-KA1  | GM64395-KA2 | GM6435-KA3 |
| 1    | Block Heater (CSM Style)              |              | GM62498      | GM62499     | GM62500    |
| 1    | Block Heater replacement element      |              | GM62638      | GM62639     | GM62640    |
| 1    | Tag, hang                             | 279047       |              |             |            |
| 1    | Tag, instruction                      | 299896       |              |             |            |
| 4    | Vibromount                            | 328645       |              |             |            |
| 2    | Valve, shutoff (3/4-14 NPT)           | GM19666      |              |             |            |
| 1    | Valve, shutoff (1/2-14 NPT)           | GM19670      |              |             |            |
| 1    | Bracket, block heater                 | GM60615      |              |             |            |
| 1    | Bushing, reducing (3/4 x 1"npt)       | X-202-1      |              |             |            |
| 1    | Pipe, Nipple (3/4" npt x 2.00")       | X-206-2      |              |             |            |
| 1    | Cross, pipe (1" npt)                  | X-207-1      |              |             |            |
| 2    | Pipe (1/2"npt x 1.50")                | X-209-5      |              |             |            |
| 2    | Elbow, street (90 deg x 1/2"nptf)     | X-211-3      |              |             |            |
| 1    | Nipple, pipe, 1 x 1 1/2 in.           | X-218-24     |              |             |            |
| 2    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-10     |              |             |            |
| 1    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-13     |              |             |            |
| 1    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-2      |              |             |            |
| 4    | Stud, 5/15-18 x 1.5 in.               | X-352-65     |              |             |            |
| 6    | Clamp, hose, .69/1.25 in.             | X-426-12     |              |             |            |
| 3    | Connector, hose                       | X-582-15     |              |             |            |
| 2    | Connector, hose                       | X-582-7      |              |             |            |
| 1    | Connector, hose                       | X-582-8      |              |             |            |
| 2    | Washer, beveled, .44 ID x 1.25 in. OD | X-6011-4     |              |             |            |
| 1    | Hose, coolant                         | X-6367-15    |              |             |            |
| 1    | Hose, coolant 70"                     | X-6367-3     |              |             |            |
| 1    | Hose, coolant 40"                     | X-6367-7     |              |             |            |
| 1    | Plug, pipe (1" nptf)                  | X-75-13      |              |             |            |

| Qty. | Description                           | Common Parts | Unique Parts |             |             |
|------|---------------------------------------|--------------|--------------|-------------|-------------|
|      |                                       |              | GM64395-KA4  | GM64395-KA5 | GM64395-KA6 |
| 1    | Block Heater (CSM Style)              |              | GM62501      | GM62502     | GM62509     |
| 1    | Block Heater replacement element      |              | GM62641      | GM62642     | GM62649     |
| 1    | Tag, hang                             | 279047       |              |             |             |
| 1    | Tag, instruction                      | 299896       |              |             |             |
| 4    | Vibromount                            | 328645       |              |             |             |
| 2    | Valve, shutoff (3/4-14 NPT)           | GM19666      |              |             |             |
| 1    | Valve, shutoff (1/2-14 NPT)           | GM19670      |              |             |             |
| 1    | Bracket, block heater                 | GM60615      |              |             |             |
| 1    | Bushing, reducing (3/4 x 1"npt)       | X-202-1      |              |             |             |
| 1    | Pipe, Nipple (3/4" npt x 2.00")       | X-206-2      |              |             |             |
| 1    | Cross, pipe (1" npt)                  | X-207-1      |              |             |             |
| 2    | Pipe (1/2"npt x 1.50")                | X-209-5      |              |             |             |
| 2    | Elbow, street (90 deg x 1/2"nptf)     | X-211-3      |              |             |             |
| 1    | Nipple, pipe, 1 x 1 1/2 in.           | X-218-24     |              |             |             |
| 2    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-10     |              |             |             |
| 1    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-13     |              |             |             |
| 1    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-2      |              |             |             |
| 4    | Stud, 5/15-18 x 1.5 in.               | X-352-65     |              |             |             |
| 6    | Clamp, hose, .69/1.25 in.             | X-426-12     |              |             |             |
| 3    | Connector, hose                       | X-582-15     |              |             |             |
| 2    | Connector, hose                       | X-582-7      |              |             |             |
| 1    | Connector, hose                       | X-582-8      |              |             |             |
| 2    | Washer, beveled, .44 ID x 1.25 in. OD | X-6011-4     |              |             |             |
| 1    | Hose, coolant                         | X-6367-15    |              |             |             |
| 1    | Hose, coolant 70"                     | X-6367-3     |              |             |             |
| 1    | Hose, coolant 40"                     | X-6367-7     |              |             |             |
| 1    | Plug, pipe (1" nptf)                  | X-75-13      |              |             |             |

# Cooling System Kits, continued

## Block Heater Kits: GM64396-KA1-GM64396-KA6

| Qty. | Description                           | Common Parts | Unique Parts |             |             |
|------|---------------------------------------|--------------|--------------|-------------|-------------|
|      |                                       |              | GM64396-KA1  | GM64396-KA2 | GM64396-KA3 |
| 1    | Block Heater (CSM Style)              |              | GM62499      | GM62500     | GM62501     |
| 1    | Block Heater replacement element      |              | GM62639      | GM62640     | GM62641     |
| 1    | Elbow, street (90 deg x 1"nptf)       | 151385       |              |             |             |
| 1    | Tag, hang                             | 279047       |              |             |             |
| 1    | Tag, instruction                      | 299896       |              |             |             |
| 4    | Vibromount                            | 328645       |              |             |             |
| 2    | Bushing, adapter                      | GM10577      |              |             |             |
| 2    | Valve, shutoff (3/4-14 NPT)           | GM19666      |              |             |             |
| 1    | Valve, shutoff (1/2-14 NPT)           | GM19670      |              |             |             |
| 1    | Bracket, block heater                 | GM60615      |              |             |             |
| 2    | Fitting, tee, pipe, 1 x 1 x 1 in.     | X-203-2      |              |             |             |
| 1    | Pipe (3/4 in. NPT x 2.50 in.)         | X-206-4      |              |             |             |
| 1    | Pipe (3/4 in. NPT x 1.38 in.)         | X-206-9      |              |             |             |
| 1    | Pipe (1/2 in. NPT x 1.19 in.)         | X-209-2      |              |             |             |
| 1    | Fitting, elbow, street 1/2 in.        | X-211-1      |              |             |             |
| 2    | Nipple, pipe, 1 x 1 1/2 in.           | X-218-24     |              |             |             |
| 2    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-2      |              |             |             |
| 4    | Stud, 5/15-18 x 1.5 in.               | X-352-65     |              |             |             |
| 6    | Clamp, hose, .69/1.25 in.             | X-426-12     |              |             |             |
| 3    | Connector, hose                       | X-582-15     |              |             |             |
| 1    | Connector, hose                       | X-582-7      |              |             |             |
| 2    | Connector, hose                       | X-582-8      |              |             |             |
| 2    | Washer, beveled, .44 ID x 1.25 in. OD | X-6011-4     |              |             |             |
| 2    | Washer, nylon, .878 ID x .132 in OD   | X-6278-4     |              |             |             |
| 1    | Hose, coolant                         | X-6367-14    |              |             |             |
| 1    | Hose, coolant                         | X-6367-15    |              |             |             |
| 1    | Hose, coolant                         | X-6367-5     |              |             |             |
| 2    | Clamp, insulated, 1.06 in.            | X-672-32     |              |             |             |
| 1    | Plug, pipe (1" nptf)                  | X-75-13      |              |             |             |

| Qty. | Description                           | Common Parts | Unique Parts |             |             |
|------|---------------------------------------|--------------|--------------|-------------|-------------|
|      |                                       |              | GM64396-KA4  | GM64396-KA5 | GM64396-KA6 |
| 1    | Block Heater (CSM Style)              |              | GM62502      | GM62498     | GM62509     |
| 1    | Block Heater replacement element      |              | GM62642      | GM62638     | GM62649     |
| 1    | Elbow, street (90 deg x 1"nptf)       | 151385       |              |             |             |
| 1    | Tag, hang                             | 279047       |              |             |             |
| 1    | Tag, instruction                      | 299896       |              |             |             |
| 4    | Vibromount                            | 328645       |              |             |             |
| 2    | Bushing, adapter                      | GM10577      |              |             |             |
| 2    | Valve, shutoff (3/4-14 NPT)           | GM19666      |              |             |             |
| 1    | Valve, shutoff (1/2-14 NPT)           | GM19670      |              |             |             |
| 1    | Bracket, block heater                 | GM60615      |              |             |             |
| 2    | Fitting, tee, pipe, 1 x 1 x 1 in.     | X-203-2      |              |             |             |
| 1    | Pipe (3/4 in. NPT x 2.50 in.)         | X-206-4      |              |             |             |
| 1    | Pipe (3/4 in. NPT x 1.38 in.)         | X-206-9      |              |             |             |
| 1    | Pipe (1/2 in. NPT x 1.19 in.)         | X-209-2      |              |             |             |
| 1    | Fitting, elbow, street 1/2 in.        | X-211-1      |              |             |             |
| 2    | Nipple, pipe, 1 x 1 1/2 in.           | X-218-24     |              |             |             |
| 2    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-2      |              |             |             |
| 4    | Stud, 5/15-18 x 1.5 in.               | X-352-65     |              |             |             |
| 6    | Clamp, hose, .69/1.25 in.             | X-426-12     |              |             |             |
| 3    | Connector, hose                       | X-582-15     |              |             |             |
| 1    | Connector, hose                       | X-582-7      |              |             |             |
| 2    | Connector, hose                       | X-582-8      |              |             |             |
| 2    | Washer, beveled, .44 ID x 1.25 in. OD | X-6011-4     |              |             |             |
| 2    | Washer, nylon, .878 ID x .132 in OD   | X-6278-4     |              |             |             |
| 1    | Hose, coolant                         | X-6367-14    |              |             |             |
| 1    | Hose, coolant                         | X-6367-15    |              |             |             |
| 1    | Hose, coolant                         | X-6367-5     |              |             |             |
| 2    | Clamp, insulated, 1.06 in.            | X-672-32     |              |             |             |
| 1    | Plug, pipe (1" nptf)                  | X-75-13      |              |             |             |

# Cooling System Kits, continued

## Block Heater Kits: GM64397-KA1-GM64397-KA6

| Qty. | Description                      | Common Parts | Unique Parts |             |             |
|------|----------------------------------|--------------|--------------|-------------|-------------|
|      |                                  |              | GM64397-KA1  | GM64397-KA2 | GM64397-KA3 |
| 1    | Block Heater (CSM Style)         |              | GM62499      | GM62501     | GM62502     |
| 1    | Block Heater replacement element |              | GM62639      | GM62641     | GM62642     |
| 1    | Elbow, street (90 deg x 1"nptf)  | 151385       |              |             |             |
| 1    | Tag, hang                        | 279047       |              |             |             |
| 1    | Tag, instruction                 | 299896       |              |             |             |
| 4    | Vibromount                       | 328645       |              |             |             |
| 4    | Valve, shutoff (1/2-14 NPT)      | GM19670      |              |             |             |
| 1    | Bracket, block heater            | GM60615      |              |             |             |
| 2    | Tee, pipe, 1 x 1 x 1 in.         | X-203-2      |              |             |             |
| 1    | Pipe (1/2"npt x 3.50")           | X-209-20     |              |             |             |
| 2    | Pipe (1/2"npt x 1.50")           | X-209-5      |              |             |             |
| 1    | Pipe (1/2"npt x 2.00")           | X-209-6      |              |             |             |
| 1    | Fitting, elbow, street 1/2 in.   | X-211-1      |              |             |             |
| 2    | Nipple, pipe, 1 x 1 1/2 in.      | X-218-24     |              |             |             |
| 1    | Elbow, street (45 deg x 1"npt)   | X-274-10     |              |             |             |
| 1    | Elbow, street (45 deg x 1/2"npt) | X-274-13     |              |             |             |
| 8    | Stud, 5/15-18 x 1.5 in.          | X-352-65     |              |             |             |
| 8    | Clamp, hose, .69/1.25 in.        | X-426-12     |              |             |             |
| 4    | Connector, hose                  | X-582-15     |              |             |             |
| 4    | Connector, hose                  | X-582-7      |              |             |             |
| 1    | Hose, coolant                    | X-6367-15    |              |             |             |
| 1    | Hose, coolant                    | X-6367-17    |              |             |             |
| 1    | Hose, coolant 56"                | X-6367-5     |              |             |             |
| 1    | Clamp, insulated, 1.25 in.       | X-672-20     |              |             |             |
| 2    | Clamp, insulated, .75 in.        | X-672-31     |              |             |             |
| 2    | Plug, pipe (1" nptf)             | X-75-13      |              |             |             |

| Qty. | Description                      | Common Parts | Unique Parts |             |             |
|------|----------------------------------|--------------|--------------|-------------|-------------|
|      |                                  |              | GM64397-KA4  | GM64397-KA5 | GM64397-KA6 |
| 1    | Block Heater (CSM Style)         |              | GM62498      | GM62500     | GM62509     |
| 1    | Block Heater replacement element |              | GM62638      | GM62640     | GM62649     |
| 1    | Elbow, street (90 deg x 1"nptf)  | 151385       |              |             |             |
| 1    | Tag, hang                        | 279047       |              |             |             |
| 1    | Tag, instruction                 | 299896       |              |             |             |
| 4    | Vibromount                       | 328645       |              |             |             |
| 4    | Valve, shutoff (1/2-14 NPT)      | GM19670      |              |             |             |
| 1    | Bracket, block heater            | GM60615      |              |             |             |
| 2    | Tee, pipe, 1 x 1 x 1 in.         | X-203-2      |              |             |             |
| 1    | Pipe (1/2"npt x 3.50")           | X-209-20     |              |             |             |
| 2    | Pipe (1/2"npt x 1.50")           | X-209-5      |              |             |             |
| 1    | Pipe (1/2"npt x 2.00")           | X-209-6      |              |             |             |
| 1    | Fitting, elbow, street 1/2 in.   | X-211-1      |              |             |             |
| 2    | Nipple, pipe, 1 x 1 1/2 in.      | X-218-24     |              |             |             |
| 1    | Elbow, street (45 deg x 1"npt)   | X-274-10     |              |             |             |
| 1    | Elbow, street (45 deg x 1/2"npt) | X-274-13     |              |             |             |
| 8    | Stud, 5/15-18 x 1.5 in.          | X-352-65     |              |             |             |
| 8    | Clamp, hose, .69/1.25 in.        | X-426-12     |              |             |             |
| 4    | Connector, hose                  | X-582-15     |              |             |             |
| 4    | Connector, hose                  | X-582-7      |              |             |             |
| 1    | Hose, coolant                    | X-6367-15    |              |             |             |
| 1    | Hose, coolant                    | X-6367-17    |              |             |             |
| 1    | Hose, coolant 56"                | X-6367-5     |              |             |             |
| 1    | Clamp, insulated, 1.25 in.       | X-672-20     |              |             |             |
| 2    | Clamp, insulated, .75 in.        | X-672-31     |              |             |             |
| 2    | Plug, pipe (1" nptf)             | X-75-13      |              |             |             |

# Cooling System Kits, continued

## Block Heater Kits: GM64399-KA1-GM64399-KA6

| Qty. | Description                       | Common Parts | Unique Parts |             |             |
|------|-----------------------------------|--------------|--------------|-------------|-------------|
|      |                                   |              | GM64399-KA1  | GM64399-KA2 | GM64399-KA3 |
| 1    | Block Heater (CSM Style)          |              | GM62499      | GM62501     | GM62502     |
| 1    | Block Heater replacement element  |              | GM62639      | GM62641     | GM62642     |
| 1    | Elbow, street (90 deg x 1"nptf)   | 151385       |              |             |             |
| 1    | Tag, hang                         | 279047       |              |             |             |
| 1    | Tag, instruction                  | 299896       |              |             |             |
| 8    | Vibromount                        | 328645       |              |             |             |
| 6    | Valve, shutoff (1/2-14 NPT)       | GM19670      |              |             |             |
| 2    | Bracket, block heater             | GM60615      |              |             |             |
| 2    | Tee, pipe, 1 x 1 x 1 in.          | X-203-2      |              |             |             |
| 1    | Cross, pipe (1" npt)              | X-207-1      |              |             |             |
| 1    | Pipe (1/2"npt x 1.19")            | X-209-2      |              |             |             |
| 2    | Pipe (1/2"npt x 4.50")            | X-209-21     |              |             |             |
| 5    | Pipe (1/2"npt x 1.50")            | X-209-5      |              |             |             |
| 1    | Fitting, elbow, street 1/2 in.    | X-211-1      |              |             |             |
| 2    | Elbow, street (90 deg x 1/2"nptf) | X-211-3      |              |             |             |
| 2    | Elbow, pipe (90 deg x 1/2"npt)    | X-215-1      |              |             |             |
| 3    | Nipple, pipe, 1 x 1 1/2 in.       | X-218-24     |              |             |             |
| 1    | Elbow, street (45 deg x 1"npt)    | X-274-10     |              |             |             |
| 8    | Stud, 5/15-18 x 1.5 in.           | X-352-65     |              |             |             |
| 12   | Clamp, hose, .69/1.25 in.         | X-426-12     |              |             |             |
| 6    | Connector, hose                   | X-582-15     |              |             |             |
| 6    | Connector, hose                   | X-582-7      |              |             |             |
| 1    | Hose, coolant                     | X-6367-15    |              |             |             |
| 1    | Hose, coolant                     | X-6367-16    |              |             |             |
| 2    | Hose, coolant                     | X-6367-17    |              |             |             |
| 1    | Hose, coolant 70"                 | X-6367-3     |              |             |             |
| 1    | Hose, coolant 56"                 | X-6367-5     |              |             |             |
| 1    | Clamp, insulated, .75 in.         | X-672-31     |              |             |             |
| 2    | Plug, pipe (1" nptf)              | X-75-13      |              |             |             |

| Qty. | Description                       | Common Parts | Unique Parts |             |             |
|------|-----------------------------------|--------------|--------------|-------------|-------------|
|      |                                   |              | GM64399-KA4  | GM64399-KA5 | GM64399-KA6 |
| 1    | Block Heater (CSM Style)          |              | GM62498      | GM62500     | GM62509     |
| 1    | Block Heater replacement element  |              | GM62638      | GM62640     | GM62649     |
| 1    | Elbow, street (90 deg x 1"nptf)   | 151385       |              |             |             |
| 1    | Tag, hang                         | 279047       |              |             |             |
| 1    | Tag, instruction                  | 299896       |              |             |             |
| 8    | Vibromount                        | 328645       |              |             |             |
| 6    | Valve, shutoff (1/2-14 NPT)       | GM19670      |              |             |             |
| 2    | Bracket, block heater             | GM60615      |              |             |             |
| 2    | Tee, pipe, 1 x 1 x 1 in.          | X-203-2      |              |             |             |
| 1    | Cross, pipe (1" npt)              | X-207-1      |              |             |             |
| 1    | Pipe (1/2"npt x 1.19")            | X-209-2      |              |             |             |
| 2    | Pipe (1/2"npt x 4.50")            | X-209-21     |              |             |             |
| 5    | Pipe (1/2"npt x 1.50")            | X-209-5      |              |             |             |
| 1    | Fitting, elbow, street 1/2 in.    | X-211-1      |              |             |             |
| 2    | Elbow, street (90 deg x 1/2"nptf) | X-211-3      |              |             |             |
| 2    | Elbow, pipe (90 deg x 1/2"npt)    | X-215-1      |              |             |             |
| 3    | Nipple, pipe, 1 x 1 1/2 in.       | X-218-24     |              |             |             |
| 1    | Elbow, street (45 deg x 1"npt)    | X-274-10     |              |             |             |
| 8    | Stud, 5/15-18 x 1.5 in.           | X-352-65     |              |             |             |
| 12   | Clamp, hose, .69/1.25 in.         | X-426-12     |              |             |             |
| 6    | Connector, hose                   | X-582-15     |              |             |             |
| 6    | Connector, hose                   | X-582-7      |              |             |             |
| 1    | Hose, coolant                     | X-6367-15    |              |             |             |
| 1    | Hose, coolant                     | X-6367-16    |              |             |             |
| 2    | Hose, coolant                     | X-6367-17    |              |             |             |
| 1    | Hose, coolant 70"                 | X-6367-3     |              |             |             |
| 1    | Hose, coolant 56"                 | X-6367-5     |              |             |             |
| 1    | Clamp, insulated, .75 in.         | X-672-31     |              |             |             |
| 2    | Plug, pipe (1" nptf)              | X-75-13      |              |             |             |



# Cooling System Kits, continued

## Block Heater Kits: GM79185-KA1-GM79185-KA3

| Qty. | Description                             | Common Parts | Unique Parts |             |             |
|------|---|--------------|--------------|-------------|-------------|
|      |   |              | GM79185-KA1  | GM79185-KA2 | GM79185-KA3 |
| 1    | Heater, block                           |              | GM79182      | GM79183     | GM79184     |
| 1    | Bushing, reducing (1/2 x 3/4 in NPT)    | 153659       |              |             |             |
| 1    | Tag, hang                               | 279047       |              |             |             |
| 1    | Bushing, adapter                        | GM10577      |              |             |             |
| 2    | Valve, shutoff                          | GM19670      |              |             |             |
| 1    | Bracket, block heater                   | GM38834      |              |             |             |
| 1    | Bushing, reducing (1/4 x 1/2"npt)       | X-202-47     |              |             |             |
| 1    | Fitting, tee, pipe, 1/2 x 1/2 x 1/2 in. | X-203-13     |              |             |             |
| 1    | Pipe, 1/2 NPT x 3 in.                   | X-209-11     |              |             |             |
| 2    | Pipe, 1/2 NPT x 1.19 in.                | X-209-2      |              |             |             |
| 1    | Fitting, elbow, street 1/2 in.          | X-211-1      |              |             |             |
| 1    | Valve, drain (1/4 in. NPT)              | X-256-3      |              |             |             |
| 3    | Elbow, street (45 deg. x 1/2 in. NPT)   | X-274-13     |              |             |             |
| 1    | Elbow, street (45 deg. x 3/4 in. NPT)   | X-274-15     |              |             |             |
| 4    | Clamp, hose, .69/1.25 in.               | X-426-12     |              |             |             |
| 2    | Connector, hose                         | X-582-7      |              |             |             |
| 2    | Hose, coolant 40 in.                    | X-6367-7     |              |             |             |

# Cooling System Kits, continued

## Block Heater Kits: GM77395-KA1-GM77395-KA6

| Qty. | Description                           | Common Parts | Unique Parts |             |             |
|------|---------------------------------------|--------------|--------------|-------------|-------------|
|      |                                       |              | GM77395-KA1  | GM77395-KA2 | GM77395-KA3 |
| 1    | Block Heater (CSM Style)              |              | GM62498      | GM62499     | GM62500     |
| 1    | Block Heater replacement element      |              | GM62638      | GM62639     | GM62640     |
| 1    | Tag, hang                             | 279047       |              |             |             |
| 1    | Tag, instruction                      | 299896       |              |             |             |
| 4    | Vibromount                            | 328645       |              |             |             |
| 1    | Valve, shutoff (3/4-14 NPT)           | GM19666      |              |             |             |
| 2    | Valve, shutoff (1/2-14 NPT)           | GM19670      |              |             |             |
| 1    | Bracket, block heater                 | GM60615      |              |             |             |
| 1    | Bushing, reducing (3/4 x 1"npt)       | X-202-1      |              |             |             |
| 1    | Pipe, Nipple (3/4" npt x 2.00")       | X-206-2      |              |             |             |
| 1    | Cross, pipe (1" npt)                  | X-207-1      |              |             |             |
| 2    | Pipe (1/2"npt x 1.50")                | X-209-5      |              |             |             |
| 2    | Elbow, street (90 deg x 1/2"nptf)     | X-211-3      |              |             |             |
| 1    | Nipple, pipe, 1 x 1 1/2 in.           | X-218-24     |              |             |             |
| 2    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-10     |              |             |             |
| 1    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-13     |              |             |             |
| 1    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-2      |              |             |             |
| 4    | Stud, 5/15-18 x 1.5 in.               | X-352-65     |              |             |             |
| 6    | Clamp, hose, .69/1.25 in.             | X-426-12     |              |             |             |
| 3    | Connector, hose                       | X-582-15     |              |             |             |
| 2    | Connector, hose                       | X-582-7      |              |             |             |
| 1    | Connector, hose                       | X-582-8      |              |             |             |
| 1    | Hose, coolant                         | X-6367-15    |              |             |             |
| 1    | Hose, coolant 70"                     | X-6367-3     |              |             |             |
| 1    | Hose, coolant 40"                     | X-6367-7     |              |             |             |
| 1    | Plug, pipe (1" nptf)                  | X-75-13      |              |             |             |

| Qty. | Description                           | Common Parts | Unique Parts |             |             |
|------|---------------------------------------|--------------|--------------|-------------|-------------|
|      |                                       |              | GM77395-KA4  | GM77395-KA5 | GM77395-KA6 |
| 1    | Block Heater (CSM Style)              |              | GM62501      | GM62502     | GM62509     |
| 1    | Block Heater replacement element      |              | GM62641      | GM62642     | GM62649     |
| 1    | Tag, hang                             | 279047       |              |             |             |
| 1    | Tag, instruction                      | 299896       |              |             |             |
| 4    | Vibromount                            | 328645       |              |             |             |
| 1    | Valve, shutoff (3/4-14 NPT)           | GM19666      |              |             |             |
| 2    | Valve, shutoff (1/2-14 NPT)           | GM19670      |              |             |             |
| 1    | Bracket, block heater                 | GM60615      |              |             |             |
| 1    | Bushing, reducing (3/4 x 1"npt)       | X-202-1      |              |             |             |
| 1    | Pipe, Nipple (3/4" npt x 2.00")       | X-206-2      |              |             |             |
| 1    | Cross, pipe (1" npt)                  | X-207-1      |              |             |             |
| 2    | Pipe (1/2"npt x 1.50")                | X-209-5      |              |             |             |
| 2    | Elbow, street (90 deg x 1/2"nptf)     | X-211-3      |              |             |             |
| 1    | Nipple, pipe, 1 x 1 1/2 in.           | X-218-24     |              |             |             |
| 2    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-10     |              |             |             |
| 1    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-13     |              |             |             |
| 1    | Elbow, street (45 deg. x 3/4 in. NPT) | X-274-2      |              |             |             |
| 4    | Stud, 5/15-18 x 1.5 in.               | X-352-65     |              |             |             |
| 6    | Clamp, hose, .69/1.25 in.             | X-426-12     |              |             |             |
| 3    | Connector, hose                       | X-582-15     |              |             |             |
| 2    | Connector, hose                       | X-582-7      |              |             |             |
| 1    | Connector, hose                       | X-582-8      |              |             |             |
| 1    | Hose, coolant                         | X-6367-15    |              |             |             |
| 1    | Hose, coolant 70"                     | X-6367-3     |              |             |             |
| 1    | Hose, coolant 40"                     | X-6367-7     |              |             |             |
| 1    | Plug, pipe (1" nptf)                  | X-75-13      |              |             |             |

# Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

|           |  |          |  |                      |  |
|-----------|--|----------|--|----------------------|--|
| A, amp    | ampere   | CG       | center of gravity  | etc.                 | et cetera (and so forth)                             |
| ABDC      | after bottom dead center   | CID      | cubic inch displacement  | exh.                 | exhaust  |
| AC        | alternating current  | CL       | centerline   | ext.                 | external   |
| A/D       | analog to digital  | cm       | centimeter   | F                    | Fahrenheit, female                                   |
| ADC       | advanced digital control;<br>analog to digital converter                                   | CMOS     | complementary metal oxide<br>substrate (semiconductor)                               | fglass.              | fiberglass   |
| adj.      | adjust, adjustment   | cogen.   | cogeneration   | FHM                  | flat head machine (screw)                            |
| ADV       | advertising dimensional<br>drawing   | com      | communications (port)  | fl. oz.              | fluid ounce  |
| Ah        | amp-hour   | coml     | commercial   | flex.                | flexible   |
| AHWT      | anticipatory high water<br>temperature   | Coml/Rec | Commercial/Recreational  | freq.                | frequency  |
| AISI      | American Iron and Steel<br>Institute   | conn.    | connection   | FS                   | full scale   |
| ALOP      | anticipatory low oil pressure  | cont.    | continued  | ft.                  | foot, feet   |
| alt.      | alternator   | CPVC     | chlorinated polyvinyl chloride   | ft. lb.              | foot pounds (torque)                                 |
| Al        | aluminum   | crit.    | critical   | ft./min.             | feet per minute                                      |
| ANSI      | American National Standards<br>Institute (formerly American<br>Standards Association, ASA) | CRT      | cathode ray tube   | ftp                  | file transfer protocol                               |
| AO        | anticipatory only  | CSA      | Canadian Standards<br>Association  | g                    | gram   |
| APDC      | Air Pollution Control District   | CT       | current transformer  | ga.                  | gauge (meters, wire size)                            |
| API       | American Petroleum Institute   | Cu       | copper   | gal.                 | gallon   |
| approx.   | approximate, approximately   | cUL      | Canadian Underwriter's<br>Laboratories   | gen.                 | generator  |
| AR        | as required, as requested  | CUL      | Canadian Underwriter's<br>Laboratories   | genset               | generator set  |
| AS        | as supplied, as stated, as<br>suggested  | cu. in.  | cubic inch   | GFI                  | ground fault interrupter                             |
| ASE       | American Society of Engineers  | cw.      | clockwise  | GND, ⊕               | ground   |
| ASME      | American Society of<br>Mechanical Engineers  | CWC      | city water-cooled  | gov.                 | governor   |
| assy.     | assembly   | cyl.     | cylinder   | gph                  | gallons per hour                                     |
| ASTM      | American Society for Testing<br>Materials  | D/A      | digital to analog  | gpm                  | gallons per minute                                   |
| ATDC      | after top dead center  | DAC      | digital to analog converter  | gr.                  | grade, gross   |
| ATS       | automatic transfer switch  | dB       | decibel  | GRD                  | equipment ground                                     |
| auto.     | automatic  | dB(A)    | decibel (A weighted)   | gr. wt.              | gross weight   |
| aux.      | auxiliary  | DC       | direct current   | H x W x D            | height by width by depth                             |
| avg.      | average  | DCR      | direct current resistance  | HC                   | hex cap  |
| AVR       | automatic voltage regulator  | deg., °  | degree   | HCHT                 | high cylinder head temperature                       |
| AWG       | American Wire Gauge  | dept.    | department   | HD                   | heavy duty   |
| AWM       | appliance wiring material  | DFMEA    | Design Failure Mode and<br>Effects Analysis  | HET                  | high exhaust temp., high<br>engine temp.             |
| bat.      | battery  | dia.     | diameter   | hex                  | hexagon  |
| BBDC      | before bottom dead center  | DI/EO    | dual inlet/end outlet  | Hg                   | mercury (element)                                    |
| BC        | battery charger, battery<br>charging   | DIN      | Deutsches Institut fur Normung<br>e. V. (also Deutsche Industrie<br>Normenausschuss) | HH                   | hex head   |
| BCA       | battery charging alternator  | DIP      | dual inline package  | HHC                  | hex head cap   |
| BCI       | Battery Council International  | DPDT     | double-pole, double-throw  | HP                   | horsepower   |
| BDC       | before dead center   | DPST     | double-pole, single-throw  | hr.                  | hour   |
| BHP       | brake horsepower   | DS       | disconnect switch  | HS                   | heat shrink  |
| blk.      | black (paint color), block<br>(engine)   | DVR      | digital voltage regulator  | hsg.                 | housing  |
| blk. htr. | block heater   | E, emer. | emergency (power source)   | HWT                  | high water temperature                               |
| BMEP      | brake mean effective pressure  | ECM      | electronic control module,<br>engine control module                                  | Hz                   | hertz (cycles per second)                            |
| bps       | bits per second  | EFR      | emergency frequency relay  | IC                   | integrated circuit                                   |
| br.       | brass  | e.g.     | for example ( <i>exempli gratia</i> )  | ID                   | inside diameter, identification                      |
| BTDC      | before top dead center   | EG       | electronic governor  | IEC                  | International Electrotechnical<br>Commission         |
| Btu       | British thermal unit   | EGSA     | Electrical Generating Systems<br>Association   | IEEE                 | Institute of Electrical and<br>Electronics Engineers |
| Btu/min.  | British thermal units per minute   | EIA      | Electronic Industries<br>Association   | IMS                  | improved motor starting                              |
| C         | Celsius, centigrade  | EI/EO    | end inlet/end outlet   | in.                  | inch   |
| cal.      | calorie  | EMI      | electromagnetic interference   | in. H <sub>2</sub> O | inches of water                                      |
| CAN       | controller area network  | emiss.   | emission   | in. Hg               | inches of mercury                                    |
| CARB      | California Air Resources Board   | eng.     | engine   | in. lb.              | inch pounds  |
| CB        | circuit breaker  | EPA      | Environmental Protection<br>Agency   | Inc.                 | incorporated   |
| cc        | cubic centimeter   | EPS      | emergency power system   | ind.                 | industrial   |
| CCA       | cold cranking amps   | ER       | emergency relay  | int.                 | internal   |
| ccw.      | counterclockwise   | ES       | engineering special,<br>engineered special   | int./ext.            | internal/external                                    |
| CEC       | Canadian Electrical Code   | ESD      | electrostatic discharge  | I/O                  | input/output   |
| cert.     | certificate, certification, certified  | est.     | estimated  | IP                   | iron pipe  |
| cfh       | cubic feet per hour  | E-Stop   | emergency stop   | ISO                  | International Organization for<br>Standardization    |
| cfm       | cubic feet per minute  |          |  | J                    | joule  |
|           |  |          |  | JIS                  | Japanese Industry Standard                           |
|           |  |          |  | k                    | kilo (1000)  |
|           |  |          |  | K                    | kelvin   |
|           |  |          |  | kA                   | kiloampere   |
|           |  |          |  | KB                   | kilobyte (2 <sup>10</sup> bytes)                     |

|                      |  |           |   |         |  |
|----------------------|--|-----------|---|---------|--|
| KBus                 | Kohler communication protocol                        | MW        | megawatt  | rnd.    | round  |
| kg                   | kilogram   | mW        | milliwatt   | ROM     | read only memory   |
| kg/cm <sup>2</sup>   | kilograms per square centimeter                      | μF        | microfarad  | rot.    | rotate, rotating   |
| kgm                  | kilogram-meter                                       | N, norm.  | normal (power source)                               | rpm     | revolutions per minute   |
| kg/m <sup>3</sup>    | kilograms per cubic meter                            | NA        | not available, not applicable                       | RS      | right side   |
| kHz                  | kilohertz  | nat. gas  | natural gas   | RTU     | remote terminal unit   |
| kJ                   | kilojoule  | NBS       | National Bureau of Standards                        | RTV     | room temperature vulcanization   |
| km                   | kilometer  | NC        | normally closed                                     | RW      | read/write   |
| kOhm, kΩ             | kilo-ohm   | NEC       | National Electrical Code                            | SAE     | Society of Automotive Engineers  |
| kPa                  | kilopascal   | NEMA      | National Electrical Manufacturers Association       | scfm    | standard cubic feet per minute   |
| kph                  | kilometers per hour                                  | NFPA      | National Fire Protection Association                | SCR     | silicon controlled rectifier   |
| kV                   | kilovolt   | Nm        | newton meter  | s, sec. | second   |
| kVA                  | kilovolt ampere                                      | NO        | normally open                                       | SI      | <i>Systeme internationale d'unites</i> , International System of Units |
| kVAR                 | kilovolt ampere reactive                             | no., nos. | number, numbers                                     | SI/EO   | side in/end out  |
| kW                   | kilowatt   | NPS       | National Pipe, Straight                             | sil.    | silencer   |
| kWh                  | kilowatt-hour  | NPSC      | National Pipe, Straight-coupling                    | SN      | serial number  |
| kWm                  | kilowatt mechanical                                  | NPT       | National Standard taper pipe thread per general use | SNMP    | simple network management protocol                                     |
| kWth                 | kilowatt-thermal                                     | NPTF      | National Pipe, Taper-Fine                           | SPDT    | single-pole, double-throw  |
| L                    | liter  | NR        | not required, normal relay                          | SPST    | single-pole, single-throw  |
| LAN                  | local area network                                   | ns        | nanosecond  | spec    | specification  |
| L x W x H            | length by width by height                            | OC        | overcrank   | specs   | specification(s)   |
| lb.                  | pound, pounds  | OD        | outside diameter                                    | sq.     | square   |
| lbm/ft <sup>3</sup>  | pounds mass per cubic feet                           | OEM       | original equipment manufacturer                     | sq. cm  | square centimeter  |
| LCB                  | line circuit breaker                                 | OF        | overfrequency                                       | sq. in. | square inch  |
| LCD                  | liquid crystal display                               | opt.      | option, optional                                    | SS      | stainless steel  |
| ld. shd.             | load shed  | OS        | oversize, overspeed                                 | std.    | standard   |
| LED                  | light emitting diode                                 | OSHA      | Occupational Safety and Health Administration       | stl.    | steel  |
| Lph                  | liters per hour                                      | OV        | overvoltage   | tach.   | tachometer   |
| Lpm                  | liters per minute                                    | oz.       | ounce   | TD      | time delay   |
| LOP                  | low oil pressure                                     | p., pp.   | page, pages   | TDC     | top dead center  |
| LP                   | liquefied petroleum                                  | PC        | personal computer                                   | TDEC    | time delay engine cooldown   |
| LPG                  | liquefied petroleum gas                              | PCB       | printed circuit board                               | TDEN    | time delay emergency to normal   |
| LS                   | left side  | pF        | picofarad   | TDES    | time delay engine start  |
| L <sub>wa</sub>      | sound power level, A weighted                        | PF        | power factor  | TDNE    | time delay normal to emergency   |
| LWL                  | low water level                                      | ph., ∅    | phase   | TDOE    | time delay off to emergency  |
| LWT                  | low water temperature                                | PHC       | Phillips® head Crimptite® (screw)                   | TDON    | time delay off to normal   |
| m                    | meter, milli (1/1000)                                | PHH       | Phillips® hex head (screw)                          | temp.   | temperature  |
| M                    | mega (10 <sup>6</sup> when used with SI units), male | PHM       | pan head machine (screw)                            | term.   | terminal   |
| m <sup>3</sup>       | cubic meter  | PLC       | programmable logic control                          | THD     | total harmonic distortion  |
| m <sup>3</sup> /hr.  | cubic meters per hour                                | PMG       | permanent magnet generator                          | TIF     | telephone influence factor   |
| m <sup>3</sup> /min. | cubic meters per minute                              | pot       | potentiometer, potential                            | TIR     | total indicator reading  |
| mA                   | milliampere  | ppm       | parts per million                                   | tol.    | tolerance  |
| man.                 | manual   | PROM      | programmable read-only memory                       | turbo.  | turbocharger   |
| max.                 | maximum  | psi       | pounds per square inch                              | typ.    | typical (same in multiple locations)                                   |
| MB                   | megabyte (2 <sup>20</sup> bytes)                     | psig      | pounds per square inch gauge                        | UF      | underfrequency   |
| MCCB                 | molded-case circuit breaker                          | pt.       | pint  | UHF     | ultrahigh frequency  |
| MCM                  | one thousand circular mils                           | PTC       | positive temperature coefficient                    | UL      | Underwriter's Laboratories, Inc.                                       |
| meggar               | megohmmeter  | PTO       | power takeoff                                       | UNC     | unified coarse thread (was NC)   |
| MHz                  | megahertz  | PVC       | polyvinyl chloride                                  | UNF     | unified fine thread (was NF)   |
| mi.                  | mile   | qt.       | quart, quarts                                       | univ.   | universal  |
| mil                  | one one-thousandth of an inch                        | qty.      | quantity  | US      | undersize, underspeed  |
| min.                 | minimum, minute                                      | R         | replacement (emergency) power source                | UV      | ultraviolet, undervoltage  |
| misc.                | miscellaneous  | rad.      | radiator, radius                                    | V       | volt   |
| MJ                   | megajoule  | RAM       | random access memory                                | VAC     | volts alternating current  |
| mJ                   | millijoule   | RDO       | relay driver output                                 | VAR     | voltampere reactive  |
| mm                   | millimeter   | ref.      | reference   | VDC     | volts direct current   |
| mOhm, mΩ             | milliohm   | rem.      | remote  | VFD     | vacuum fluorescent display   |
| MOhm, MΩ             | megohm   | Res/Coml  | Residential/Commercial                              | VGA     | video graphics adapter   |
| MOV                  | metal oxide varistor                                 | RFI       | radio frequency interference                        | VHF     | very high frequency  |
| MPa                  | megapascal   | RH        | round head  | W       | watt   |
| mpg                  | miles per gallon                                     | RHM       | round head machine (screw)                          | WCR     | withstand and closing rating   |
| mph                  | miles per hour                                       | rly.      | relay   | w/      | with   |
| MS                   | military standard                                    | rms       | root mean square                                    | w/o     | without  |
| ms                   | millisecond  |           |   | wt.     | weight   |
| m/sec.               | meters per second                                    |           |   | xfrm    | transformer  |
| MTBF                 | mean time between failure                            |           |   |         |  |
| MTBO                 | mean time between overhauls                          |           |   |         |  |
| mtg.                 | mounting   |           |   |         |  |
| MTU                  | Motoren-und Turbinen-Union                           |           |   |         |  |

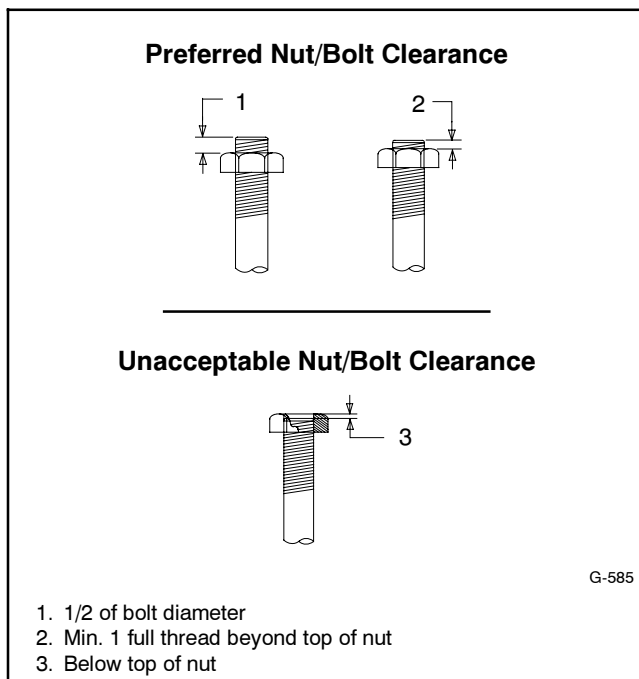
# Appendix B Common Hardware Application Guidelines

Use the information below and on the following pages to identify proper fastening techniques when no specific reference for reassembly is made.

**Bolt/Screw Length:** When bolt/screw length is not given, use Figure 1 as a guide. As a general rule, a minimum length of one thread beyond the nut and a maximum length of 1/2 the bolt/screw diameter beyond the nut is the preferred method.

**Washers and Nuts:** Use split lock washers as a bolt locking device where specified. Use SAE flat washers with whiz nuts, spirallock nuts, or standard nuts and preloading (torque) of the bolt in all other applications.

See Appendix C, General Torque Specifications, and other torque specifications in the service literature.



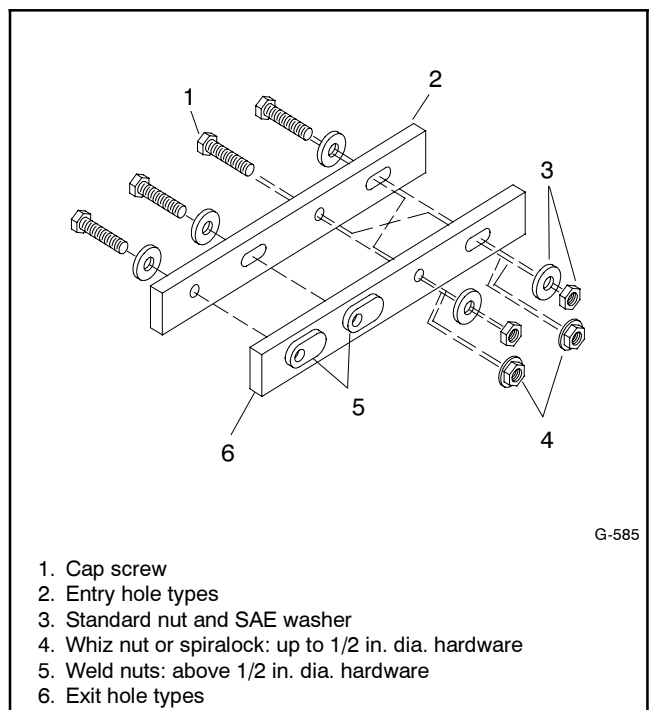
**Figure 1** Acceptable Bolt Lengths

Steps for common hardware application:

1. Determine entry hole type: round or slotted.
2. Determine exit hole type: fixed female thread (weld nut), round, or slotted.

For round and slotted exit holes, determine if hardware is greater than 1/2 inch in diameter, or 1/2 inch in diameter or less. Hardware that is *greater than 1/2 inch* in diameter takes a standard nut and SAE washer. Hardware *1/2 inch or less* in diameter can take a properly torqued whiz nut or spirallock nut. See Figure 2.

3. Follow these SAE washer rules after determining exit hole type:
  - a. Always use a washer between hardware and a slot.
  - b. Always use a washer under a nut (see 2 above for exception).
  - c. Use a washer under a bolt when the female thread is fixed (weld nut).
4. Refer to Figure 2, which depicts the preceding hardware configuration possibilities.



**Figure 2** Acceptable Hardware Combinations

# Appendix C General Torque Specifications















| American Standard Fasteners Torque Specifications |                    |                                   |             |              |                                      |
|---|--------------------|-----------------------------------|-------------|--------------|--------------------------------------|
| Size  | Torque Measurement | Assembled into Cast Iron or Steel |             |              | Assembled into Aluminum Grade 2 or 5 |
|   |                    | Grade 2                           | Grade 5     | Grade 8      |                                      |
| 8-32  | Nm (in. lb.)       | 1.8 (16)                          | 2.3 (20)    | —            | See Note 3                           |
| 10-24   | Nm (in. lb.)       | 2.9 (26)                          | 3.6 (32)    | —            |                                      |
| 10-32   | Nm (in. lb.)       | 2.9 (26)                          | 3.6 (32)    | —            |                                      |
| 1/4-20  | Nm (in. lb.)       | 6.8 (60)                          | 10.8 (96)   | 14.9 (132)   |                                      |
| 1/4-28  | Nm (in. lb.)       | 8.1 (72)                          | 12.2 (108)  | 16.3 (144)   |                                      |
| 5/16-18   | Nm (in. lb.)       | 13.6 (120)                        | 21.7 (192)  | 29.8 (264)   |                                      |
| 5/16-24   | Nm (in. lb.)       | 14.9 (132)                        | 23.1 (204)  | 32.5 (288)   |                                      |
| 3/8-16  | Nm (ft. lb.)       | 24.0 (18)                         | 38.0 (28)   | 53.0 (39)    |                                      |
| 3/8-24  | Nm (ft. lb.)       | 27.0 (20)                         | 42.0 (31)   | 60.0 (44)    |                                      |
| 7/16-14   | Nm (ft. lb.)       | 39.0 (29)                         | 60.0 (44)   | 85.0 (63)    |                                      |
| 7/16-20   | Nm (ft. lb.)       | 43.0 (32)                         | 68.0 (50)   | 95.0 (70)    |                                      |
| 1/2-13  | Nm (ft. lb.)       | 60.0 (44)                         | 92.0 (68)   | 130.0 (96)   |                                      |
| 1/2-20  | Nm (ft. lb.)       | 66.0 (49)                         | 103.0 (76)  | 146.0 (108)  |                                      |
| 9/16-12   | Nm (ft. lb.)       | 81.0 (60)                         | 133.0 (98)  | 187.0 (138)  |                                      |
| 9/16-18   | Nm (ft. lb.)       | 91.0 (67)                         | 148.0 (109) | 209.0 (154)  |                                      |
| 5/8-11  | Nm (ft. lb.)       | 113.0 (83)                        | 183.0 (135) | 259.0 (191)  |                                      |
| 5/8-18  | Nm (ft. lb.)       | 128.0 (94)                        | 208.0 (153) | 293.0 (216)  |                                      |
| 3/4-10  | Nm (ft. lb.)       | 199.0 (147)                       | 325.0 (240) | 458.0 (338)  |                                      |
| 3/4-16  | Nm (ft. lb.)       | 222.0 (164)                       | 363.0 (268) | 513.0 (378)  |                                      |
| 1-8   | Nm (ft. lb.)       | 259.0 (191)                       | 721.0 (532) | 1109.0 (818) |                                      |
| 1-12  | Nm (ft. lb.)       | 283.0 (209)                       | 789.0 (582) | 1214.0 (895) |                                      |












| Metric Fasteners Torque Specifications, Measured in Nm (ft. lb.) |                                   |             |             |  |
|--|-----------------------------------|-------------|-------------|--|
| Size (mm)  | Assembled into Cast Iron or Steel |             |             | Assembled into Aluminum Grade 5.8 or 8.8 |
|  | Grade 5.8                         | Grade 8.8   | Grade 10.9  |  |
| M6 x 1.00  | 6.2 (4.6)                         | 9.5 (7)     | 13.6 (10)   | See Note 3                               |
| M8 x 1.25  | 15.0 (11)                         | 23.0 (17)   | 33.0 (24)   |  |
| M8 x 1.00  | 16.0 (11)                         | 24.0 (18)   | 34.0 (25)   |  |
| M10 x 1.50   | 30.0 (22)                         | 45.0 (34)   | 65.0 (48)   |  |
| M10 x 1.25   | 31.0 (23)                         | 47.0 (35)   | 68.0 (50)   |  |
| M12 x 1.75   | 53.0 (39)                         | 80.0 (59)   | 115.0 (85)  |  |
| M12 x 1.50   | 56.0 (41)                         | 85.0 (63)   | 122.0 (90)  |  |
| M14 x 2.00   | 83.0 (61)                         | 126.0 (93)  | 180.0 (133) |  |
| M14 x 1.50   | 87.0 (64)                         | 133.0 (98)  | 190.0 (140) |  |
| M16 x 2.00   | 127.0 (94)                        | 194.0 (143) | 278.0 (205) |  |
| M16 x 1.50   | 132.0 (97)                        | 201.0 (148) | 287.0 (212) |  |
| M18 x 2.50   | 179.0 (132)                       | 273.0 (201) | 390.0 (288) |  |
| M18 x 1.50   | 189.0 (140)                       | 289.0 (213) | 413.0 (305) |  |

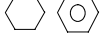




**Notes:**

1. The torque values above are general guidelines. Always use the torque values specified in the service manuals and/or assembly drawings when they differ from the above torque values.
2. The torque values above are based on new plated threads. Increase torque values by 15% if non-plated threads are used.
3. Hardware threaded into aluminum must have either two diameters of thread engagement or a 30% or more reduction in the torque to prevent stripped threads.
4. Torque values are calculated as equivalent stress loading on American hardware with an approximate preload of 90% of the yield strength and a friction coefficient of 0.125.

# Appendix D Common Hardware Identification

| Screw/Bolts/Studs                            |   |
|--|---|
| Head Styles                                  |   |
| Hex Head or Machine Head                     |    |
| Hex Head or Machine Head with Washer         |    |
| Flat Head (FHM)                              |    |
| Round Head (RHM)                             |    |
| Pan Head                                     |    |
| Hex Socket Head Cap or Allen™ Head Cap       |    |
| Hex Socket Head or Allen™ Head Shoulder Bolt |    |
| Sheet Metal Screw                            |    |
| Stud   |    |
| Drive Styles                                 |   |
| Hex  |    |
| Hex and Slotted                              |   |
| Phillips®                                    |  |
| Slotted                                      |  |
| Hex Socket                                   |  |

| Nuts                         |   |
|------------------------------|---|
| Nut Styles                   |   |
| Hex Head                     |    |
| Lock or Elastic              |    |
| Square                       |    |
| Cap or Acorn                 |    |
| Wing                         |    |
| Washers                      |   |
| Washer Styles                |   |
| Plain                        |    |
| Split Lock or Spring         |    |
| Spring or Wave               |    |
| External Tooth Lock          |    |
| Internal Tooth Lock          |   |
| Internal-External Tooth Lock |  |

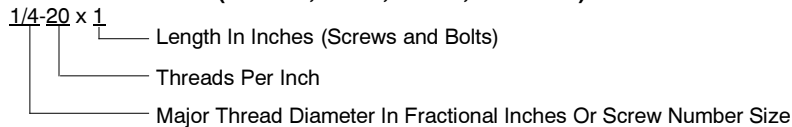
| Hardness Grades                       |   |
|---------------------------------------|---|
| American Standard                     |   |
| Grade 2                               |  |
| Grade 5                               |  |
| Grade 8                               |  |
| Grade 8/9 (Hex Socket Head)           |  |
| Metric                                |   |
| Number stamped on hardware; 5.8 shown |  |

Allen™ head screw is a trademark of Holo-Krome Co.

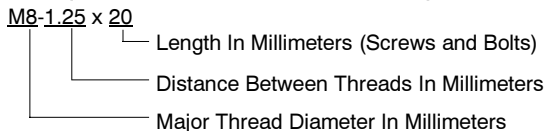
Phillips® screw is a registered trademark of Phillips Screw Company.

## Sample Dimensions

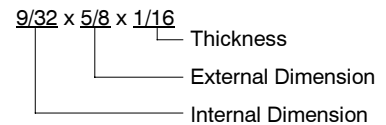
### American Standard (Screws, Bolts, Studs, and Nuts)



### Metric (Screws, Bolts, Studs, and Nuts)



### Plain Washers



### Lock Washers



# Appendix E Common Hardware List

The Common Hardware List lists part numbers and dimensions for common hardware items.

## American Standard

| Part No.                        | Dimensions     | Part No.  | Dimensions     | Part No.  | Dimensions | Type      |
|---------------------------------|----------------|-----------|----------------|-----------|------------|-----------|
| <b>Hex Head Bolts (Grade 5)</b> |                |           |                |           |            |           |
| X-465-17                        | 1/4-20 x .38   | X-6238-14 | 3/8-24 x .75   | X-6009-1  | 1-8        | Standard  |
| X-465-6                         | 1/4-20 x .50   | X-6238-16 | 3/8-24 x 1.25  | X-6210-3  | 6-32       | Whiz      |
| X-465-2                         | 1/4-20 x .62   | X-6238-21 | 3/8-24 x 4.00  | X-6210-4  | 8-32       | Whiz      |
| X-465-16                        | 1/4-20 x .75   | X-6238-22 | 3/8-24 x 4.50  | X-6210-5  | 10-24      | Whiz      |
| X-465-18                        | 1/4-20 x .88   |           |                | X-6210-1  | 10-32      | Whiz      |
| X-465-7                         | 1/4-20 x 1.00  | X-6024-5  | 7/16-14 x .75  |           |            |           |
| X-465-8                         | 1/4-20 x 1.25  | X-6024-2  | 7/16-14 x 1.00 | X-6210-2  | 1/4-20     | Spiralock |
| X-465-9                         | 1/4-20 x 1.50  | X-6024-8  | 7/16-14 x 1.25 | X-6210-6  | 1/4-28     | Spiralock |
| X-465-10                        | 1/4-20 x 1.75  | X-6024-3  | 7/16-14 x 1.50 | X-6210-7  | 5/16-18    | Spiralock |
| X-465-11                        | 1/4-20 x 2.00  | X-6024-4  | 7/16-14 x 2.00 | X-6210-8  | 5/16-24    | Spiralock |
| X-465-12                        | 1/4-20 x 2.25  | X-6024-11 | 7/16-14 x 2.75 | X-6210-9  | 3/8-16     | Spiralock |
| X-465-14                        | 1/4-20 x 2.75  | X-6024-12 | 7/16-14 x 6.50 | X-6210-10 | 3/8-24     | Spiralock |
| X-465-21                        | 1/4-20 x 5.00  | X-129-15  | 1/2-13 x .75   | X-6210-11 | 7/16-14    | Spiralock |
| X-465-25                        | 1/4-28 x .38   | X-129-17  | 1/2-13 x 1.00  | X-6210-12 | 1/2-13     | Spiralock |
| X-465-20                        | 1/4-28 x 1.00  | X-129-18  | 1/2-13 x 1.25  | X-6210-15 | 7/16-20    | Spiralock |
|                                 |                | X-129-19  | 1/2-13 x 1.50  | X-6210-14 | 1/2-20     | Spiralock |
| X-125-33                        | 5/16-18 x .50  | X-129-20  | 1/2-13 x 1.75  |           |            |           |
| X-125-23                        | 5/16-18 x .62  | X-129-21  | 1/2-13 x 2.00  | X-85-3    | 5/8-11     | Standard  |
| X-125-3                         | 5/16-18 x .75  | X-129-22  | 1/2-13 x 2.25  | X-88-12   | 3/4-10     | Standard  |
| X-125-31                        | 5/16-18 x .88  | X-129-23  | 1/2-13 x 2.50  | X-89-2    | 1/2-20     | Standard  |
| X-125-5                         | 5/16-18 x 1.00 | X-129-24  | 1/2-13 x 2.75  |           |            |           |
| X-125-24                        | 5/16-18 x 1.25 | X-129-25  | 1/2-13 x 3.00  |           |            |           |
| X-125-34                        | 5/16-18 x 1.50 | X-129-27  | 1/2-13 x 3.50  |           |            |           |
| X-125-25                        | 5/16-18 x 1.75 | X-129-29  | 1/2-13 x 4.00  |           |            |           |
| X-125-26                        | 5/16-18 x 2.00 | X-129-30  | 1/2-13 x 4.50  |           |            |           |
| 230578                          | 5/16-18 x 2.25 | X-463-9   | 1/2-13 x 5.50  |           |            |           |
| X-125-29                        | 5/16-18 x 2.50 | X-129-44  | 1/2-13 x 6.00  |           |            |           |
| X-125-27                        | 5/16-18 x 2.75 |           |                |           |            |           |
| X-125-28                        | 5/16-18 x 3.00 | X-129-51  | 1/2-20 x .75   |           |            |           |
| X-125-22                        | 5/16-18 x 4.50 | X-129-45  | 1/2-20 x 1.25  |           |            |           |
| X-125-32                        | 5/16-18 x 5.00 | X-129-52  | 1/2-20 x 1.50  |           |            |           |
| X-125-35                        | 5/16-18 x 5.50 |           |                |           |            |           |
| X-125-36                        | 5/16-18 x 6.00 | X-6021-3  | 5/8-11 x 1.00  |           |            |           |
| X-125-40                        | 5/16-18 x 6.50 | X-6021-4  | 5/8-11 x 1.25  |           |            |           |
|                                 |                | X-6021-2  | 5/8-11 x 1.50  |           |            |           |
| X-125-43                        | 5/16-24 x 1.75 | X-6021-1  | 5/8-11 x 1.75  |           |            |           |
| X-125-44                        | 5/16-24 x 2.50 | 273049    | 5/8-11 x 2.00  |           |            |           |
| X-125-30                        | 5/16-24 x .75  | X-6021-5  | 5/8-11 x 2.25  |           |            |           |
| X-125-39                        | 5/16-24 x 2.00 | X-6021-6  | 5/8-11 x 2.50  |           |            |           |
| X-125-38                        | 5/16-24 x 2.75 | X-6021-7  | 5/8-11 x 2.75  |           |            |           |
|                                 |                | X-6021-12 | 5/8-11 x 3.75  |           |            |           |
| X-6238-2                        | 3/8-16 x .62   | X-6021-11 | 5/8-11 x 4.50  |           |            |           |
| X-6238-10                       | 3/8-16 x .75   | X-6021-10 | 5/8-11 x 6.00  |           |            |           |
| X-6238-3                        | 3/8-16 x .88   |           |                |           |            |           |
| X-6238-11                       | 3/8-16 x 1.00  | X-6021-9  | 5/8-18 x 2.50  |           |            |           |
| X-6238-4                        | 3/8-16 x 1.25  |           |                |           |            |           |
| X-6238-5                        | 3/8-16 x 1.50  | X-6239-1  | 3/4-10 x 1.00  |           |            |           |
| X-6238-1                        | 3/8-16 x 1.75  | X-6239-8  | 3/4-10 x 1.25  |           |            |           |
| X-6238-6                        | 3/8-16 x 2.00  | X-6239-2  | 3/4-10 x 1.50  |           |            |           |
| X-6238-17                       | 3/8-16 x 2.25  | X-6239-3  | 3/4-10 x 2.00  |           |            |           |
| X-6238-7                        | 3/8-16 x 2.50  | X-6239-4  | 3/4-10 x 2.50  |           |            |           |
| X-6238-8                        | 3/8-16 x 2.75  | X-6239-5  | 3/4-10 x 3.00  |           |            |           |
| X-6238-9                        | 3/8-16 x 3.00  | X-6239-6  | 3/4-10 x 3.50  |           |            |           |
| X-6238-19                       | 3/8-16 x 3.25  |           |                |           |            |           |
| X-6238-12                       | 3/8-16 x 3.50  | X-792-1   | 1-8 x 2.25     |           |            |           |
| X-6238-20                       | 3/8-16 x 3.75  | X-792-5   | 1-8 x 3.00     |           |            |           |
| X-6238-13                       | 3/8-16 x 4.50  | X-792-8   | 1-8 x 5.00     |           |            |           |
| X-6238-18                       | 3/8-16 x 5.50  |           |                |           |            |           |
| X-6238-25                       | 3/8-16 x 6.50  |           |                |           |            |           |

| <b>Hex Nuts</b> |       |       |        |                |      |
|-----------------|-------|-------|--------|----------------|------|
| Part No.        | ID    | OD    | Thick. | Bolt/<br>Screw | Type |
| X-25-46         | .125  | .250  | .022   | #4             |      |
| X-25-9          | .156  | .375  | .049   | #6             |      |
| X-25-48         | .188  | .438  | .049   | #8             |      |
| X-25-36         | .219  | .500  | .049   | #10            |      |
| X-25-40         | .281  | .625  | .065   | 1/4            |      |
| X-25-85         | .344  | .687  | .065   | 5/16           |      |
| X-25-37         | .406  | .812  | .065   | 3/8            |      |
| X-25-34         | .469  | .922  | .065   | 7/16           |      |
| X-25-26         | .531  | 1.062 | .095   | 1/2            |      |
| X-25-15         | .656  | 1.312 | .095   | 5/8            |      |
| X-25-29         | .812  | 1.469 | .134   | 3/4            |      |
| X-25-127        | 1.062 | 2.000 | .134   | 1              |      |



## Metric

Hex head bolts are hardness grade 8.8 unless noted.

| Part No.  | Dimensions      | Part No. | Dimensions | Part No. | Dimensions |
|---|-----------------|----------|------------|----------|------------|
| <b>Hex Head Bolts (Partial Thread)</b>            |                 |          |            |          |            |
| M931-05055-60                                     | M5-0.80 x 55    |          |            |          |            |
| M931-06040-60                                     | M6-1.00 x 40    |          |            |          |            |
| M931-06055-60                                     | M6-1.00 x 55    |          |            |          |            |
| M931-06060-60                                     | M6-1.00 x 60    |          |            |          |            |
| M931-06060-SS                                     | M6-1.00 x 60    |          |            |          |            |
| M931-06070-60                                     | M6-1.00 x 70    |          |            |          |            |
| M931-06070-SS                                     | M6-1.00 x 70    |          |            |          |            |
| M931-06075-60                                     | M6-1.00 x 75    |          |            |          |            |
| M931-06090-60                                     | M6-1.00 x 90    |          |            |          |            |
| M931-06145-60                                     | M6-1.00 x 145   |          |            |          |            |
| M931-06150-60                                     | M6-1.00 x 150   |          |            |          |            |
| <b>Hex Head Bolts (Full Thread)</b>               |                 |          |            |          |            |
| M931-08035-60                                     | M8-1.25 x 35    |          |            |          |            |
| M931-08040-60                                     | M8-1.25 x 40    |          |            |          |            |
| M931-08045-60                                     | M8-1.25 x 45    |          |            |          |            |
| M931-08050-60                                     | M8-1.25 x 50    |          |            |          |            |
| M931-08055-60                                     | M8-1.25 x 55    |          |            |          |            |
| M931-08055-82                                     | M8-1.25 x 55*   |          |            |          |            |
| M931-08060-60                                     | M8-1.25 x 60    |          |            |          |            |
| M931-08070-60                                     | M8-1.25 x 70    |          |            |          |            |
| M931-08070-82                                     | M8-1.25 x 70*   |          |            |          |            |
| M931-08075-60                                     | M8-1.25 x 75    |          |            |          |            |
| M931-08080-60                                     | M8-1.25 x 80    |          |            |          |            |
| M931-08090-60                                     | M8-1.25 x 90    |          |            |          |            |
| M931-08095-60                                     | M8-1.25 x 95    |          |            |          |            |
| M931-08100-60                                     | M8-1.25 x 100   |          |            |          |            |
| M931-08110-60                                     | M8-1.25 x 110   |          |            |          |            |
| M931-08120-60                                     | M8-1.25 x 120   |          |            |          |            |
| M931-08130-60                                     | M8-1.25 x 130   |          |            |          |            |
| M931-08140-60                                     | M8-1.25 x 140   |          |            |          |            |
| M931-08150-60                                     | M8-1.25 x 150   |          |            |          |            |
| M931-08200-60                                     | M8-1.25 x 200   |          |            |          |            |
| M931-10040-82                                     | M10-1.25 x 40*  |          |            |          |            |
| M931-10040-60                                     | M10-1.50 x 40   |          |            |          |            |
| M931-10045-60                                     | M10-1.50 x 45   |          |            |          |            |
| M931-10050-60                                     | M10-1.50 x 50   |          |            |          |            |
| M931-10050-82                                     | M10-1.25 x 50*  |          |            |          |            |
| M931-10055-60                                     | M10-1.50 x 55   |          |            |          |            |
| M931-10060-60                                     | M10-1.50 x 60   |          |            |          |            |
| M931-10065-60                                     | M10-1.50 x 65   |          |            |          |            |
| M931-10070-60                                     | M10-1.50 x 70   |          |            |          |            |
| M931-10080-60                                     | M10-1.50 x 80   |          |            |          |            |
| M931-10080-82                                     | M10-1.25 x 80*  |          |            |          |            |
| M931-10090-60                                     | M10-1.50 x 90   |          |            |          |            |
| M931-10090-82                                     | M10-1.50 x 90*  |          |            |          |            |
| M931-10100-60                                     | M10-1.50 x 100  |          |            |          |            |
| M931-10110-60                                     | M10-1.50 x 110  |          |            |          |            |
| M931-10120-60                                     | M10-1.50 x 120  |          |            |          |            |
| M931-10130-60                                     | M10-1.50 x 130  |          |            |          |            |
| M931-10140-60                                     | M10-1.50 x 140  |          |            |          |            |
| M931-10180-60                                     | M10-1.50 x 180  |          |            |          |            |
| M931-10235-60                                     | M10-1.50 x 235  |          |            |          |            |
| M931-10260-60                                     | M10-1.50 x 260  |          |            |          |            |
| M960-10330-60                                     | M10-1.25 x 330  |          |            |          |            |
| M931-12045-60                                     | M12-1.75 x 45   |          |            |          |            |
| M960-12050-60                                     | M12-1.25 x 50   |          |            |          |            |
| M960-12050-82                                     | M12-1.25 x 50*  |          |            |          |            |
| M931-12050-60                                     | M12-1.75 x 50   |          |            |          |            |
| M931-12050-82                                     | M12-1.75 x 50*  |          |            |          |            |
| M931-12055-60                                     | M12-1.75 x 55   |          |            |          |            |
| M931-12060-60                                     | M12-1.75 x 60   |          |            |          |            |
| M931-12060-82                                     | M12-1.75 x 60*  |          |            |          |            |
| M931-12065-60                                     | M12-1.75 x 65   |          |            |          |            |
| M931-12075-60                                     | M12-1.75 x 75   |          |            |          |            |
| M931-12080-60                                     | M12-1.75 x 80   |          |            |          |            |
| M931-12090-60                                     | M12-1.75 x 90   |          |            |          |            |
| M931-12100-60                                     | M12-1.75 x 100  |          |            |          |            |
| M931-12110-60                                     | M12-1.75 x 110  |          |            |          |            |
| <b>Hex Head Bolts (Partial Thread), continued</b> |                 |          |            |          |            |
| M960-16090-60                                     | M16-1.50 x 90   |          |            |          |            |
| M931-16090-60                                     | M16-2.00 x 90   |          |            |          |            |
| M931-16100-60                                     | M16-2.00 x 100  |          |            |          |            |
| M931-16100-82                                     | M16-2.00 x 100* |          |            |          |            |
| M931-16120-60                                     | M16-2.00 x 120  |          |            |          |            |
| M931-16150-60                                     | M16-2.00 x 150  |          |            |          |            |
| M931-20065-60                                     | M20-2.50 x 65   |          |            |          |            |
| M931-20090-60                                     | M20-2.50 x 90   |          |            |          |            |
| M931-20100-60                                     | M20-2.50 x 100  |          |            |          |            |
| M931-20120-60                                     | M20-2.50 x 120  |          |            |          |            |
| M931-20140-60                                     | M20-2.50 x 140  |          |            |          |            |
| M931-20160-60                                     | M20-2.50 x 160  |          |            |          |            |
| M931-22090-60                                     | M22-2.50 x 90   |          |            |          |            |
| M931-22120-60                                     | M22-2.50 x 120  |          |            |          |            |
| M931-22160-60                                     | M22-2.50 x 160  |          |            |          |            |
| M931-24090-60                                     | M24-3.00 x 90   |          |            |          |            |
| M931-24120-60                                     | M24-3.00 x 120  |          |            |          |            |
| M931-24160-60                                     | M24-3.00 x 160  |          |            |          |            |
| M931-24200-60                                     | M24-3.00 x 200  |          |            |          |            |
| <b>Hex Head Bolts (Full Thread)</b>               |                 |          |            |          |            |
| M933-04006-60                                     | M4-0.70 x 6     |          |            |          |            |
| M933-05030-60                                     | M5-0.80 x 30    |          |            |          |            |
| M933-05035-60                                     | M5-0.80 x 35    |          |            |          |            |
| M933-05050-60                                     | M5-0.80 x 50    |          |            |          |            |
| M933-06010-60                                     | M6-1.00 x 10    |          |            |          |            |
| M933-06012-60                                     | M6-1.00 x 12    |          |            |          |            |
| M933-06014-60                                     | M6-1.00 x 14    |          |            |          |            |
| M933-06016-60                                     | M6-1.00 x 16    |          |            |          |            |
| M933-06020-60                                     | M6-1.00 x 20    |          |            |          |            |
| M933-06025-60                                     | M6-1.00 x 25    |          |            |          |            |
| M933-06030-60                                     | M6-1.00 x 30    |          |            |          |            |
| M933-06040-60                                     | M6-1.00 x 40    |          |            |          |            |
| M933-06050-60                                     | M6-1.00 x 50    |          |            |          |            |
| M933-07025-60                                     | M7-1.00 x 25    |          |            |          |            |
| M933-08010-60                                     | M8-1.25 x 10    |          |            |          |            |
| M933-08012-60                                     | M8-1.25 x 12    |          |            |          |            |
| M933-08016-60                                     | M8-1.25 x 16    |          |            |          |            |
| M933-08020-60                                     | M8-1.25 x 20    |          |            |          |            |
| M933-08025-60                                     | M8-1.25 x 25    |          |            |          |            |
| M933-08030-60                                     | M8-1.25 x 30    |          |            |          |            |
| M933-08030-82                                     | M8-1.25 x 30*   |          |            |          |            |
| M933-10012-60                                     | M10-1.50 x 12   |          |            |          |            |
| M961-10020-60                                     | M10-1.25 x 20   |          |            |          |            |
| M933-10020-60                                     | M10-1.50 x 20   |          |            |          |            |
| M933-10025-60                                     | M10-1.50 x 25   |          |            |          |            |
| M961-10025-60                                     | M10-1.25 x 25   |          |            |          |            |
| M933-10025-82                                     | M10-1.50 x 25*  |          |            |          |            |
| M961-10030-60                                     | M10-1.25 x 30   |          |            |          |            |
| M933-10030-60                                     | M10-1.50 x 30   |          |            |          |            |
| M933-10030-82                                     | M10-1.50 x 30*  |          |            |          |            |
| M961-10035-60                                     | M10-1.25 x 35   |          |            |          |            |
| M933-10035-60                                     | M10-1.50 x 35   |          |            |          |            |
| M933-10035-82                                     | M10-1.50 x 35*  |          |            |          |            |
| M961-10040-60                                     | M10-1.25 x 40   |          |            |          |            |
| <b>Hex Head Bolts (Full Thread), continued</b>    |                 |          |            |          |            |
| M933-12016-60                                     | M12-1.75 x 16   |          |            |          |            |
| M933-12020-60                                     | M12-1.75 x 20   |          |            |          |            |
| M961-12020-60F                                    | M12-1.50 x 20   |          |            |          |            |
| M933-12025-60                                     | M12-1.75 x 25   |          |            |          |            |
| M933-12025-82                                     | M12-1.75 x 25*  |          |            |          |            |
| M961-12030-60                                     | M12-1.25 x 30   |          |            |          |            |
| M933-12030-82                                     | M12-1.75 x 30*  |          |            |          |            |
| M961-12030-82F                                    | M12-1.50 x 30*  |          |            |          |            |
| M933-12030-60                                     | M12-1.75 x 30   |          |            |          |            |
| M933-12035-60                                     | M12-1.75 x 35   |          |            |          |            |
| M961-12040-82                                     | M12-1.25 x 40*  |          |            |          |            |
| M933-12040-60                                     | M12-1.75 x 40   |          |            |          |            |
| M933-12040-82                                     | M12-1.75 x 40*  |          |            |          |            |
| M961-14025-60                                     | M14-1.50 x 25   |          |            |          |            |
| M933-14025-60                                     | M14-2.00 x 25   |          |            |          |            |
| M961-14050-82                                     | M14-1.50 x 50*  |          |            |          |            |
| M961-16025-60                                     | M16-1.50 x 25   |          |            |          |            |
| M933-16025-60                                     | M16-2.00 x 25   |          |            |          |            |
| M961-16030-82                                     | M16-1.50 x 30*  |          |            |          |            |
| M933-16030-82                                     | M16-2.00 x 30*  |          |            |          |            |
| M933-16035-60                                     | M16-2.00 x 35   |          |            |          |            |
| M961-16040-60                                     | M16-1.50 x 40   |          |            |          |            |
| M933-16040-60                                     | M16-2.00 x 40   |          |            |          |            |
| M961-16045-82                                     | M16-1.50 x 45*  |          |            |          |            |
| M933-16045-82                                     | M16-2.00 x 45*  |          |            |          |            |
| M933-16050-60                                     | M16-2.00 x 50   |          |            |          |            |
| M933-16050-82                                     | M16-2.00 x 50*  |          |            |          |            |
| M933-16060-60                                     | M16-2.00 x 60   |          |            |          |            |
| M933-16070-60                                     | M16-2.00 x 70   |          |            |          |            |
| M933-18035-60                                     | M18-2.50 x 35   |          |            |          |            |
| M933-18050-60                                     | M18-2.50 x 50   |          |            |          |            |
| M933-18060-60                                     | M18-2.50 x 60   |          |            |          |            |
| M933-20050-60                                     | M20-2.50 x 50   |          |            |          |            |
| M933-20055-60                                     | M20-2.50 x 55   |          |            |          |            |
| M933-24060-60                                     | M24-3.00 x 60   |          |            |          |            |
| M933-24065-60                                     | M24-3.00 x 65   |          |            |          |            |
| M933-24070-60                                     | M24-3.00 x 70   |          |            |          |            |
| <b>Pan Head Machine Screws</b>                    |                 |          |            |          |            |
| M7985A-03010-20                                   | M3-0.50 x 10    |          |            |          |            |
| M7985A-03012-20                                   | M3-0.50 x 12    |          |            |          |            |
| M7985A-04010-20                                   | M4-0.70 x 10    |          |            |          |            |
| M7985A-04016-20                                   | M4-0.70 x 16    |          |            |          |            |
| M7985A-04020-20                                   | M4-0.70 x 20    |          |            |          |            |
| M7985A-04050-20                                   | M4-0.70 x 50    |          |            |          |            |
| M7985A-04100-20                                   | M4-0.70 x 100   |          |            |          |            |
| M7985A-05010-20                                   | M5-0.80 x 10    |          |            |          |            |
| M7985A-05012-20                                   | M5-0.80 x 12    |          |            |          |            |
| M7985A-05016-20                                   | M5-0.80 x 16    |          |            |          |            |
| M7985A-05020-20                                   | M5-0.80 x 20    |          |            |          |            |
| M7985A-05025-20                                   | M5-0.80 x 25    |          |            |          |            |
| M7985A-05030-20                                   | M5-0.80 x 30    |          |            |          |            |
| M7985A-05080-20                                   | M5-0.80 x 80    |          |            |          |            |
| M7985A-05100-20                                   | M5-0.80 x 100   |          |            |          |            |
| M7985A-06100-20                                   | M6-1.00 x 100   |          |            |          |            |
| <b>Flat Head Machine Screws</b>                   |                 |          |            |          |            |
| M965A-04012-SS                                    | M4-0.70 x 12    |          |            |          |            |
| M965A-05012-SS                                    | M5-0.80 x 12    |          |            |          |            |
| M965A-05016-20                                    | M5-0.80 x 16    |          |            |          |            |
| M965A-06012-20                                    | M6-1.00 x 12    |          |            |          |            |

\* This metric hex bolt's hardness is grade 10.9.

## Metric, continued

| Part No.        | Dimensions | Type         |
|-----------------|------------|--------------|
| <b>Hex Nuts</b> |            |              |
| M934-03-50      | M3-0.50    | Standard     |
| M934-04-50      | M4-0.70    | Standard     |
| M934-04-B       | M4-0.70    | Brass        |
| M934-05-50      | M5-0.80    | Standard     |
| M934-06-60      | M6-1.00    | Standard     |
| M934-06-64      | M6-1.00    | Std. (green) |
| M6923-06-80     | M6-1.00    | Spirallock   |
| M982-06-80      | M6-1.00    | Elastic Stop |
| M934-08-60      | M8-1.25    | Standard     |
| M6923-08-80     | M8-1.25    | Spirallock   |
| M982-08-80      | M8-1.25    | Elastic Stop |
| M934-10-60      | M10-1.50   | Standard     |
| M934-10-60F     | M10-1.25   | Standard     |
| M6923-10-80     | M10-1.50   | Spirallock   |
| M6923-10-62     | M10-1.50   | Spirallock†  |
| M982-10-80      | M10-1.50   | Elastic Stop |
| M934-12-60      | M12-1.75   | Standard     |
| M934-12-60F     | M12-1.25   | Standard     |
| M6923-12-80     | M12-1.75   | Spirallock   |
| M982-12-80      | M12-1.75   | Elastic Stop |
| M982-14-60      | M14-2.00   | Elastic Stop |
| M6923-16-80     | M16-2.00   | Spirallock   |
| M982-16-80      | M16-2.00   | Elastic Stop |
| M934-18-80      | M18-2.5    | Standard     |
| M982-18-60      | M18-2.50   | Elastic Stop |
| M934-20-80      | M20-2.50   | Standard     |
| M982-20-80      | M20-2.50   | Elastic Stop |
| M934-22-60      | M22-2.50   | Standard     |
| M934-24-80      | M24-3.00   | Standard     |
| M982-24-60      | M24-3.00   | Elastic Stop |
| M934-30-80      | M30-3.50   | Standard     |

## Washers

| Part No.    | ID   | OD   | Thick. | Bolt/<br>Screw |
|-------------|------|------|--------|----------------|
| M125A-03-80 | 3.2  | 7.0  | 0.5    | M3             |
| M125A-04-80 | 4.3  | 9.0  | 0.8    | M4             |
| M125A-05-80 | 5.3  | 10.0 | 1.0    | M5             |
| M125A-06-80 | 6.4  | 12.0 | 1.6    | M6             |
| M125A-08-80 | 8.4  | 16.0 | 1.6    | M8             |
| M125A-10-80 | 10.5 | 20.0 | 2.0    | M10            |
| M125A-12-80 | 13.0 | 24.0 | 2.5    | M12            |
| M125A-14-80 | 15.0 | 28.0 | 2.5    | M14            |
| M125A-16-80 | 17.0 | 30.0 | 3.0    | M16            |
| M125A-18-80 | 19.0 | 34.0 | 3.0    | M18            |
| M125A-20-80 | 21.0 | 37.0 | 3.0    | M20            |
| M125A-24-80 | 25.0 | 44.0 | 4.0    | M24            |

† This metric hex nut's hardness is grade 8.

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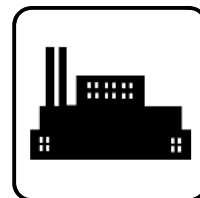
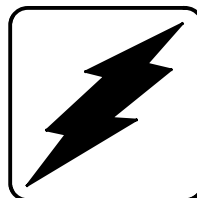
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# Service Parts

## Generator Set Controllers



Model:

# Decision-Maker<sup>®</sup> 550 Controller

Junction Box Panel-Mounted

**KOHLER**<sup>®</sup>  
POWER SYSTEMS

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**KOHLER**  
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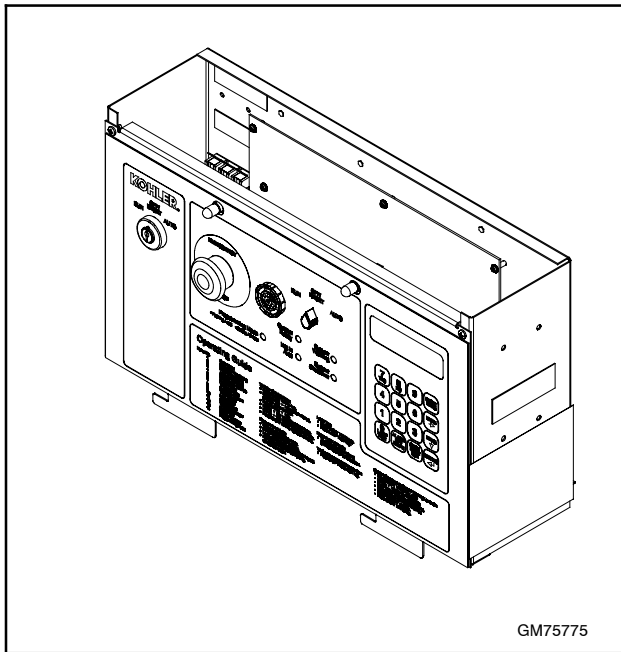
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# Section 1 Introduction

This manual lists service replacement parts for Decision-Maker® 550 controllers. See Figure 1 for controller identification.



**Figure 1** Decision-Maker® 550 Controller

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This manual includes the following main sections:

**Table of Contents.** Lists the sections of the manual.

**Introduction (and other information sections).** Contains introductory material about part numbers, illustrations, and hardware.

**Module Parts Lists.** Lists modules and their parts.

**Appendices.** Include Abbreviations, Common Hardware Application Guidelines, General Torque Specifications, Common Hardware Identification, and Common Hardware List.

**Index.** Lists part numbers and page number of modules listed in this manual.

## Numbering System Significance

This manual uses the following numbering systems:

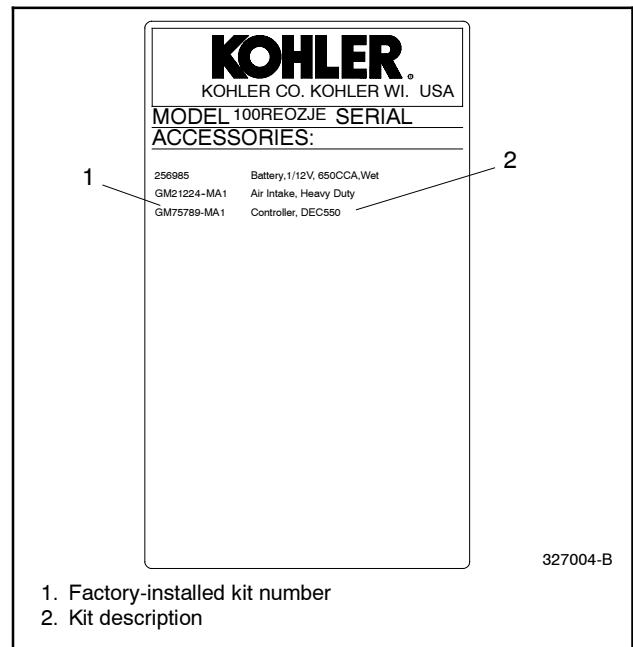
**Module Number.** A product identification number located on the generator set nameplate. Each module in this manual performs the same function with different parts lists. For example, a 12 volt controller and a 24 volt controller both perform the same function; however, with different parts. Each difference requires a module number.

**Part Number.** The part number identifies an individual assembly, subassembly, or component.

## How to Find Part Numbers

The controller module contains the controller assembly, controller mounting hardware, transformers, wiring harnesses, and other related parts. Follow the steps below to identify controller group service part numbers.

1. Locate the generator set nameplate listing accessories to **identify an optional installed controller module number**. On some models this nameplate is mounted inside the generator junction box. See Figure 2 for an example of the nameplate.
2. **Use the Index at the back of the manual** to locate the module identified in step 1.
3. **Find the part on the illustration** and note the item number of the part or **find the part description in the parts list**.



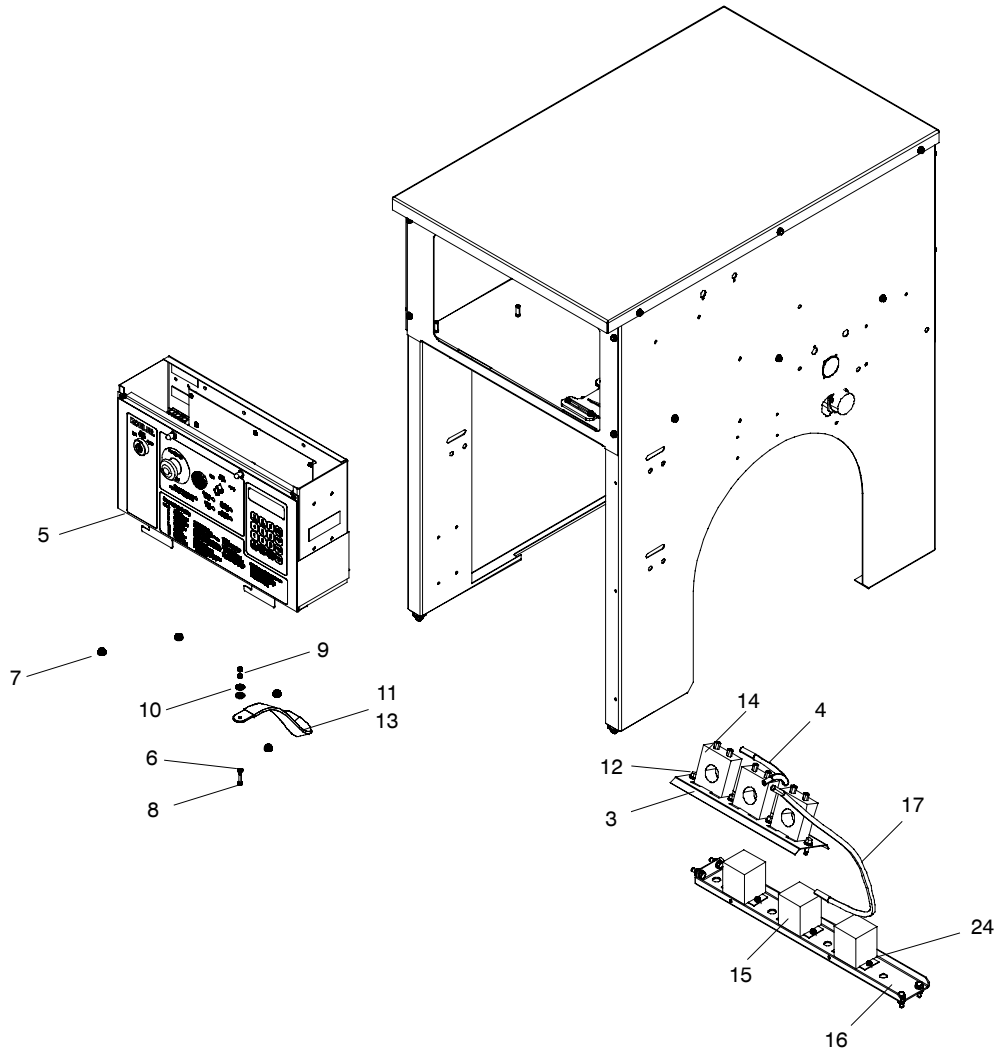
**Figure 2** Generator Accessory Nameplate

## Hardware References

Many common hardware items do not appear in parts manuals. Obtain common hardware locally or, if contacting the factory, use the Common Hardware List in the appendix to identify the common hardware part number and specifications. See Common Hardware Application Guidelines in the appendix for mating hardware instructions.

# Section 2: Controller Module Parts, 20-150 kW

4PX/4QX Alternators (GM77388-, GM77543-, GM80190-)



GM77388\_C

## Section 2: Controller Module Parts, 20-150 kW

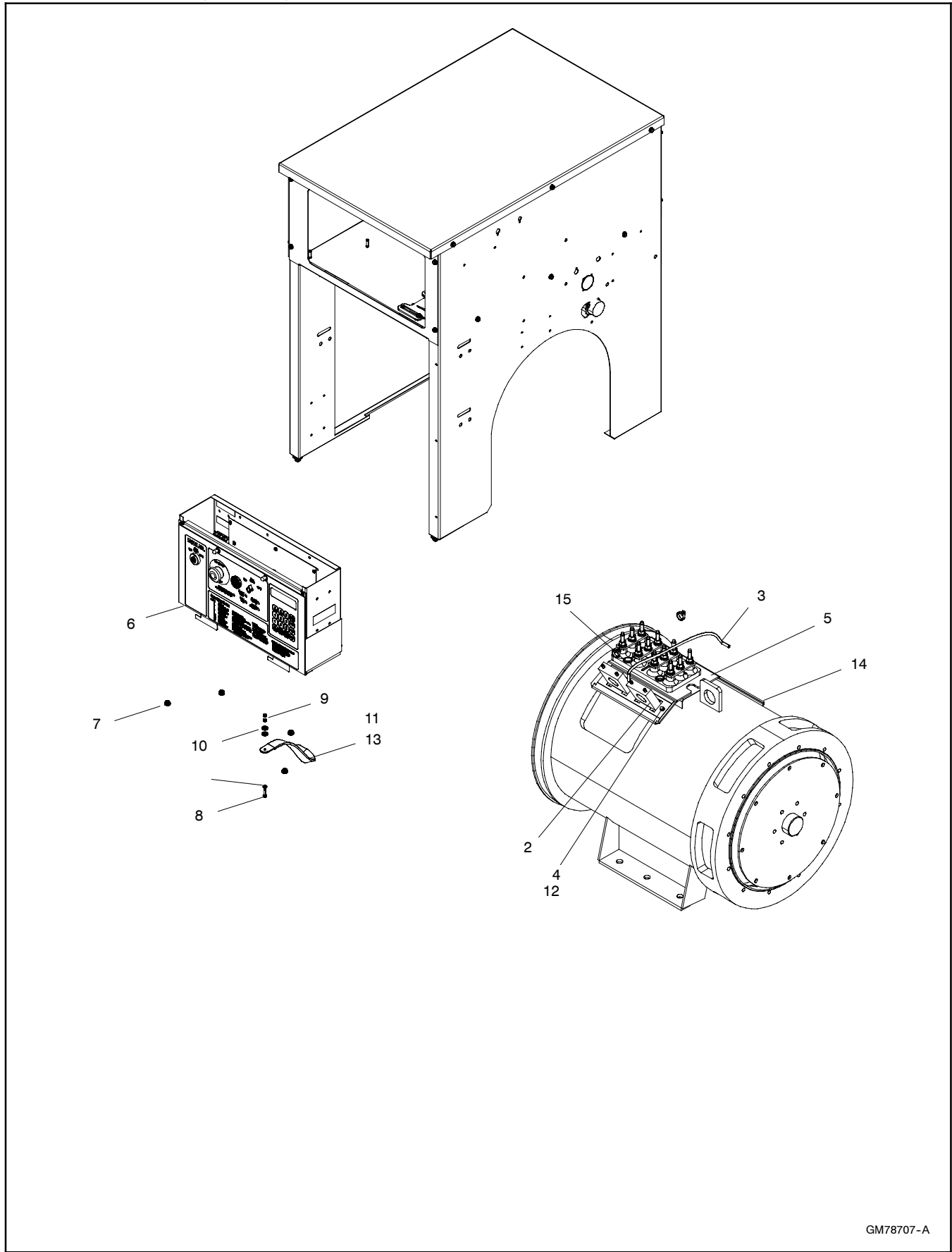
| Kit No.      | Part Number                       |                               |                                   |                                      |                                    |                               |                   |
|--------------|-----------------------------------|-------------------------------|-----------------------------------|--------------------------------------|------------------------------------|-------------------------------|-------------------|
|              | Item 3<br>Bracket, CT<br>mounting | Item 5<br>Controller<br>Assy. | Item 14<br>Current<br>Transformer | Item 15<br>Transformer,<br>Potential | Item 16<br>Bracket, PT<br>mounting | Item 17<br>Harness,<br>wiring | Item 24<br>Spacer |
| GM77388-MA1  | 276417                            | GM75775-3*                    | GM16248 (3)                       | 258990 (3)                           | GM58692                            | GM59009                       | X-400-145 (6)     |
| GM77388-MA2  | 276417                            | GM75775-3*                    | GM16249 (3)                       | 258990 (3)                           | GM58692                            | GM59009                       | X-400-145 (6)     |
| GM77388-MA3  | 276417                            | GM75775-3*                    | GM16251 (3)                       | -                                    | -                                  | -                             | -                 |
| GM77388-MA4  | 276417                            | GM75775-3*                    | GM16252 (2)                       | -                                    | -                                  | -                             | -                 |
| GM77388-MA5  | 276417                            | GM75775-3*                    | GM16252 (3)                       | -                                    | -                                  | -                             | -                 |
| GM77388-MA6  | 276417                            | GM75775-3*                    | GM16254 (2)                       | -                                    | -                                  | -                             | -                 |
| GM77388-MA7  | 276417                            | GM75775-3*                    | GM16254 (3)                       | -                                    | -                                  | -                             | -                 |
| GM77388-MA8  | 276417                            | GM75775-3*                    | GM16255 (2)                       | -                                    | -                                  | -                             | -                 |
| GM77388-MA9  | 276417                            | GM75775-3*                    | GM16255 (3)                       | -                                    | -                                  | -                             | -                 |
| GM77543-MA1  | 276417                            | GM75775-3*                    | GM16252 (3)                       | 258990 (3)                           | GM35175                            | GM59010                       | X-400-145 (6)     |
| GM77543-MA2  | 299966                            | GM75775-3*                    | GM16258 (2)                       | -                                    | -                                  | -                             | -                 |
| GM77543-MA3  | 276417                            | GM75775-3*                    | GM16257 (3)                       | -                                    | -                                  | -                             | -                 |
| GM77543-MA4  | 299966                            | GM75775-3*                    | GM16258 (3)                       | -                                    | -                                  | -                             | -                 |
| GM77543-MA5  | 299966                            | GM75775-3*                    | GM24898 (3)                       | -                                    | -                                  | -                             | -                 |
| GM77543-MA6  | 276417                            | GM75775-3*                    | GM16257 (2)                       | -                                    | -                                  | -                             | -                 |
| GM77543-MA7  | 299966                            | GM75775-3*                    | GM16259 (2)                       | -                                    | -                                  | -                             | -                 |
| GM80190-MA1  | 276417                            | GM75775-4*                    | GM16251 (3)                       | 258990 (3)                           | GM35175                            | GM59010                       | X-400-145 (6)     |
| GM80190-MA2  | 276417                            | GM75775-4*                    | GM16252 (3)                       | 258990 (3)                           | GM35175                            | GM59010                       | X-400-145 (6)     |
| GM80190-MA3  | 276417                            | GM75775-4*                    | GM16254 (3)                       | 258990 (3)                           | GM35175                            | GM59010                       | X-400-145 (6)     |
| GM80190-MA4  | 276417                            | GM75775-4*                    | GM16257 (2)                       | -                                    | -                                  | -                             | -                 |
| GM80190-MA5  | 299966                            | GM75775-4*                    | GM16258 (2)                       | -                                    | -                                  | -                             | -                 |
| GM80190-MA6  | 299966                            | GM75775-4*                    | GM16259 (2)                       | -                                    | -                                  | -                             | -                 |
| GM80190-MA7  | 276417                            | GM75775-4*                    | GM16257 (3)                       | -                                    | -                                  | -                             | -                 |
| GM80190-MA8  | 299966                            | GM75775-4*                    | GM16258 (3)                       | -                                    | -                                  | -                             | -                 |
| GM80190-MA9  | 299966                            | GM75775-4*                    | GM24898 (3)                       | -                                    | -                                  | -                             | -                 |
| GM80190-MA10 | 276417                            | GM75775-4*                    | GM16252 (3)                       | 258990 (3)                           | GM35175                            | GM59009                       | X-400-145 (6)     |

\* See Controller Assembly Parts on page 16 for parts list.

| Common Parts |                 |   |      |
|--------------|-----------------|---|------|
| Item         | Part Number     | Description   | Qty. |
| 4            | GM17424         | Harness, Wiring Current Transformer                     | 1    |
| 6            | M125A-04-80     | Washer, Plain   | 1    |
| 7            | M6923-06-80     | Nut, Hex 6mm  | 4    |
| 8            | M7985A-04020-20 | Screw, pan head machine                                 | 1    |
| 9            | M934-04-50      | Nut, Hex 4mm  | 2    |
| 10           | X-22-50         | Washer, lock, .20 ID x .595 in.OD                       | 2    |
| 11           | X-696-5         | Tubing, Vinyl   | 1    |
| 12           | X-794-1         | Screw, hex wshr hd, drill 1/4-14 x 5/8                  | 4    |
| 13           | X-6046-2        | Strap, ground (32 in.)                                  | 1    |
| -            | -               | Panel, Controller Face (See Generator Set Parts Manual) | 1    |
| -            | -               | Junction Box (See Generator Set Parts Manual)           | 1    |

# Section 3: Controller Module Parts, 180 kW

4M, 1 Phase Alternators (GM78707-)



GM78707-A

## Section 3: Controller Module Parts, 180 kW

|                | Part Number                      |                                   |
|----------------|----------------------------------|-----------------------------------|
|                | Item 2<br>Current<br>Transformer | Item 5<br>Bracket,<br>CT Mounting |
| <b>Kit No.</b> |                                  |                                   |
| GM78707-MA1    | GM16262 (2)                      | GM75520                           |

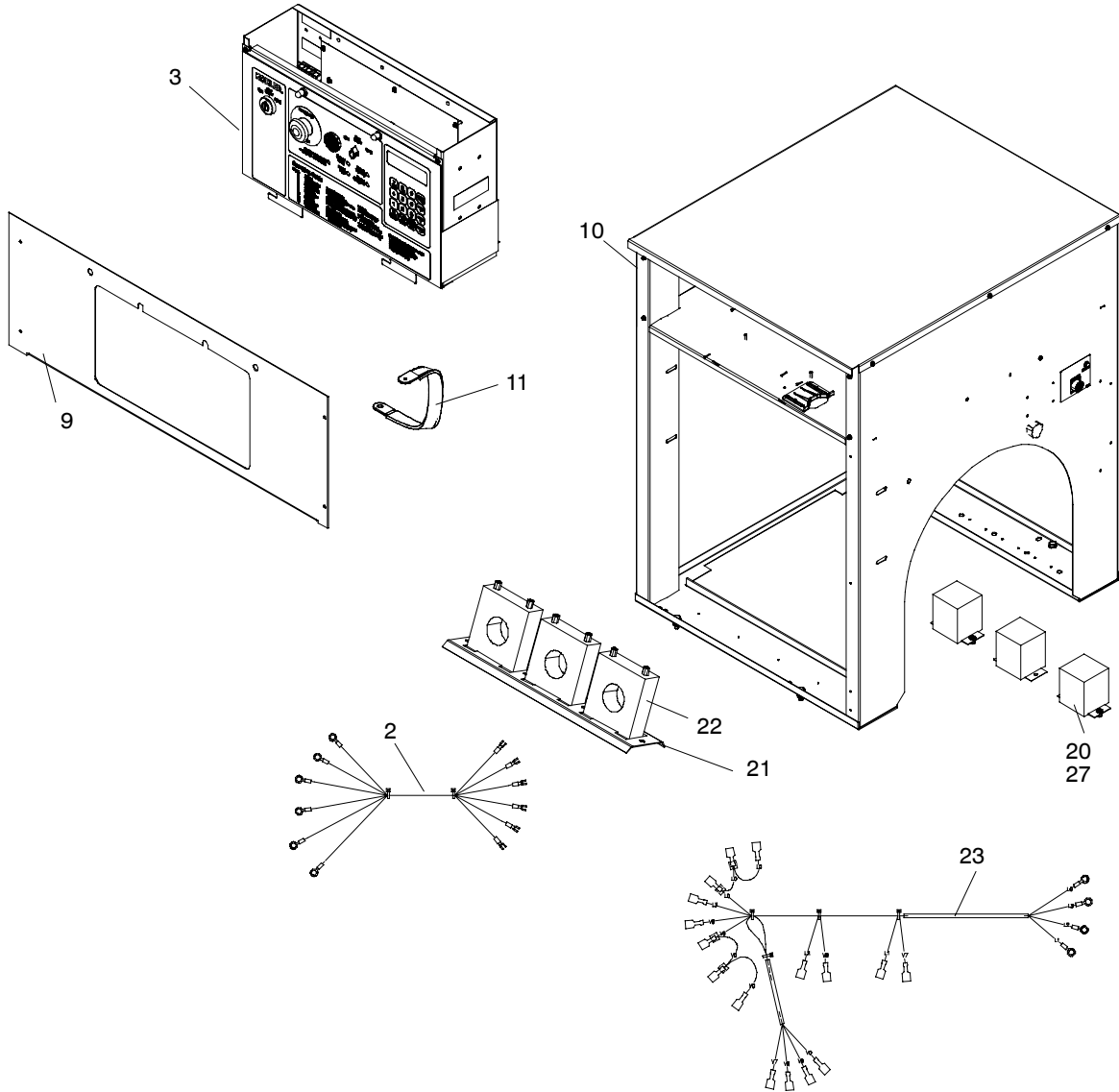
### Parts List

| Item | Part Number     | Description   | Qty. |
|------|-----------------|---|------|
| 3    | GM75506         | Harness, Wiring Current Transformer                     | 1    |
| 4    | GM75519         | Bracket, CT support                                     | 1    |
| 6    | GM75775-4*      | Controller Assy, Kohler DEC550,24V                      | 1    |
| 7    | M6923-06-80     | Nut, Hex 6mm  | 4    |
| 8    | M7985A-04020-20 | Screw, pan head machine                                 | 1    |
| 9    | M934-04-50      | Nut, Hex 4mm  | 2    |
| 10   | X-22-50         | Washer, lock, .20 ID x .595 in.OD                       | 2    |
| 11   | X-696-5         | Tubing, Vinyl   | 1    |
| 12   | X-794-1         | Screw, hex wshr hd, drill 1/4-14 x 5/8                  | 4    |
| 13   | X-6046-2        | Strap, ground (32 in.)                                  | 1    |
| 14   | X-6047-33       | Channel, U  | 1    |
| 15   | X-6238-4        | Bolt, hex cap   | 4    |
|      | -               | Panel, Controller Face (See Generator Set Parts Manual) | 1    |
|      | -               | Junction Box (See Generator Set Parts Manual)           | 1    |

\* See Controller Assembly Parts on page 16 for parts list.

# Section 4: Controller Module Parts, 230-300 kW

4UA Alternators GM75789-



GM75789\_D

## Section 4: Controller Module Parts, 230-300 kW

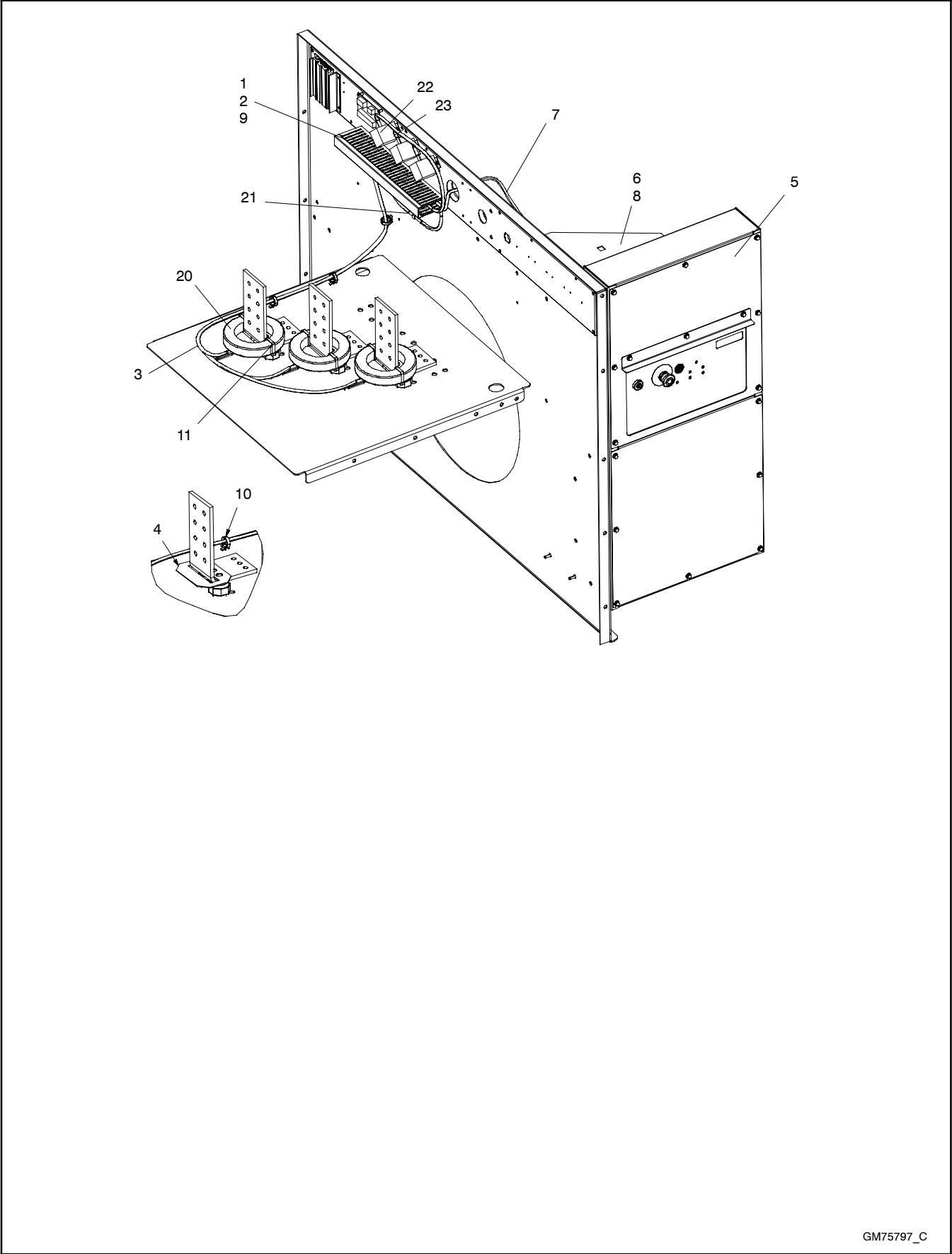
| Kit No.     | Part Number                          |                                    |                                   |                              |                   |
|-------------|--------------------------------------|------------------------------------|-----------------------------------|------------------------------|-------------------|
|             | Item 20<br>Transformer,<br>Potential | Item 21<br>Bracket, CT<br>Mounting | Item 22<br>Current<br>Transformer | Item 23<br>Wiring<br>Harness | Item 27<br>Spacer |
| GM75789-MA1 | 258990 (3)                           | 276417                             | GM16257 (3)                       | GM75860                      | X-400-145 (6)     |
| GM75789-MA2 | -                                    | 299966                             | GM24898 (3)                       | -                            | -                 |
| GM75789-MA3 | -                                    | 299966                             | GM66775 (3)                       | -                            | -                 |
| GM75789-MA4 | -                                    | 299966                             | GM24898 (2)                       | -                            | -                 |

| Common Parts |             |   |      |
|--------------|-------------|---|------|
| Item         | Part Number | Description   | Qty. |
| 2            | GM17424     | Harness, Wiring C.T., 230-300                           | 1    |
| 3            | GM75775-4   | Controller Assy., DEC550, 24V*                          | 1    |
| 9            | -           | Panel, Controller Face (See Generator Set Parts Manual) | 1    |
| 10           | -           | Junction Box (See Generator Set Parts Manual)           | 1    |
| 11           | X-6046-2    | Strap, ground (32 in.)                                  | 1    |

\* See Controller Assembly Parts on page 16 for parts list.

# Section 5: Controller Module Parts, 350-2250 kW

GM75797-



GM75797\_C



## Section 5: Controller Module Parts, 350-2250 kW

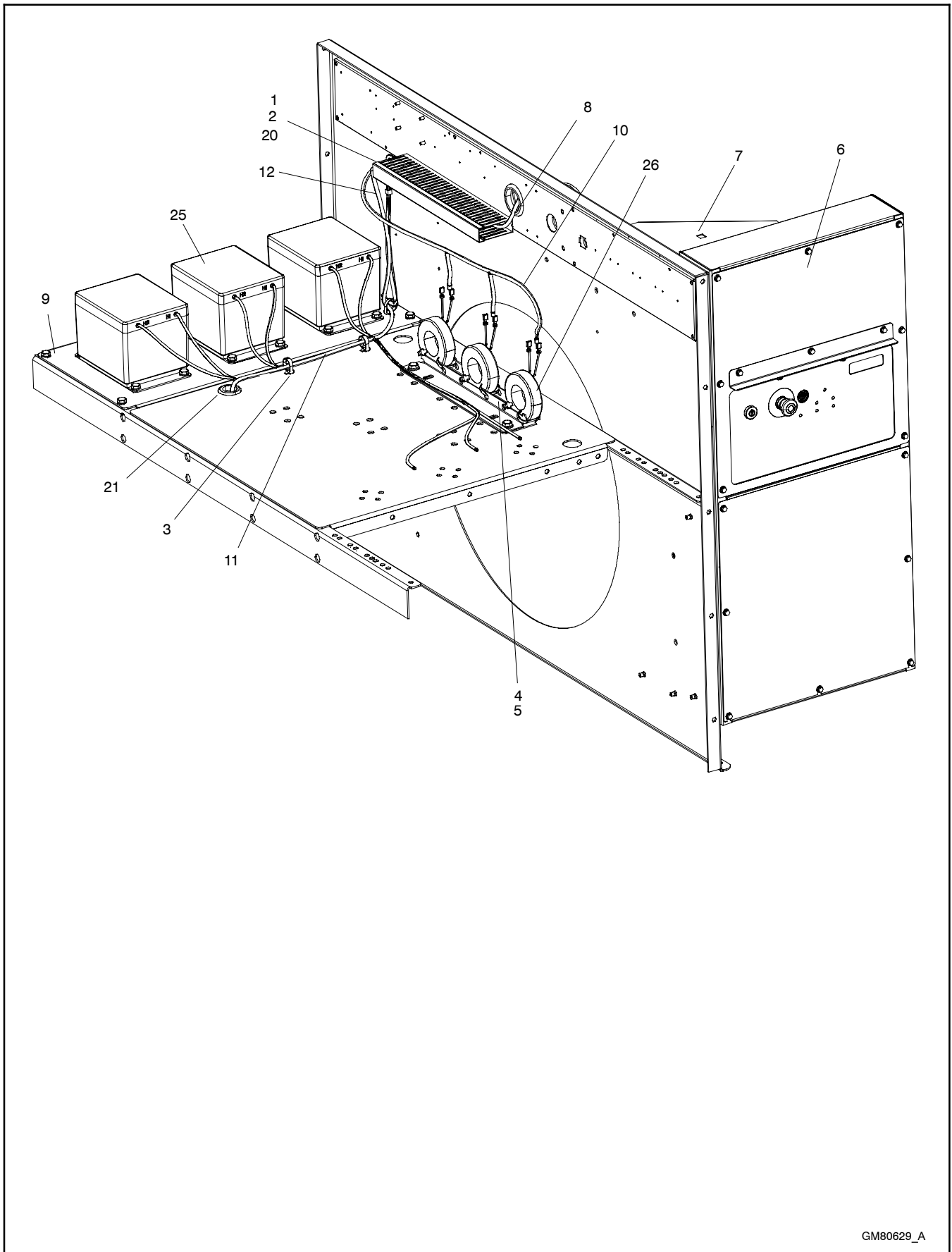
| Kit No.      | Part Number                       |                              |                                     |                  |
|--------------|-----------------------------------|------------------------------|-------------------------------------|------------------|
|              | Item 20<br>Current<br>Transformer | Item 21<br>Harness,<br>V-Tap | Item 22<br>Potential<br>Transformer | Item 23<br>Screw |
| GM75797-MA1  | GM16269                           | GM77974                      | 258990                              | X-67-59          |
| GM75797-MA2  | GM16260                           | GM77974                      | 258990                              | X-67-59          |
| GM75797-MA3  | GM16265                           | GM78060                      | -                                   | -                |
| GM75797-MA4  | GM16266                           | GM78060                      | -                                   | -                |
| GM75797-MA5  | GM16267                           | GM78060                      | -                                   | -                |
| GM75797-MA6  | GM16268                           | GM78060                      | -                                   | -                |
| GM75797-MA7  | GM30579                           | GM78060                      | -                                   | -                |
| GM75797-MA8  | GM16263                           | GM77974                      | 258990                              | X-67-59          |
| GM75797-MA9  | GM16265                           | GM77974                      | 258990                              | X-67-59          |
| GM75797-MA10 | GM16266                           | GM77974                      | 258990                              | X-67-59          |
| GM75797-MA11 | GM16260                           | GM77974                      | 276578                              | X-67-59          |
| GM75797-MA12 | GM16263                           | GM77974                      | 276578                              | X-67-59          |
| GM75797-MA13 | GM16265                           | GM77974                      | 276578                              | X-67-59          |
| GM75797-MA14 | GM16266                           | GM77974                      | 276578                              | X-67-59          |
| GM75797-MA15 | GM16267                           | GM77974                      | 276578                              | X-67-59          |
| GM75797-MA16 | GM16268                           | GM77974                      | 276578                              | X-67-59          |
| GM75797-MA17 | GM16267                           | GM77974                      | 258990                              | X-67-59          |

| Common Parts |                |   |      |
|--------------|----------------|---|------|
| Item         | Part Number    | Description                             | Qty. |
| 1            | 29758-01030    | Duct, Wire                              | 1.4  |
| 2            | 29759-00010    | Cover, Wire Duct                        | 1.4  |
| 3            | GM11501        | Harness, CT                             | 1    |
| 4            | GM75902        | Support, CT                             | 3    |
| 5            | GM76122-2*     | Controller Assy, DEC550                 | 1    |
| 6            | GM77907        | Brace, Pedestal                         | 2    |
| 7            | GM77972        | Harness, AC                             | 1    |
| 8            | M6921-06016-60 | Screw, Hex Flnge M6x16mm fly thrd js500 | 8    |
| 9            | X-67-59        | Screw, hex washer, thread-forming       | 2    |
| 10           | X-468-1        | Cable Tie                               | 3    |
| 11           | X-468-4        | Cable Tie                               | 6    |

\* See Controller Assembly Parts on page 18 for parts list.

# Section 6: Controller Module Parts, 1250-2250 kW, 3300/4160V

GM80629-



GM80629\_A

## Section 6: Controller Module Parts, 1250-2250 kW, 3300/4160V

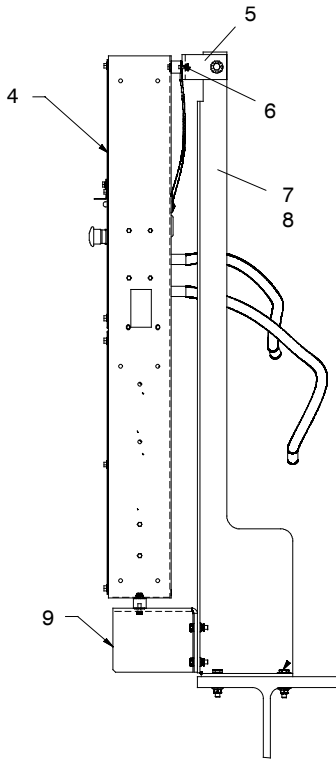
| Kit No.     | Part Number                       |
|-------------|-----------------------------------|
|             | Item 26<br>Current<br>transformer |
| GM80629-MA1 | GM17249                           |
| GM80629-MA2 | GM17250                           |
| GM80629-MA3 | GM60264                           |

| Common Parts |             |  |      |
|--------------|-------------|--|------|
| Item         | Part Number | Description                              | Qty. |
| 1            | 29758 01030 | Wiring Duct, Narrow Slot 1" x 3" White   | 1.4  |
| 2            | 29759 00010 | Wiring Duct Cover, 1" Wide White         | 1.4  |
| 3            | 361567      | Base, tie wrap snapin                    | 4    |
| 4            | 365620      | Bracket, CT Mounting                     | 1    |
| 5            | 365621      | Bracket, CT Mounting                     | 1    |
| 6            | GM76122-2*  | Controller Assy, Dec550 24V              | 1    |
| 7            | GM77907     | Bracket, Pedestal                        | 2    |
| 8            | GM77972     | Harness, A/C                             | 1    |
| 9            | GM78483     | Panel, PT                                | 1    |
| 10           | GM81342     | Harness, Wiring Current Transformer      | 1    |
| 11           | GM81343     | Harness,PT Wiring Medium Voltage Primary | 1    |
| 12           | GM81344     | Harness, PT Wiring Med Voltage Secondary | 1    |
| 20           | X-67-59     | Screw, hex washer, thread-forming        | 2    |
| 21           | X-284-2     | Grommet, round                           | 1    |
| 22           | X-431-52    | Terminal, fast-on, female, 14-16 AWG     | 6    |
| 25           | X-6121-55   | Transformer, 1905 V, 110 V               | 3    |

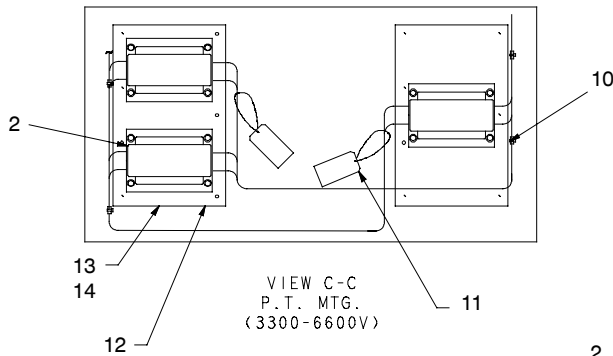
\* See Controller Assembly Parts on page 18 for parts list.

# Section 7: Controller Module Parts, 2500-3250 kW

Pedestal/Remote Mounted (GM81703-)

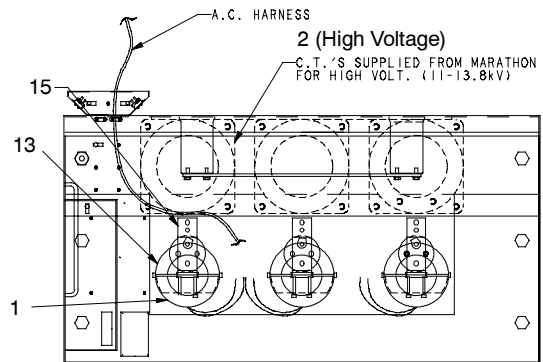


Skid Mounted Controller Shown

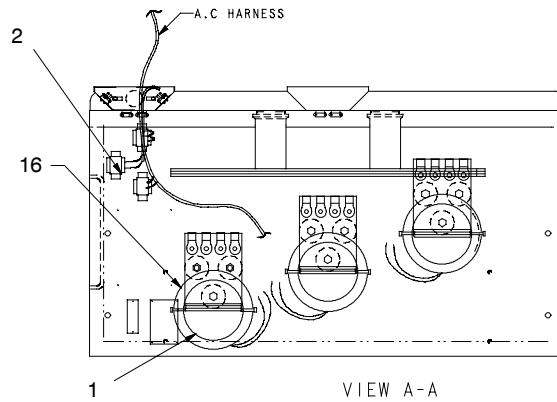


VIEW C-C  
P.T. MTG.  
(3300-6600V)

Items not shown: 3



VIEW B-B  
C.T. MTG.  
(3300-13.8kV)



VIEW A-A  
C.T. & P.T. MTG.  
(380-600V)

GM81703\_B

## Section 7: Controller Module Parts, 2500-3250 kW

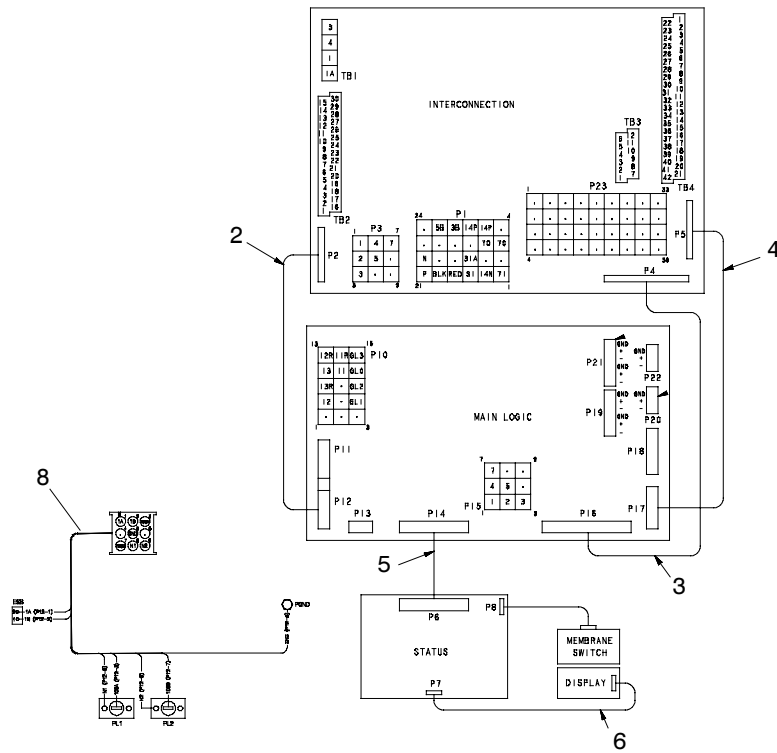
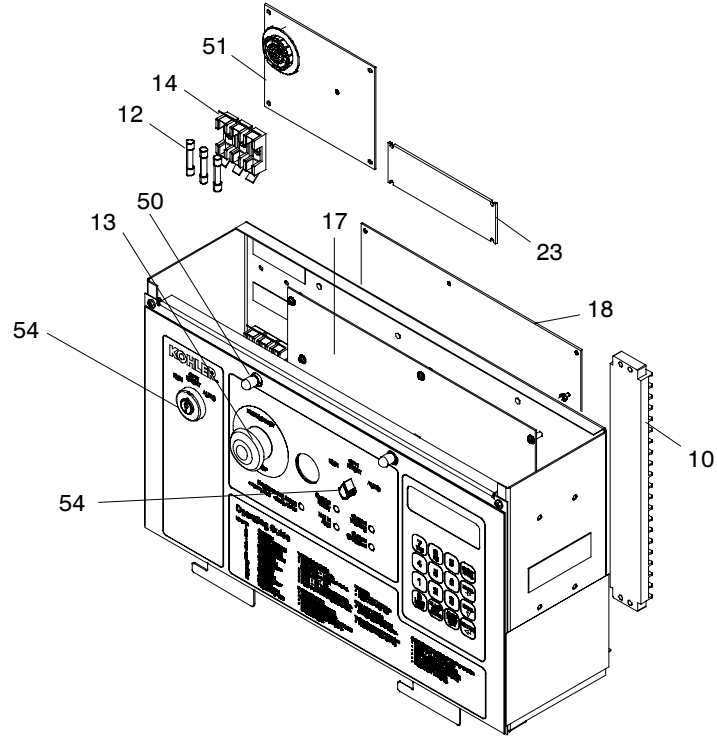
| Module       | Description                | Item/Part Number            |                               |                        |
|--------------|----------------------------|-----------------------------|-------------------------------|------------------------|
|              |                            | 1<br>Current<br>Transformer | 2<br>Potential<br>Transformer | 3<br>Remote<br>Harness |
| GM81703-MA1  | Skid mtd, 480 V            | GM40042                     | 276578                        | N/A                    |
| GM81703-MA2  | Skid mtd, 600 V            | GM40049                     | 258990                        | N/A                    |
| GM81703-MA3  | Skid mtd, 4160 V, 3300 V   | GM30104                     | X-6121-55                     | N/A                    |
| GM81703-MA4  | Skid mtd, 11-13.80 kV      | N/A                         | N/A                           | N/A                    |
| GM81703-MA5  | Skid mtd, 380 V            | GM47501                     | 276578                        | N/A                    |
| GM81703-MA6  | Skid mtd, 6600 V           | GM30580                     | X-6121-111                    | N/A                    |
| GM81703-MA7  | Remote mtd, 480 V          | GM40042                     | 276578                        | GM79929                |
| GM81703-MA8  | Remote mtd, 600 V          | GM40049                     | 258990                        | GM79929                |
| GM81703-MA9  | Remote mtd, 4160 V, 3300 V | GM30104                     | X-6121-55                     | GM79929                |
| GM81703-MA10 | Remote mtd, 11-13.80 kW    | N/A                         | N/A                           | GM79929                |
| GM81703-MA11 | Remote mtd, 380 V          | GM47501                     | 276578                        | GM79929                |
| GM81703-MA12 | Remote mtd, 6600 V         | GM30580                     | X-6121-111                    | GM79929                |
| GM81703-MA13 | Skid mtd, 480 V            | GM40041                     | 276578                        | N/A                    |
| GM81703-MA14 | Remote mtd, 480 V          | GM40041                     | 276578                        | GM79929                |

### Common Parts

| Item | Part Number | Description                             | Qty. |
|------|-------------|---|------|
| 4    | GM76122-2*  | Controller Assy, Dec550 24V             | 1    |
| 5    | GM81699     | Bracket, Controller Top                 | 1    |
| 6    | GM38784-2   | Vibromount, Controller                  | 4    |
| 7    | GM81697     | Bracket, Controller Mtg. LS             | 1    |
| 8    | GM81698     | Bracket, Controller Mtg. RS             | 1    |
| 9    | GM81700     | Bracket, Controller, Bottom             | 1    |
| 10   | GM40078     | Harness, PT Wiring Med. Voltage Primary | 1    |
| 11   | GM11913     | Tag, Instruction                        | 2    |
| 12   | X-400-228   | Spacer, .344 ID x .625 OD x 1.141 in.   | 6    |
| 13   | GM40028     | Plate, P.T. Mounting                    | 2    |
| 14   | 292834      | Vibromount                              | 8    |
| 15   | GM82002     | Bus, Load                               | 3    |
| 16   | GM40043     | Support, CT                             | 3    |

\* See Controller Assembly Parts on page 18 for parts list.

# Section 8: Controller Assembly Parts



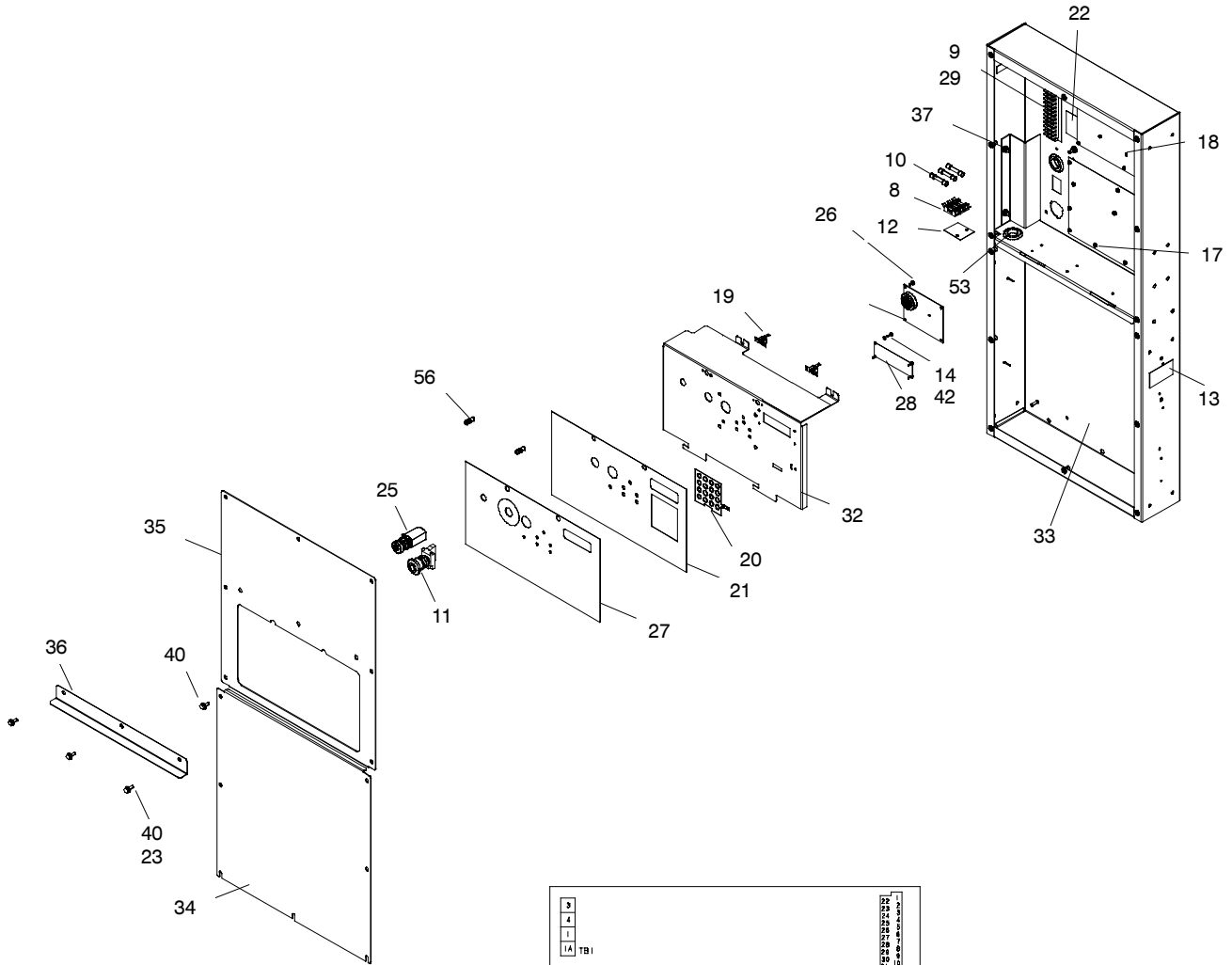
GM75775

## Section 8: Controller Assembly Parts

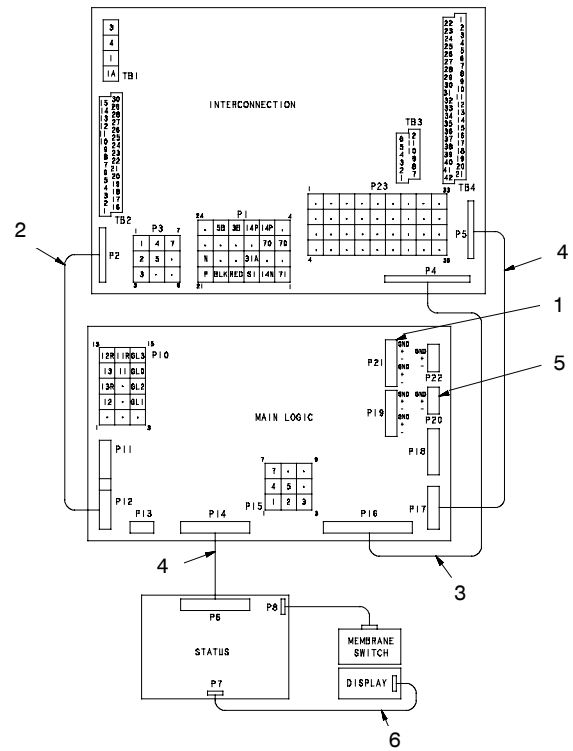
### Controller Part Numbers

| Item | Description   | Part Number                  |           |                           |           |
|------|---|------------------------------|-----------|---------------------------|-----------|
|      |   | Controller Without Keyswitch |           | Controller With Keyswitch |           |
|      |   | 12 V                         | 24 V      | 12 V                      | 24 V      |
| -    | Controller assembly   | GM75775-1                    | GM75775-2 | GM75775-3                 | GM75775-4 |
| 2    | Cable, ribbon, 24-position (P12 on main logic to P2 on interconnection) | GM10118                      | GM10118   | GM10118                   | GM10118   |
| 3    | Cable, ribbon, 40-position (P16 on main logic to P4 on interconnection) | GM10119                      | GM10119   | GM10119                   | GM10119   |
| 4    | Cable, ribbon, 34-position (P17 on main logic to P5 on interconnection) | GM10120                      | GM10120   | GM10120                   | GM10120   |
| 5    | Cable, ribbon, 34-position (display board to P14 on main logic board)   | GM10120                      | GM10120   | GM10120                   | GM10120   |
| 6    | Cable, ribbon, 16-position (CN1 on display panel to display board)      | GM10124                      | GM10124   | GM10124                   | GM10124   |
| 8    | Harness, cotroller front panel  | GM78717                      | GM78717   | GM78717                   | GM78717   |
| 10   | Terminal block  | 273769                       | 273769    | 273769                    | 273769    |
| 12   | Fuse, 1.5 A, 250 V (3)  | 291207                       | 291207    | 291207                    | 291207    |
| 13   | Switch, emergency stop pushbutton                                       | 292364                       | 292364    | 292364                    | 292364    |
| 14   | Holder, fuse  | 292821                       | 292821    | 292821                    | 292821    |
| 17   | Circuit board, main logic   | GM70535                      | GM70535   | GM70535                   | GM70535   |
| 18   | Circuit board, interconnection  | B-365487                     | B-365487  | B-365487                  | B-365487  |
| 23   | Panel, display (kit-service only)                                       | GM13616                      | GM13616   | GM13616                   | GM13616   |
| 50   | Lamp, panel (2)   | 255126                       | 283420    | 255126                    | 283420    |
| 51   | Circuit board, display (board with alarm horn)                          | A-365485                     | A-365485  | GM17398                   | GM17398   |
| 54   | Knob, rotary switch   | GM10125                      | GM10125   | -                         | -         |
| 54   | Switch, key   | -                            | -         | GM17397                   | GM17397   |

# Section 9: Controller Assembly Parts (Pedestal)



Items not shown: 38, 39, 41-51



GM76122\_E



## Section 9: Controller Assembly Parts (Pedestal)

| <b>Controller Part Numbers</b> |                 |   |      |
|--------------------------------|-----------------|---|------|
| Item                           | Part Number     | Description                                       | Qty. |
|                                | GM76122-1       | Controller Assy, Dec550 12V (includes items 1-57) | 1    |
|                                | GM76122-2       | Controller Assy, Dec550 24V (includes items 1-57) | 1    |
| 1                              | 294619          | Connector, plug, 6-position                       | 1    |
| 2                              | GM10118         | Cable, Ribbon, 24 Position, P2-P12                | 1    |
| 3                              | GM10119         | Cable, Ribbon, 40 Position, P4-P16                | 1    |
| 4                              | GM10120         | Cable, Ribbon, 34 Position, P5-P17                | 2    |
| 5                              | GM10124         | Cable, Ribbon, 16 Position, P7-Display            | 1    |
| 6                              | GM11496         | Connector, Plug, 3-Position                       | 1    |
| 8                              | 225179          | Strip, marker                                     | 1    |
| 9                              | 273769          | Terminal block                                    | 1    |
| 10                             | 291207          | Fuse, 1.5 A, 250 V                                | 3    |
| 11                             | 292364          | Switch, emergency stop pushbutton                 | 1    |
| 12                             | 292821          | Fuse holder                                       | 1    |
| 13                             | 294520          | Decal, danger, high voltage                       | 1    |
| 14                             | 322575          | Washer, fiber, .12 ID x .25in.OD                  | 4    |
| 17                             | B-361590        | PCB Assy, DEC550 Main Logic                       | 1    |
| 18                             | B-365487        | PCB Assy., DEC550 Interconnection                 | 1    |
| 19                             | GM10126         | Socket, Light                                     | 2    |
| 20                             | GM10188         | Switch, Membrane                                  | 1    |
| 21                             | GM10191         | Spacer, Membrane Switch                           | 1    |
| 22                             | GM10285         | Decal   | 1    |
| 23                             | GM11040-7       | Insert, Threaded (M6 x 1.0 Hex)                   | 3    |
| 25                             | GM17397         | Switch, Key Selector                              | 1    |
| 26                             | GM17398         | PCB Assy,DEC550 Display Board                     | 1    |
| 27                             | GM19822         | Decal, Decision-Maker 550                         | 1    |
| 28                             | GM41780         | Display, Vacuum Fluorescent                       | 1    |
| 29                             | GM75602         | Strip, Marker                                     | 1    |
| 32                             | GM76126         | Panel, Controller                                 | 1    |
| 33                             | GM81354         | Enclosure Assy.                                   | 1    |
| 34                             | GM76128         | Cover, Controller Bottom                          | 1    |
| 35                             | GM78102         | Cover, Controller Top                             | 1    |
| 36                             | GM76130         | Guard, Lamp                                       | 1    |
| 37                             | GM76194         | Cover, Wire                                       | 1    |
| 38                             | M125A-03-80     | Washer, Plain #3 Screw Size                       | 1    |
| 39                             | M125A-05-80     | Washer, Plain                                     | 1    |
| 40                             | M6921-06016-60  | Screw, Hex Flnge M6x16mm fly thrd js500           | 17   |
| 41                             | M6923-06-80     | Nut, Hex 6mm                                      | 11   |
| 42                             | M7985A-03012-20 | Screw, pan head M3 X 12                           | 15   |
| 44                             | M7985A-04010-20 | Screw, Pan Head Machined                          | 12   |
| 45                             | M7985A-04016-20 | Screw, Pan Head Machine                           | 5    |
| 46                             | M7985A-05020-20 | Screw, Pan Head Machine                           | 1    |
| 47                             | M934-03-50      | Nut, Hex 3mm                                      | 9    |
| 48                             | M934-05-50      | Nut, Hex 5mm                                      | 1    |
| 49                             | X-22-12         | Washer, lock, .262 ID x .743 in. OD               | 2    |
| 50                             | X-22-24         | Washer, lock, .119 ID x .263 in. OD               | 4    |
| 51                             | X-22-6          | Washer, lock, .146 ID x .285 in. OD               | 35   |
| 52                             | X-22-7          | Washer, lock, .172 ID x .333 in. OD               | 17   |
| 53                             | X-284-3         | Grommet, round                                    | 2    |
| 55                             | X-6046-12       | Strap, Ground                                     | 1    |
| 56                             | 255126          | Lamp, 14.4 V, 1.7 W (12V controller)              | 2    |
| 56                             | 283420          | Lamp, 28 V, 4.8 W (24V controller)                | 2    |

# Appendix A Abbreviations

The following list contains abbreviations that may appear in this publication.

|           |  |          |  |                      |  |
|-----------|--|----------|--|----------------------|--|
| A, amp    | ampere   | cfm      | cubic feet per minute  | est.                 | estimated  |
| ABDC      | after bottom dead center   | CG       | center of gravity  | E-Stop               | emergency stop                                       |
| AC        | alternating current  | CID      | cubic inch displacement  | etc.                 | et cetera (and so forth)                             |
| A/D       | analog to digital  | CL       | centerline   | exh.                 | exhaust  |
| ADC       | advanced digital control;<br>analog to digital converter                                   | cm       | centimeter   | ext.                 | external   |
| adj.      | adjust, adjustment   | CMOS     | complementary metal oxide<br>substrate (semiconductor)                               | F                    | Fahrenheit, female                                   |
| ADV       | advertising dimensional<br>drawing   | cogen.   | cogeneration   | fglass.              | fiberglass   |
| Ah        | amp-hour   | com      | communications (port)  | FHM                  | flat head machine (screw)                            |
| AHWT      | anticipatory high water<br>temperature   | coml     | commercial   | fl. oz.              | fluid ounce  |
| AISI      | American Iron and Steel<br>Institute   | Coml/Rec | Commercial/Recreational  | flex.                | flexible   |
| ALOP      | anticipatory low oil pressure  | conn.    | connection   | freq.                | frequency  |
| alt.      | alternator   | cont.    | continued  | FS                   | full scale   |
| Al        | aluminum   | CPVC     | chlorinated polyvinyl chloride   | ft.                  | foot, feet   |
| ANSI      | American National Standards<br>Institute (formerly American<br>Standards Association, ASA) | crit.    | critical   | ft. lb.              | foot pounds (torque)                                 |
| AO        | anticipatory only  | CRT      | cathode ray tube   | ft./min.             | feet per minute                                      |
| APDC      | Air Pollution Control District   | CSA      | Canadian Standards<br>Association  | ftp                  | file transfer protocol                               |
| API       | American Petroleum Institute   | CT       | current transformer  | g                    | gram   |
| approx.   | approximate, approximately   | Cu       | copper   | ga.                  | gauge (meters, wire size)                            |
| AQMD      | Air Quality Management District  | cUL      | Canadian Underwriter's<br>Laboratories   | gal.                 | gallon   |
| AR        | as required, as requested  | CUL      | Canadian Underwriter's<br>Laboratories   | gen.                 | generator  |
| AS        | as supplied, as stated, as<br>suggested  | cu. in.  | cubic inch   | genset               | generator set  |
| ASE       | American Society of Engineers  | cw.      | clockwise  | GFI                  | ground fault interrupter                             |
| ASME      | American Society of<br>Mechanical Engineers  | CWC      | city water-cooled  | GND, ⊕               | ground   |
| assy.     | assembly   | cyl.     | cylinder   | gov.                 | governor   |
| ASTM      | American Society for Testing<br>Materials  | D/A      | digital to analog  | gph                  | gallons per hour                                     |
| ATDC      | after top dead center  | DAC      | digital to analog converter  | gpm                  | gallons per minute                                   |
| ATS       | automatic transfer switch  | dB       | decibel  | gr.                  | grade, gross   |
| auto.     | automatic  | dB(A)    | decibel (A weighted)   | GRD                  | equipment ground                                     |
| aux.      | auxiliary  | DC       | direct current   | gr. wt.              | gross weight   |
| avg.      | average  | DCR      | direct current resistance  | H x W x D            | height by width by depth                             |
| AVR       | automatic voltage regulator  | deg., °  | degree   | HC                   | hex cap  |
| AWG       | American Wire Gauge  | dept.    | department   | HCHT                 | high cylinder head temperature                       |
| AWM       | appliance wiring material  | DFMEA    | Design Failure Mode and<br>Effects Analysis  | HD                   | heavy duty   |
| bat.      | battery  | dia.     | diameter   | HET                  | high exhaust temp., high<br>engine temp.             |
| BBDC      | before bottom dead center  | DI/EO    | dual inlet/end outlet  | hex                  | hexagon  |
| BC        | battery charger, battery<br>charging   | DIN      | Deutsches Institut für Normung<br>e. V. (also Deutsche Industrie<br>Normenausschuss) | Hg                   | mercury (element)                                    |
| BCA       | battery charging alternator  | DIP      | dual inline package  | HH                   | hex head   |
| BCI       | Battery Council International  | DPDT     | double-pole, double-throw  | HHC                  | hex head cap   |
| BDC       | before dead center   | DS       | disconnect switch  | HP                   | horsepower   |
| BHP       | brake horsepower   | DVR      | digital voltage regulator  | hr.                  | hour   |
| blk.      | black (paint color), block<br>(engine)   | E, emer. | emergency (power source)   | HS                   | heat shrink  |
| blk. htr. | block heater   | ECM      | electronic control module,<br>engine control module                                  | hsg.                 | housing  |
| BMEP      | brake mean effective pressure  | EDI      | electronic data interchange  | HVAC                 | heating, ventilation, and air<br>conditioning        |
| bps       | bits per second  | EFR      | emergency frequency relay  | HWT                  | high water temperature                               |
| br.       | brass  | e.g.     | for example ( <i>exempli gratia</i> )  | Hz                   | hertz (cycles per second)                            |
| BTDC      | before top dead center   | EG       | electronic governor  | IC                   | integrated circuit                                   |
| Btu       | British thermal unit   | EGSA     | Electrical Generating Systems<br>Association   | ID                   | inside diameter, identification                      |
| Btu/min.  | British thermal units per minute   | EIA      | Electronic Industries<br>Association   | IEC                  | International Electrotechnical<br>Commission         |
| C         | Celsius, centigrade  | EI/EO    | end inlet/end outlet   | IEEE                 | Institute of Electrical and<br>Electronics Engineers |
| cal.      | calorie  | EMI      | electromagnetic interference   | IMS                  | improved motor starting                              |
| CAN       | controller area network  | emiss.   | emission   | in.                  | inch   |
| CARB      | California Air Resources Board   | eng.     | engine   | in. H <sub>2</sub> O | inches of water                                      |
| CB        | circuit breaker  | EPA      | Environmental Protection<br>Agency   | in. Hg               | inches of mercury                                    |
| cc        | cubic centimeter   | ES       | emergency special,<br>engineered special   | in. lb.              | inch pounds  |
| CCA       | cold cranking amps   | ESD      | electrostatic discharge  | Inc.                 | incorporated   |
| ccw.      | counterclockwise   |          |  | ind.                 | industrial   |
| CEC       | Canadian Electrical Code   |          |  | int.                 | internal   |
| cert.     | certificate, certification, certified  |          |  | int./ext.            | internal/external                                    |
| cfh       | cubic feet per hour  |          |  | I/O                  | input/output   |
|           |  |          |  | IP                   | iron pipe  |
|           |  |          |  | ISO                  | International Organization for<br>Standardization    |
|           |  |          |  | J                    | joule  |
|           |  |          |  | JIS                  | Japanese Industry Standard                           |

|                      |  |           |   |         |   |
|----------------------|--|-----------|---|---------|---|
| k                    | kilo (1000)  | MW        | megawatt  | rnd.    | round   |
| K                    | kelvin   | mW        | milliwatt   | ROM     | read only memory  |
| kA                   | kiloampere   | μF        | microfarad  | rot.    | rotate, rotating  |
| KB                   | kilobyte (2 <sup>10</sup> bytes)                     | N, norm.  | normal (power source)                               | rpm     | revolutions per minute  |
| KBus                 | Kohler communication protocol                        | NA        | not available, not applicable                       | RS      | right side  |
| kg                   | kilogram   | nat. gas  | natural gas   | RTU     | remote terminal unit  |
| kg/cm <sup>2</sup>   | kilograms per square centimeter                      | NBS       | National Bureau of Standards                        | RTV     | room temperature vulcanization  |
| kgm                  | kilogram-meter                                       | NC        | normally closed                                     | RW      | read/write  |
| kg/m <sup>3</sup>    | kilograms per cubic meter                            | NEC       | National Electrical Code                            | SAE     | Society of Automotive Engineers                                       |
| kHz                  | kilohertz  | NEMA      | National Electrical Manufacturers Association       | scfm    | standard cubic feet per minute  |
| km                   | kilometer  | NFPA      | National Fire Protection Association                | SCR     | silicon controlled rectifier  |
| kOhm, kΩ             | kilo-ohm   | Nm        | newton meter  | s, sec. | second  |
| kPa                  | kilopascal   | NO        | normally open                                       | SI      | <i>Système international d'unités</i> , International System of Units |
| kph                  | kilometers per hour                                  | no., nos. | number, numbers                                     | SI/EO   | side in/end out   |
| kV                   | kilovolt   | NPS       | National Pipe, Straight                             | sil.    | silencer  |
| kVA                  | kilovolt ampere                                      | NPSC      | National Pipe, Straight-coupling                    | SN      | serial number   |
| kVAR                 | kilovolt ampere reactive                             | NPT       | National Standard taper pipe thread per general use | SNMP    | simple network management protocol                                    |
| kW                   | kilowatt   | NPTF      | National Pipe, Taper-Fine                           | SPDT    | single-pole, double-throw   |
| kWh                  | kilowatt-hour  | NR        | not required, normal relay                          | SPST    | single-pole, single-throw   |
| kWm                  | kilowatt mechanical                                  | ns        | nanosecond  | spec    | specification   |
| kWth                 | kilowatt-thermal                                     | OC        | overcrank   | specs   | specification(s)  |
| L                    | liter  | OD        | outside diameter                                    | sq.     | square  |
| LAN                  | local area network                                   | OEM       | original equipment manufacturer                     | sq. cm  | square centimeter   |
| L x W x H            | length by width by height                            | OF        | overfrequency                                       | sq. in. | square inch   |
| lb.                  | pound, pounds  | opt.      | option, optional                                    | SS      | stainless steel   |
| lbm/ft <sup>3</sup>  | pounds mass per cubic feet                           | OS        | oversize, overspeed                                 | std.    | standard  |
| LCB                  | line circuit breaker                                 | OSHA      | Occupational Safety and Health Administration       | stl.    | steel   |
| LCD                  | liquid crystal display                               | OV        | overvoltage   | tach.   | tachometer  |
| ld. shd.             | load shed  | oz.       | ounce   | TD      | time delay  |
| LED                  | light emitting diode                                 | p., pp.   | page, pages   | TDC     | top dead center   |
| Lph                  | liters per hour                                      | PC        | personal computer                                   | TDEC    | time delay engine cooldown  |
| Lpm                  | liters per minute                                    | PCB       | printed circuit board                               | TDEN    | time delay emergency to normal  |
| LOP                  | low oil pressure                                     | pF        | picofarad   | TDES    | time delay engine start   |
| LP                   | liquefied petroleum                                  | PF        | power factor  | TDNE    | time delay normal to emergency  |
| LPG                  | liquefied petroleum gas                              | ph., ∅    | phase   | TDOE    | time delay off to emergency   |
| LS                   | left side  | PHC       | Phillips® head Crimptite® (screw)                   | TDON    | time delay off to normal  |
| L <sub>wa</sub>      | sound power level, A weighted                        | PHH       | Phillips® hex head (screw)                          | temp.   | temperature   |
| LWL                  | low water level                                      | PHM       | pan head machine (screw)                            | term.   | terminal  |
| LWT                  | low water temperature                                | PLC       | programmable logic control                          | THD     | total harmonic distortion   |
| m                    | meter, milli (1/1000)                                | PMG       | permanent magnet generator                          | TIF     | telephone influence factor  |
| M                    | mega (10 <sup>6</sup> when used with SI units), male | pot       | potentiometer, potential                            | TIR     | total indicator reading   |
| m <sup>3</sup>       | cubic meter  | ppm       | parts per million                                   | tol.    | tolerance   |
| m <sup>3</sup> /hr.  | cubic meters per hour                                | PROM      | programmable read-only memory                       | turbo.  | turbocharger  |
| m <sup>3</sup> /min. | cubic meters per minute                              | psi       | pounds per square inch                              | typ.    | typical (same in multiple locations)                                  |
| mA                   | milliampere  | psig      | pounds per square inch gauge                        | UF      | underfrequency  |
| man.                 | manual   | pt.       | pint  | UHF     | ultrahigh frequency   |
| max.                 | maximum  | PTC       | positive temperature coefficient                    | UL      | Underwriter's Laboratories, Inc.                                      |
| MB                   | megabyte (2 <sup>20</sup> bytes)                     | PTO       | power takeoff                                       | UNC     | unified coarse thread (was NC)  |
| MCCB                 | molded-case circuit breaker                          | PVC       | polyvinyl chloride                                  | UNF     | unified fine thread (was NF)  |
| MCM                  | one thousand circular mils                           | qt.       | quart, quarts                                       | univ.   | universal   |
| meggar               | megohmmeter  | qty.      | quantity  | US      | undersize, underspeed   |
| MHz                  | megahertz  | R         | replacement (emergency) power source                | UV      | ultraviolet, undervoltage   |
| mi.                  | mile   | rad.      | radiator, radius                                    | V       | volt  |
| mil                  | one one-thousandth of an inch                        | RAM       | random access memory                                | VAC     | volts alternating current   |
| min.                 | minimum, minute                                      | RDO       | relay driver output                                 | VAR     | voltampere reactive   |
| misc.                | miscellaneous  | ref.      | reference   | VDC     | volts direct current  |
| MJ                   | megajoule  | rem.      | remote  | VFD     | vacuum fluorescent display  |
| mm                   | millimeter   | Res/Coml  | Residential/Commercial                              | VGA     | video graphics adapter  |
| mOhm, mΩ             | milliohm   | RFI       | radio frequency interference                        | VHF     | very high frequency   |
| MOhm, MΩ             | megohm   | RH        | round head  | W       | watt  |
| MPa                  | megapascal   | RHM       | round head machine (screw)                          | WCR     | withstand and closing rating  |
| mpg                  | miles per gallon                                     | rly.      | relay   | w/      | with  |
| mph                  | miles per hour                                       | rms       | root mean square                                    | w/o     | without   |
| MS                   | military standard                                    |           |   | wt.     | weight  |
| m/sec.               | meters per second                                    |           |   | xfrm    | transformer   |
| MTBF                 | mean time between failure                            |           |   |         |   |
| MTBO                 | mean time between overhauls                          |           |   |         |   |
| mtg.                 | mounting   |           |   |         |   |
| MTU                  | Motoren-und Turbinen-Union                           |           |   |         |   |

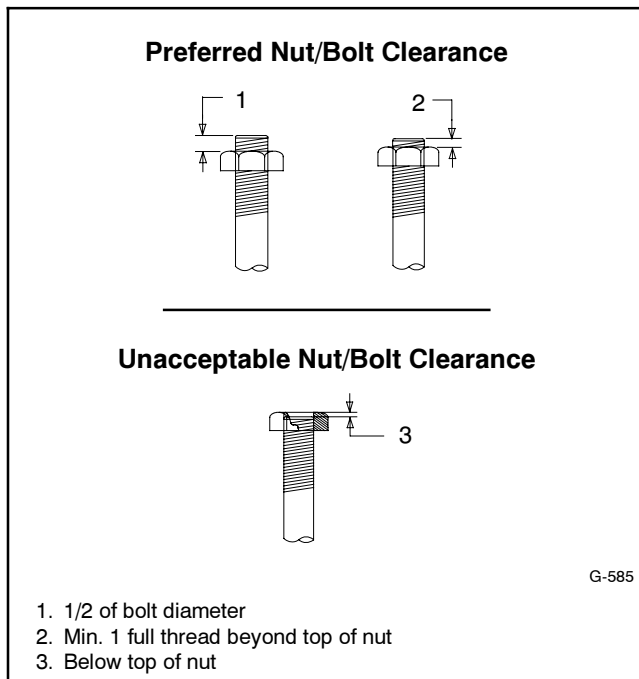
## Appendix B Common Hardware Application Guidelines

Use the information below and on the following pages to identify proper fastening techniques when no specific reference for reassembly is made.

**Bolt/Screw Length:** When bolt/screw length is not given, use Figure 1 as a guide. As a general rule, a minimum length of one thread beyond the nut and a maximum length of 1/2 the bolt/screw diameter beyond the nut is the preferred method.

**Washers and Nuts:** Use split lock washers as a bolt locking device where specified. Use SAE flat washers with whiz nuts, spirallock nuts, or standard nuts and preloading (torque) of the bolt in all other applications.

See Appendix C, General Torque Specifications, and other torque specifications in the service literature.



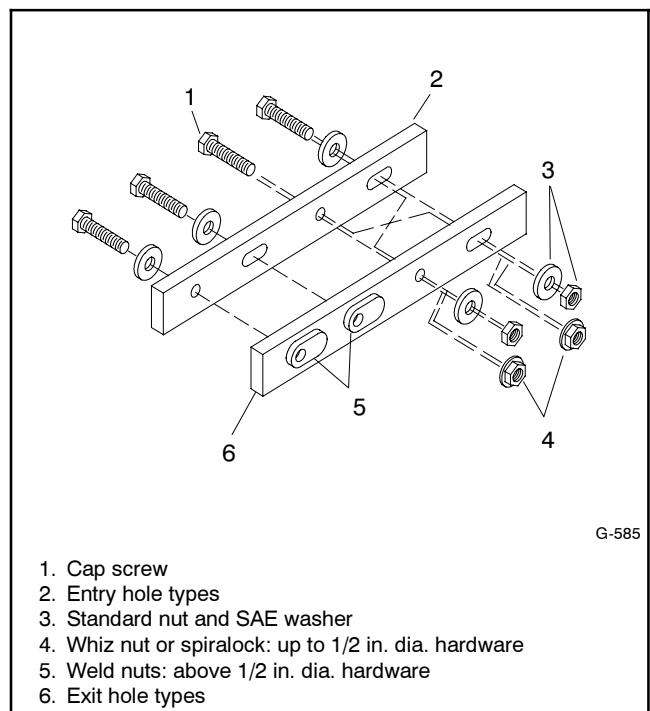
**Figure 1** Acceptable Bolt Lengths

Steps for common hardware application:

1. Determine entry hole type: round or slotted.
2. Determine exit hole type: fixed female thread (weld nut), round, or slotted.

For round and slotted exit holes, determine if hardware is greater than 1/2 inch in diameter, or 1/2 inch in diameter or less. Hardware that is *greater than 1/2 inch* in diameter takes a standard nut and SAE washer. Hardware *1/2 inch or less* in diameter can take a properly torqued whiz nut or spirallock nut. See Figure 2.

3. Follow these SAE washer rules after determining exit hole type:
  - a. Always use a washer between hardware and a slot.
  - b. Always use a washer under a nut (see 2 above for exception).
  - c. Use a washer under a bolt when the female thread is fixed (weld nut).
4. Refer to Figure 2, which depicts the preceding hardware configuration possibilities.



**Figure 2** Acceptable Hardware Combinations

# Appendix C General Torque Specifications















| American Standard Fasteners Torque Specifications |                    |                                   |             |              |                                      |
|---|--------------------|-----------------------------------|-------------|--------------|--------------------------------------|
| Size  | Torque Measurement | Assembled into Cast Iron or Steel |             |              | Assembled into Aluminum Grade 2 or 5 |
|   |                    | Grade 2                           | Grade 5     | Grade 8      |                                      |
| 8-32  | Nm (in. lb.)       | 1.8 (16)                          | 2.3 (20)    | —            | See Note 3                           |
| 10-24   | Nm (in. lb.)       | 2.9 (26)                          | 3.6 (32)    | —            |                                      |
| 10-32   | Nm (in. lb.)       | 2.9 (26)                          | 3.6 (32)    | —            |                                      |
| 1/4-20  | Nm (in. lb.)       | 6.8 (60)                          | 10.8 (96)   | 14.9 (132)   |                                      |
| 1/4-28  | Nm (in. lb.)       | 8.1 (72)                          | 12.2 (108)  | 16.3 (144)   |                                      |
| 5/16-18   | Nm (in. lb.)       | 13.6 (120)                        | 21.7 (192)  | 29.8 (264)   |                                      |
| 5/16-24   | Nm (in. lb.)       | 14.9 (132)                        | 23.1 (204)  | 32.5 (288)   |                                      |
| 3/8-16  | Nm (ft. lb.)       | 24.0 (18)                         | 38.0 (28)   | 53.0 (39)    |                                      |
| 3/8-24  | Nm (ft. lb.)       | 27.0 (20)                         | 42.0 (31)   | 60.0 (44)    |                                      |
| 7/16-14   | Nm (ft. lb.)       | 39.0 (29)                         | 60.0 (44)   | 85.0 (63)    |                                      |
| 7/16-20   | Nm (ft. lb.)       | 43.0 (32)                         | 68.0 (50)   | 95.0 (70)    |                                      |
| 1/2-13  | Nm (ft. lb.)       | 60.0 (44)                         | 92.0 (68)   | 130.0 (96)   |                                      |
| 1/2-20  | Nm (ft. lb.)       | 66.0 (49)                         | 103.0 (76)  | 146.0 (108)  |                                      |
| 9/16-12   | Nm (ft. lb.)       | 81.0 (60)                         | 133.0 (98)  | 187.0 (138)  |                                      |
| 9/16-18   | Nm (ft. lb.)       | 91.0 (67)                         | 148.0 (109) | 209.0 (154)  |                                      |
| 5/8-11  | Nm (ft. lb.)       | 113.0 (83)                        | 183.0 (135) | 259.0 (191)  |                                      |
| 5/8-18  | Nm (ft. lb.)       | 128.0 (94)                        | 208.0 (153) | 293.0 (216)  |                                      |
| 3/4-10  | Nm (ft. lb.)       | 199.0 (147)                       | 325.0 (240) | 458.0 (338)  |                                      |
| 3/4-16  | Nm (ft. lb.)       | 222.0 (164)                       | 363.0 (268) | 513.0 (378)  |                                      |
| 1-8   | Nm (ft. lb.)       | 259.0 (191)                       | 721.0 (532) | 1109.0 (818) |                                      |
| 1-12  | Nm (ft. lb.)       | 283.0 (209)                       | 789.0 (582) | 1214.0 (895) |                                      |












| Metric Fasteners Torque Specifications, Measured in Nm (ft. lb.) |                                   |             |             |  |
|--|-----------------------------------|-------------|-------------|--|
| Size (mm)  | Assembled into Cast Iron or Steel |             |             | Assembled into Aluminum Grade 5.8 or 8.8 |
|  | Grade 5.8                         | Grade 8.8   | Grade 10.9  |  |
| M6 x 1.00  | 6.2 (4.6)                         | 9.5 (7)     | 13.6 (10)   | See Note 3                               |
| M8 x 1.25  | 15.0 (11)                         | 23.0 (17)   | 33.0 (24)   |  |
| M8 x 1.00  | 16.0 (11)                         | 24.0 (18)   | 34.0 (25)   |  |
| M10 x 1.50   | 30.0 (22)                         | 45.0 (34)   | 65.0 (48)   |  |
| M10 x 1.25   | 31.0 (23)                         | 47.0 (35)   | 68.0 (50)   |  |
| M12 x 1.75   | 53.0 (39)                         | 80.0 (59)   | 115.0 (85)  |  |
| M12 x 1.50   | 56.0 (41)                         | 85.0 (63)   | 122.0 (90)  |  |
| M14 x 2.00   | 83.0 (61)                         | 126.0 (93)  | 180.0 (133) |  |
| M14 x 1.50   | 87.0 (64)                         | 133.0 (98)  | 190.0 (140) |  |
| M16 x 2.00   | 127.0 (94)                        | 194.0 (143) | 278.0 (205) |  |
| M16 x 1.50   | 132.0 (97)                        | 201.0 (148) | 287.0 (212) |  |
| M18 x 2.50   | 179.0 (132)                       | 273.0 (201) | 390.0 (288) |  |
| M18 x 1.50   | 189.0 (140)                       | 289.0 (213) | 413.0 (305) |  |

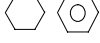




**Notes:**

1. The torque values above are general guidelines. Always use the torque values specified in the service manuals and/or assembly drawings when they differ from the above torque values.
2. The torque values above are based on new plated threads. Increase torque values by 15% if non-plated threads are used.
3. Hardware threaded into aluminum must have either two diameters of thread engagement or a 30% or more reduction in the torque to prevent stripped threads.
4. Torque values are calculated as equivalent stress loading on American hardware with an approximate preload of 90% of the yield strength and a friction coefficient of 0.125.

# Appendix D Common Hardware Identification

| Screw/Bolts/Studs                            |   |
|--|---|
| Head Styles                                  |   |
| Hex Head or Machine Head                     |    |
| Hex Head or Machine Head with Washer         |    |
| Flat Head (FHM)                              |    |
| Round Head (RHM)                             |    |
| Pan Head                                     |    |
| Hex Socket Head Cap or Allen™ Head Cap       |    |
| Hex Socket Head or Allen™ Head Shoulder Bolt |    |
| Sheet Metal Screw                            |    |
| Stud   |    |
| Drive Styles                                 |   |
| Hex  |    |
| Hex and Slotted                              |   |
| Phillips®                                    |  |
| Slotted                                      |  |
| Hex Socket                                   |  |

| Nuts                         |   |
|------------------------------|---|
| Nut Styles                   |   |
| Hex Head                     |    |
| Lock or Elastic              |    |
| Square                       |    |
| Cap or Acorn                 |    |
| Wing                         |    |
| Washers                      |   |
| Washer Styles                |   |
| Plain                        |    |
| Split Lock or Spring         |    |
| Spring or Wave               |    |
| External Tooth Lock          |    |
| Internal Tooth Lock          |   |
| Internal-External Tooth Lock |  |

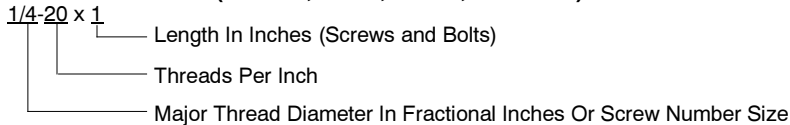
| Hardness Grades                       |   |
|---------------------------------------|---|
| American Standard                     |   |
| Grade 2                               |  |
| Grade 5                               |  |
| Grade 8                               |  |
| Grade 8/9 (Hex Socket Head)           |  |
| Metric                                |   |
| Number stamped on hardware; 5.8 shown |  |

Allen™ head screw is a trademark of Holo-Krome Co.

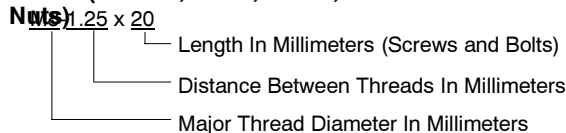
Phillips® screw is a registered trademark of Phillips Screw Company.

## Sample Dimensions

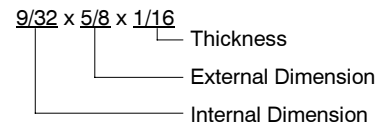
### American Standard (Screws, Bolts, Studs, and Nuts)



### Metric (Screws, Bolts, Studs, and Nuts)



### Plain Washers



### Lock Washers



# Appendix E Common Hardware List

The Common Hardware List lists part numbers and dimensions for common hardware items.

## American Standard

| Part No.                        | Dimensions     | Part No.  | Dimensions     | Part No.        | Dimensions | Type      |               |                        |
|---------------------------------|----------------|-----------|----------------|-----------------|------------|-----------|---------------|------------------------|
| <b>Hex Head Bolts (Grade 5)</b> |                |           |                |                 |            |           |               |                        |
| X-465-17                        | 1/4-20 x .38   | X-6238-14 | 3/8-24 x .75   | <b>Hex Nuts</b> |            |           |               |                        |
| X-465-6                         | 1/4-20 x .50   | X-6238-16 | 3/8-24 x 1.25  | X-6009-1        | 1-8        | Standard  |               |                        |
| X-465-2                         | 1/4-20 x .62   | X-6238-21 | 3/8-24 x 4.00  | X-6210-3        | 6-32       | Whiz      |               |                        |
| X-465-16                        | 1/4-20 x .75   | X-6238-22 | 3/8-24 x 4.50  | X-6210-4        | 8-32       | Whiz      |               |                        |
| X-465-18                        | 1/4-20 x .88   | X-6024-5  | 7/16-14 x .75  | X-6210-5        | 10-24      | Whiz      |               |                        |
| X-465-7                         | 1/4-20 x 1.00  | X-6024-2  | 7/16-14 x 1.00 | X-6210-1        | 10-32      | Whiz      |               |                        |
| X-465-8                         | 1/4-20 x 1.25  | X-6024-8  | 7/16-14 x 1.25 | X-6210-2        | 1/4-20     | Spiralock |               |                        |
| X-465-9                         | 1/4-20 x 1.50  | X-6024-3  | 7/16-14 x 1.50 | X-6210-6        | 1/4-28     | Spiralock |               |                        |
| X-465-10                        | 1/4-20 x 1.75  | X-6024-4  | 7/16-14 x 2.00 | X-6210-7        | 5/16-18    | Spiralock |               |                        |
| X-465-11                        | 1/4-20 x 2.00  | X-6024-11 | 7/16-14 x 2.75 | X-6210-8        | 5/16-24    | Spiralock |               |                        |
| X-465-12                        | 1/4-20 x 2.25  | X-6024-12 | 7/16-14 x 6.50 | X-6210-9        | 3/8-16     | Spiralock |               |                        |
| X-465-14                        | 1/4-20 x 2.75  | X-129-15  | 1/2-13 x .75   | X-6210-10       | 3/8-24     | Spiralock |               |                        |
| X-465-21                        | 1/4-20 x 5.00  | X-129-17  | 1/2-13 x 1.00  | X-6210-11       | 7/16-14    | Spiralock |               |                        |
| X-465-25                        | 1/4-28 x .38   | X-129-18  | 1/2-13 x 1.25  | X-6210-12       | 1/2-13     | Spiralock |               |                        |
| X-465-20                        | 1/4-28 x 1.00  | X-129-19  | 1/2-13 x 1.50  | X-6210-15       | 7/16-20    | Spiralock |               |                        |
| X-125-33                        | 5/16-18 x .50  | X-129-20  | 1/2-13 x 1.75  | X-6210-14       | 1/2-20     | Spiralock |               |                        |
| X-125-23                        | 5/16-18 x .62  | X-129-21  | 1/2-13 x 2.00  | X-85-3          | 5/8-11     | Standard  |               |                        |
| X-125-3                         | 5/16-18 x .75  | X-129-22  | 1/2-13 x 2.25  | X-88-12         | 3/4-10     | Standard  |               |                        |
| X-125-31                        | 5/16-18 x .88  | X-129-23  | 1/2-13 x 2.50  | X-89-2          | 1/2-20     | Standard  |               |                        |
| X-125-5                         | 5/16-18 x 1.00 | X-129-24  | 1/2-13 x 2.75  | <b>Washers</b>  |            |           |               |                        |
| X-125-24                        | 5/16-18 x 1.25 | X-129-25  | 1/2-13 x 3.00  | <b>Part No.</b> | <b>ID</b>  | <b>OD</b> | <b>Thick.</b> | <b>Bolt/<br/>Screw</b> |
| X-125-34                        | 5/16-18 x 1.50 | X-129-27  | 1/2-13 x 3.50  | X-25-46         | .125       | .250      | .022          | #4                     |
| X-125-25                        | 5/16-18 x 1.75 | X-129-29  | 1/2-13 x 4.00  | X-25-9          | .156       | .375      | .049          | #6                     |
| X-125-26                        | 5/16-18 x 2.00 | X-129-30  | 1/2-13 x 4.50  | X-25-48         | .188       | .438      | .049          | #8                     |
| 230578                          | 5/16-18 x 2.25 | X-463-9   | 1/2-13 x 5.50  | X-25-36         | .219       | .500      | .049          | #10                    |
| X-125-29                        | 5/16-18 x 2.50 | X-129-44  | 1/2-13 x 6.00  | X-25-40         | .281       | .625      | .065          | 1/4                    |
| X-125-27                        | 5/16-18 x 2.75 | X-129-51  | 1/2-20 x .75   | X-25-85         | .344       | .687      | .065          | 5/16                   |
| X-125-28                        | 5/16-18 x 3.00 | X-129-45  | 1/2-20 x 1.25  | X-25-37         | .406       | .812      | .065          | 3/8                    |
| X-125-22                        | 5/16-18 x 4.50 | X-129-52  | 1/2-20 x 1.50  | X-25-34         | .469       | .922      | .065          | 7/16                   |
| X-125-32                        | 5/16-18 x 5.00 | X-6021-3  | 5/8-11 x 1.00  | X-25-26         | .531       | 1.062     | .095          | 1/2                    |
| X-125-35                        | 5/16-18 x 5.50 | X-6021-4  | 5/8-11 x 1.25  | X-25-15         | .656       | 1.312     | .095          | 5/8                    |
| X-125-36                        | 5/16-18 x 6.00 | X-6021-2  | 5/8-11 x 1.50  | X-25-29         | .812       | 1.469     | .134          | 3/4                    |
| X-125-40                        | 5/16-18 x 6.50 | X-6021-1  | 5/8-11 x 1.75  | X-25-127        | 1.062      | 2.000     | .134          | 1                      |
| X-125-43                        | 5/16-24 x 1.75 | 273049    | 5/8-11 x 2.00  |                 |            |           |               |                        |
| X-125-44                        | 5/16-24 x 2.50 | X-6021-5  | 5/8-11 x 2.25  |                 |            |           |               |                        |
| X-125-30                        | 5/16-24 x .75  | X-6021-6  | 5/8-11 x 2.50  |                 |            |           |               |                        |
| X-125-39                        | 5/16-24 x 2.00 | X-6021-7  | 5/8-11 x 2.75  |                 |            |           |               |                        |
| X-125-38                        | 5/16-24 x 2.75 | X-6021-12 | 5/8-11 x 3.75  |                 |            |           |               |                        |
| X-6238-2                        | 3/8-16 x .62   | X-6021-11 | 5/8-11 x 4.50  |                 |            |           |               |                        |
| X-6238-10                       | 3/8-16 x .75   | X-6021-10 | 5/8-11 x 6.00  |                 |            |           |               |                        |
| X-6238-3                        | 3/8-16 x .88   | X-6021-9  | 5/8-18 x 2.50  |                 |            |           |               |                        |
| X-6238-11                       | 3/8-16 x 1.00  | X-6239-1  | 3/4-10 x 1.00  |                 |            |           |               |                        |
| X-6238-4                        | 3/8-16 x 1.25  | X-6239-8  | 3/4-10 x 1.25  |                 |            |           |               |                        |
| X-6238-5                        | 3/8-16 x 1.50  | X-6239-2  | 3/4-10 x 1.50  |                 |            |           |               |                        |
| X-6238-1                        | 3/8-16 x 1.75  | X-6239-3  | 3/4-10 x 2.00  |                 |            |           |               |                        |
| X-6238-6                        | 3/8-16 x 2.00  | X-6239-4  | 3/4-10 x 2.50  |                 |            |           |               |                        |
| X-6238-17                       | 3/8-16 x 2.25  | X-6239-5  | 3/4-10 x 3.00  |                 |            |           |               |                        |
| X-6238-7                        | 3/8-16 x 2.50  | X-6239-6  | 3/4-10 x 3.50  |                 |            |           |               |                        |
| X-6238-8                        | 3/8-16 x 2.75  | X-792-1   | 1-8 x 2.25     |                 |            |           |               |                        |
| X-6238-9                        | 3/8-16 x 3.00  | X-792-5   | 1-8 x 3.00     |                 |            |           |               |                        |
| X-6238-19                       | 3/8-16 x 3.25  | X-792-8   | 1-8 x 5.00     |                 |            |           |               |                        |
| X-6238-12                       | 3/8-16 x 3.50  |           |                |                 |            |           |               |                        |
| X-6238-20                       | 3/8-16 x 3.75  |           |                |                 |            |           |               |                        |
| X-6238-13                       | 3/8-16 x 4.50  |           |                |                 |            |           |               |                        |
| X-6238-18                       | 3/8-16 x 5.50  |           |                |                 |            |           |               |                        |
| X-6238-25                       | 3/8-16 x 6.50  |           |                |                 |            |           |               |                        |

## Metric

Hex head bolts are hardness grade 8.8 unless noted.

### Part No. Dimensions Hex Head Bolts (Partial Thread)

|               |                |
|---------------|----------------|
| M931-05055-60 | M5-0.80 x 55   |
| M931-06040-60 | M6-1.00 x 40   |
| M931-06055-60 | M6-1.00 x 55   |
| M931-06060-60 | M6-1.00 x 60   |
| M931-06060-SS | M6-1.00 x 60   |
| M931-06070-60 | M6-1.00 x 70   |
| M931-06070-SS | M6-1.00 x 70   |
| M931-06075-60 | M6-1.00 x 75   |
| M931-06090-60 | M6-1.00 x 90   |
| M931-06145-60 | M6-1.00 x 145  |
| M931-06150-60 | M6-1.00 x 150  |
| M931-08035-60 | M8-1.25 x 35   |
| M931-08040-60 | M8-1.25 x 40   |
| M931-08045-60 | M8-1.25 x 45   |
| M931-08050-60 | M8-1.25 x 50   |
| M931-08055-60 | M8-1.25 x 55   |
| M931-08055-82 | M8-1.25 x 55*  |
| M931-08060-60 | M8-1.25 x 60   |
| M931-08070-60 | M8-1.25 x 70   |
| M931-08070-82 | M8-1.25 x 70*  |
| M931-08075-60 | M8-1.25 x 75   |
| M931-08080-60 | M8-1.25 x 80   |
| M931-08090-60 | M8-1.25 x 90   |
| M931-08095-60 | M8-1.25 x 95   |
| M931-08100-60 | M8-1.25 x 100  |
| M931-08110-60 | M8-1.25 x 110  |
| M931-08120-60 | M8-1.25 x 120  |
| M931-08130-60 | M8-1.25 x 130  |
| M931-08140-60 | M8-1.25 x 140  |
| M931-08150-60 | M8-1.25 x 150  |
| M931-08200-60 | M8-1.25 x 200  |
| M931-10040-82 | M10-1.25 x 40* |
| M931-10040-60 | M10-1.50 x 40  |
| M931-10045-60 | M10-1.50 x 45  |
| M931-10050-60 | M10-1.50 x 50  |
| M931-10050-82 | M10-1.25 x 50* |
| M931-10055-60 | M10-1.50 x 55  |
| M931-10060-60 | M10-1.50 x 60  |
| M931-10065-60 | M10-1.50 x 65  |
| M931-10070-60 | M10-1.50 x 70  |
| M931-10080-60 | M10-1.50 x 80  |
| M931-10080-82 | M10-1.25 x 80* |
| M931-10090-60 | M10-1.50 x 90  |
| M931-10090-82 | M10-1.50 x 90* |
| M931-10100-60 | M10-1.50 x 100 |
| M931-10110-60 | M10-1.50 x 110 |
| M931-10120-60 | M10-1.50 x 120 |
| M931-10130-60 | M10-1.50 x 130 |
| M931-10140-60 | M10-1.50 x 140 |
| M931-10180-60 | M10-1.50 x 180 |
| M931-10235-60 | M10-1.50 x 235 |
| M931-10260-60 | M10-1.50 x 260 |
| M960-10330-60 | M10-1.25 x 330 |
| M931-12045-60 | M12-1.75 x 45  |
| M960-12050-60 | M12-1.25 x 50  |
| M960-12050-82 | M12-1.25 x 50* |
| M931-12050-60 | M12-1.75 x 50  |
| M931-12050-82 | M12-1.75 x 50* |
| M931-12055-60 | M12-1.75 x 55  |
| M931-12060-60 | M12-1.75 x 60  |
| M931-12060-82 | M12-1.75 x 60* |
| M931-12065-60 | M12-1.75 x 65  |
| M931-12075-60 | M12-1.75 x 75  |
| M931-12080-60 | M12-1.75 x 80  |
| M931-12090-60 | M12-1.75 x 90  |
| M931-12100-60 | M12-1.75 x 100 |
| M931-12110-60 | M12-1.75 x 110 |

### Part No. Dimensions Hex Head Bolts (Partial Thread), continued

|               |                 |
|---------------|-----------------|
| M960-16090-60 | M16-1.50 x 90   |
| M931-16090-60 | M16-2.00 x 90   |
| M931-16100-60 | M16-2.00 x 100  |
| M931-16100-82 | M16-2.00 x 100* |
| M931-16120-60 | M16-2.00 x 120  |
| M931-16150-60 | M16-2.00 x 150  |
| M931-20065-60 | M20-2.50 x 65   |
| M931-20090-60 | M20-2.50 x 90   |
| M931-20100-60 | M20-2.50 x 100  |
| M931-20120-60 | M20-2.50 x 120  |
| M931-20140-60 | M20-2.50 x 140  |
| M931-20160-60 | M20-2.50 x 160  |
| M931-22090-60 | M22-2.50 x 90   |
| M931-22120-60 | M22-2.50 x 120  |
| M931-22160-60 | M22-2.50 x 160  |
| M931-24090-60 | M24-3.00 x 90   |
| M931-24120-60 | M24-3.00 x 120  |
| M931-24160-60 | M24-3.00 x 160  |
| M931-24200-60 | M24-3.00 x 200  |

### Hex Head Bolts (Full Thread)

|               |                |
|---------------|----------------|
| M933-04006-60 | M4-0.70 x 6    |
| M933-05030-60 | M5-0.80 x 30   |
| M933-05035-60 | M5-0.80 x 35   |
| M933-05050-60 | M5-0.80 x 50   |
| M933-06010-60 | M6-1.00 x 10   |
| M933-06012-60 | M6-1.00 x 12   |
| M933-06014-60 | M6-1.00 x 14   |
| M933-06016-60 | M6-1.00 x 16   |
| M933-06020-60 | M6-1.00 x 20   |
| M933-06025-60 | M6-1.00 x 25   |
| M933-06030-60 | M6-1.00 x 30   |
| M933-06040-60 | M6-1.00 x 40   |
| M933-06050-60 | M6-1.00 x 50   |
| M933-07025-60 | M7-1.00 x 25   |
| M933-08010-60 | M8-1.25 x 10   |
| M933-08012-60 | M8-1.25 x 12   |
| M933-08016-60 | M8-1.25 x 16   |
| M933-08020-60 | M8-1.25 x 20   |
| M933-08025-60 | M8-1.25 x 25   |
| M933-08030-60 | M8-1.25 x 30   |
| M933-08030-82 | M8-1.25 x 30*  |
| M933-10012-60 | M10-1.50 x 12  |
| M961-10020-60 | M10-1.25 x 20  |
| M933-10020-60 | M10-1.50 x 20  |
| M933-10025-60 | M10-1.50 x 25  |
| M961-10025-60 | M10-1.25 x 25  |
| M933-10025-82 | M10-1.50 x 25* |
| M961-10030-60 | M10-1.25 x 30  |
| M933-10030-60 | M10-1.50 x 30  |
| M933-10030-82 | M10-1.50 x 30* |
| M961-10035-60 | M10-1.25 x 35  |
| M933-10035-60 | M10-1.50 x 35  |
| M933-10035-82 | M10-1.50 x 35* |
| M961-10040-60 | M10-1.25 x 40  |

### Part No. Dimensions Hex Head Bolts (Full Thread), continued

|                |                |
|----------------|----------------|
| M933-12016-60  | M12-1.75 x 16  |
| M933-12020-60  | M12-1.75 x 20  |
| M961-12020-60F | M12-1.50 x 20  |
| M933-12025-60  | M12-1.75 x 25  |
| M933-12025-82  | M12-1.75 x 25* |
| M961-12030-60  | M12-1.25 x 30  |
| M933-12030-82  | M12-1.75 x 30* |
| M961-12030-82F | M12-1.50 x 30* |
| M933-12030-60  | M12-1.75 x 30  |
| M933-12035-60  | M12-1.75 x 35  |
| M961-12040-82  | M12-1.25 x 40* |
| M933-12040-60  | M12-1.75 x 40  |
| M933-12040-82  | M12-1.75 x 40* |
| M961-14025-60  | M14-1.50 x 25  |
| M933-14025-60  | M14-2.00 x 25  |
| M961-14050-82  | M14-1.50 x 50* |
| M961-16025-60  | M16-1.50 x 25  |
| M933-16025-60  | M16-2.00 x 25  |
| M961-16030-82  | M16-1.50 x 30* |
| M933-16030-82  | M16-2.00 x 30* |
| M933-16035-60  | M16-2.00 x 35  |
| M961-16040-60  | M16-1.50 x 40  |
| M933-16040-60  | M16-2.00 x 40  |
| M961-16045-82  | M16-1.50 x 45* |
| M933-16045-82  | M16-2.00 x 45* |
| M933-16050-60  | M16-2.00 x 50  |
| M933-16050-82  | M16-2.00 x 50* |
| M933-16060-60  | M16-2.00 x 60  |
| M933-16070-60  | M16-2.00 x 70  |
| M933-18035-60  | M18-2.50 x 35  |
| M933-18050-60  | M18-2.50 x 50  |
| M933-18060-60  | M18-2.50 x 60  |
| M933-20050-60  | M20-2.50 x 50  |
| M933-20055-60  | M20-2.50 x 55  |
| M933-24060-60  | M24-3.00 x 60  |
| M933-24065-60  | M24-3.00 x 65  |
| M933-24070-60  | M24-3.00 x 70  |

### Pan Head Machine Screws

|                 |               |
|-----------------|---------------|
| M7985A-03010-20 | M3-0.50 x 10  |
| M7985A-03012-20 | M3-0.50 x 12  |
| M7985A-04010-20 | M4-0.70 x 10  |
| M7985A-04016-20 | M4-0.70 x 16  |
| M7985A-04020-20 | M4-0.70 x 20  |
| M7985A-04050-20 | M4-0.70 x 50  |
| M7985A-04100-20 | M4-0.70 x 100 |
| M7985A-05010-20 | M5-0.80 x 10  |
| M7985A-05012-20 | M5-0.80 x 12  |
| M7985A-05016-20 | M5-0.80 x 16  |
| M7985A-05020-20 | M5-0.80 x 20  |
| M7985A-05025-20 | M5-0.80 x 25  |
| M7985A-05030-20 | M5-0.80 x 30  |
| M7985A-05080-20 | M5-0.80 x 80  |
| M7985A-05100-20 | M5-0.80 x 100 |
| M7985A-06100-20 | M6-1.00 x 100 |

### Flat Head Machine Screws

|                |              |
|----------------|--------------|
| M965A-04012-SS | M4-0.70 x 12 |
| M965A-05012-SS | M5-0.80 x 12 |
| M965A-05016-20 | M5-0.80 x 16 |
| M965A-06012-20 | M6-1.00 x 12 |

\* This metric hex bolt's hardness is grade 10.9.



## Metric, continued

| Part No.        | Dimensions | Type         |
|-----------------|------------|--------------|
| <b>Hex Nuts</b> |            |              |
| M934-03-50      | M3-0.50    | Standard     |
| M934-04-50      | M4-0.70    | Standard     |
| M934-04-B       | M4-0.70    | Brass        |
| M934-05-50      | M5-0.80    | Standard     |
| M934-06-60      | M6-1.00    | Standard     |
| M934-06-64      | M6-1.00    | Std. (green) |
| M6923-06-80     | M6-1.00    | Spirallock   |
| M982-06-80      | M6-1.00    | Elastic Stop |
| M934-08-60      | M8-1.25    | Standard     |
| M6923-08-80     | M8-1.25    | Spirallock   |
| M982-08-80      | M8-1.25    | Elastic Stop |
| M934-10-60      | M10-1.50   | Standard     |
| M934-10-60F     | M10-1.25   | Standard     |
| M6923-10-80     | M10-1.50   | Spirallock   |
| M6923-10-62     | M10-1.50   | Spirallock†  |
| M982-10-80      | M10-1.50   | Elastic Stop |
| M934-12-60      | M12-1.75   | Standard     |
| M934-12-60F     | M12-1.25   | Standard     |
| M6923-12-80     | M12-1.75   | Spirallock   |
| M982-12-80      | M12-1.75   | Elastic Stop |
| M982-14-60      | M14-2.00   | Elastic Stop |
| M6923-16-80     | M16-2.00   | Spirallock   |
| M982-16-80      | M16-2.00   | Elastic Stop |
| M934-18-80      | M18-2.5    | Standard     |
| M982-18-60      | M18-2.50   | Elastic Stop |
| M934-20-80      | M20-2.50   | Standard     |
| M982-20-80      | M20-2.50   | Elastic Stop |
| M934-22-60      | M22-2.50   | Standard     |
| M934-24-80      | M24-3.00   | Standard     |
| M982-24-60      | M24-3.00   | Elastic Stop |
| M934-30-80      | M30-3.50   | Standard     |

## Washers

| Part No.    | ID   | OD   | Thick. | Bolt/<br>Screw |
|-------------|------|------|--------|----------------|
| M125A-03-80 | 3.2  | 7.0  | 0.5    | M3             |
| M125A-04-80 | 4.3  | 9.0  | 0.8    | M4             |
| M125A-05-80 | 5.3  | 10.0 | 1.0    | M5             |
| M125A-06-80 | 6.4  | 12.0 | 1.6    | M6             |
| M125A-08-80 | 8.4  | 16.0 | 1.6    | M8             |
| M125A-10-80 | 10.5 | 20.0 | 2.0    | M10            |
| M125A-12-80 | 13.0 | 24.0 | 2.5    | M12            |
| M125A-14-80 | 15.0 | 28.0 | 2.5    | M14            |
| M125A-16-80 | 17.0 | 30.0 | 3.0    | M16            |
| M125A-18-80 | 19.0 | 34.0 | 3.0    | M18            |
| M125A-20-80 | 21.0 | 37.0 | 3.0    | M20            |
| M125A-24-80 | 25.0 | 44.0 | 4.0    | M24            |

† This metric hex nut's hardness is grade 8.

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| GM75789-MA2, <i>9</i>   | GM75797-MA7, <i>11</i> | GM77543-MA6, <i>5</i>  | GM81703-MA11, <i>15</i> |
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**TP-6780 5/12b**

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# **KOHLER**<sup>®</sup> POWER SYSTEMS

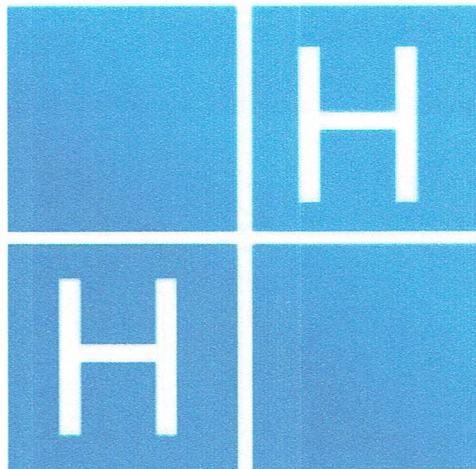
KOHLER CO. Kohler, Wisconsin 53044  
Phone 920-457-4441, Fax 920-459-1646  
For the nearest sales and service outlet in the  
US and Canada, phone 1-800-544-2444  
KohlerPower.com

Kohler Power Systems  
Asia Pacific Headquarters  
7 Jurong Pier Road  
Singapore 619159  
Phone (65) 6264-6422, Fax (65) 6264-6455

# **Operation / Installation / Commissioning**

**(O&M) – Manual**

## **H+H SCR Systems Stationary Application**



for

**AeriNOx  
“Frontier\_Esquimalt\_Graving\_Dock”**

**H+H Project No° PA2016\_390**

Date: 10.04.2017

**H+H Engineering & Service GmbH  
Herrngasse 17  
D-96242 Sonnefeld, GERMANY**



## Important

In case of a failure on any part of the SCR system an automatic error routine will be launched.  
Please follow the instructions on the control panel.

In any case the engine will run fine even with a defective or inoperable SCR system as long as the  
catalyst modules are not clogged.

If the type of fuel that the motor is using needs to be changed (e.g. use HFO instead of LFO) please  
contact H+H for system recalibration. Running the SCR with another fuel type than the one calibrated  
can clog the catalyst and therefore block the exhaust gas pipe.

For help please contact:

**AeriNOx Inc.**  
**100 Cherry Ave, Suite 6B**  
**Eaton, Colorado, 80615 UNITED STATES**  
tel.: +01 (970) 454 5639

Andy Collins  
tel.: +01 (970) 454 5639  
**Mobile: +01 (585) 943 5858**

**H+H Engineering & Service GmbH**  
**Herrngasse 17**  
**D-96242 Sonnefeld, GERMANY**  
tel.: +49 (0) 9562 / 40063 – 0

*Jürgen Müller*  
tel.: +49 (0) 9562 / 40063 – 11  
**Mobile: +49 (0) 160 979 14 288**

Or

*André Hoppe*  
tel.: +49 (0) 9562 / 40063 – 15  
**Mobile: +49 (0) 171 684 48 41**



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## 1. General Safety Instructions

These instructions are intended to complement general CLASSIFICATION and company safety instructions only.



### POISONOUS OR HARMFUL GASES

During work on the exhaust gas system remains of the exhaust gas may be released. Adequate supply of fresh air has to be ensured. We strongly recommend wearing respiratory protection. When working inside the catalyzer housing a breathing apparatus should be worn.



### CAUTION HOT SURFACE

Give all parts enough time to cool down. Control the surface temperature before touching any part. All metal parts should have a temperature below 50°C



### ENVIRONMENT

Urea is alkaline and slightly corrosive. Clarify the on-site environmental regulations for Urea and handle it accordingly.



### DUST FORMATION

There is a potential hazard of dust formation. For your safety we recommend wearing respiratory and eye protection.



### GENERAL PROTECTION

All works should only be carried out wearing protective gloves, safety shoes and work clothes.



### EYE PROTECTION

When working on Urea or pressured air pipes always wear eye protection. Residual pressure may occur anywhere in the piping system.



### TRAINED PERSONNEL

All work on the system or any subcomponent should be carried out by trained personnel only.



### HIGH VOLTAGE

Before working on any electrical equipment make sure that there is no voltage applied. Trigger main switch or disconnect the system. Refer to chapter Operation mode 'Shut down to off'.

## 2. Abbreviations

|                  |   |
|------------------|---|
| CO               | Carbon Monoxide                             |
| CO <sub>2</sub>  | Carbon Dioxide                              |
| DN               | Nominal Diameter                            |
| H <sub>2</sub> O | Water                                       |
| MSDS             | Material and Safety Data Sheets             |
| N <sub>2</sub>   | Nitrogen                                    |
| NH <sub>3</sub>  | Ammonia                                     |
| NMHC             | Non-Methane Hydrocarbons                    |
| NO               | Nitrogen Monoxide                           |
| NO <sub>2</sub>  | Nitrogen Dioxide                            |
| NO <sub>x</sub>  | Nitrogen Oxides (NO and NO <sub>2</sub> )   |
| O <sub>2</sub>   | Oxygen                                      |
| O&M              | Operation and Maintenance Manual            |
| OP               | Operation Panel                             |
| P&ID             | Process and Instrumentation Diagram         |
| PLC              | Process Logic Control                       |
| PN               | Nominal Pressure                            |
| RA               | Reducing Agent                              |
| S                | Sulfur                                      |
| SCR              | Selective Catalytic Reduction               |
| SO <sub>2</sub>  | Sulfur Dioxide                              |
| wt.              | By weight                                   |
| ECC              | Electrical Control and Communication System |
| SP               | Set Point                                   |
| RP               | Reset Point                                 |
| WNG              | Warning Message                             |
| ERR              | Error Message                               |



### **3. General Information and Theory of Operation**

#### **3.1. General Information**

This introductory training and reference manual does not include complete, detailed information on the product and cannot cover every conceivable aspect of installation, operation and maintenance. **All images are examples** and may differ from actual design. For more detailed information refer to the H+H system manuals.

#### **3.2. Safety notes**

This technical description contains introductions concerning major personal safety issues and how to prevent property damage. These instructions are intended to complement general CLASSIFICATION and company safety instructions only.

#### **3.3. Qualified personnel**

Commissioning, operation, maintenance and repairs of the H+H SCR-System shall be performed by skilled personnel only. Please read this system description and the safety instructions prior to working on or operating the SCR-System.

#### **3.4. Operation in accordance with intended purposes**

The H+H SCR-System may be used only as specified in the system documentation. When used with material, parts or components other than specified without prior written approval by H+H all guarantee voids. Correct and safe operation of the SCR-System is dependent on proper operation and maintenance procedures.

#### **3.5. Chemicals**

The SCR-System is operated with urea solution as reducing agent. The instructions for handling this compound are listed in the supplier's MSDS (Material safety data sheets). Do not work on or open piping before checking the MSDS.

When handling the catalytic material, refer to the MSDS in the H+H SCR-System documentation.

#### **3.6. Important note**

In case that any information within this manual differs from the delivered equipment, the following documents always take preference over the information within this manual:

- the order confirmation
- the drawings and engineering files (transfer files)
- agreed changes during engineering process (by e-mail or during meetings)
- the order
- the offer

The tag numbers of valves, field devices, etc. are referring to the P&ID Diagram.

### 3.7. Theory of Operation

#### SCR (DeNOx) Process description

The concentration of polluting nitrogen oxide (NOx), carbon mono-oxides (CO) and hydrocarbons (HC) in exhaust gases are to be reduced safely below particular emission limits.

The concentration of the above pollutants can be reduced drastically by means of state-of-the-art catalytic converters. In this connection, when getting into contact with the catalytic surface which has been activated accordingly, the waste gas components to be removed will turn into problem-free 'residuals'.

In the first phase of reaction, the nitrogen oxides of the waste gas transform into ecologically harmless agents H<sub>2</sub>O and N<sub>2</sub> by means of DeNOx-catalysts and an ammonia releasing liquid - the so-called reducing agent - according to the method of selective, catalytic reduction (SCR method).

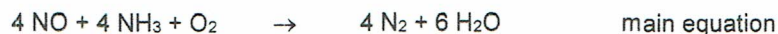
In the second phase of reaction, the oxidation catalyst (OPTION) transforms a considerable part of the toxic carbon mono-oxide into carbon dioxide (CO<sub>2</sub>). At the same time the shares of methane-free hydrocarbons are oxidizing into carbon dioxide and water.

Possible reducing agents:

|                |            |
|----------------|------------|
| Urea solution: | ≤ 40 % wt. |
| Ammonia water: | ≤ 25 % wt. |
| Ammonia gas:   | 100 %      |

When utilizing the selective reduction method, by adding ammonia NH<sub>3</sub> or ammonifiers (urea), nitrogen oxides (NO, NO<sub>2</sub>) are transformed into nitrogen N<sub>2</sub> and water vapor (H<sub>2</sub>O). Due to the toxicity of ammonia the use of urea solution is mandatory for marine applications.

With nitrogen monoxide (NO) being the most important nitrogen oxide, the following chemical equation is in general the determinative all-over reaction.



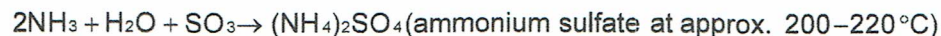
The molar ratio NH<sub>3</sub>/NO which is important to NH<sub>3</sub> consumption therefore is 1. As homogenous gas phase reaction, without utilizing the catalyst, this reaction only starts at temperatures above 900°C with satisfying velocity. At lower temperatures, reaction kinetics is too low, thus requiring the utilization of catalysts. Depending on the type of catalyst, the reaction temperature can be reduced down to 280 - 510°C.

The NOx conversion efficiency ( $\eta_{\text{NOx}}$ ) is determined from the NOx concentrations NOx<sub>in</sub> and NOx<sub>out</sub> at the catalyst inlet and outlet:

$$\eta = \frac{N_{i_1} - N_{o_1}}{N_{i_1}} * 100$$

The requisite concentration of the reducing agent, determined based on the NOx concentration *upstream* of the catalyst inlet, is virtually proportional to the NOx conversion efficiency.

If the injection of Ammonia takes place at a too low temperature, Ammonium sulfate or ammonium bisulfate can be generated as a function of the temperature and moisture content of the exhaust gas.

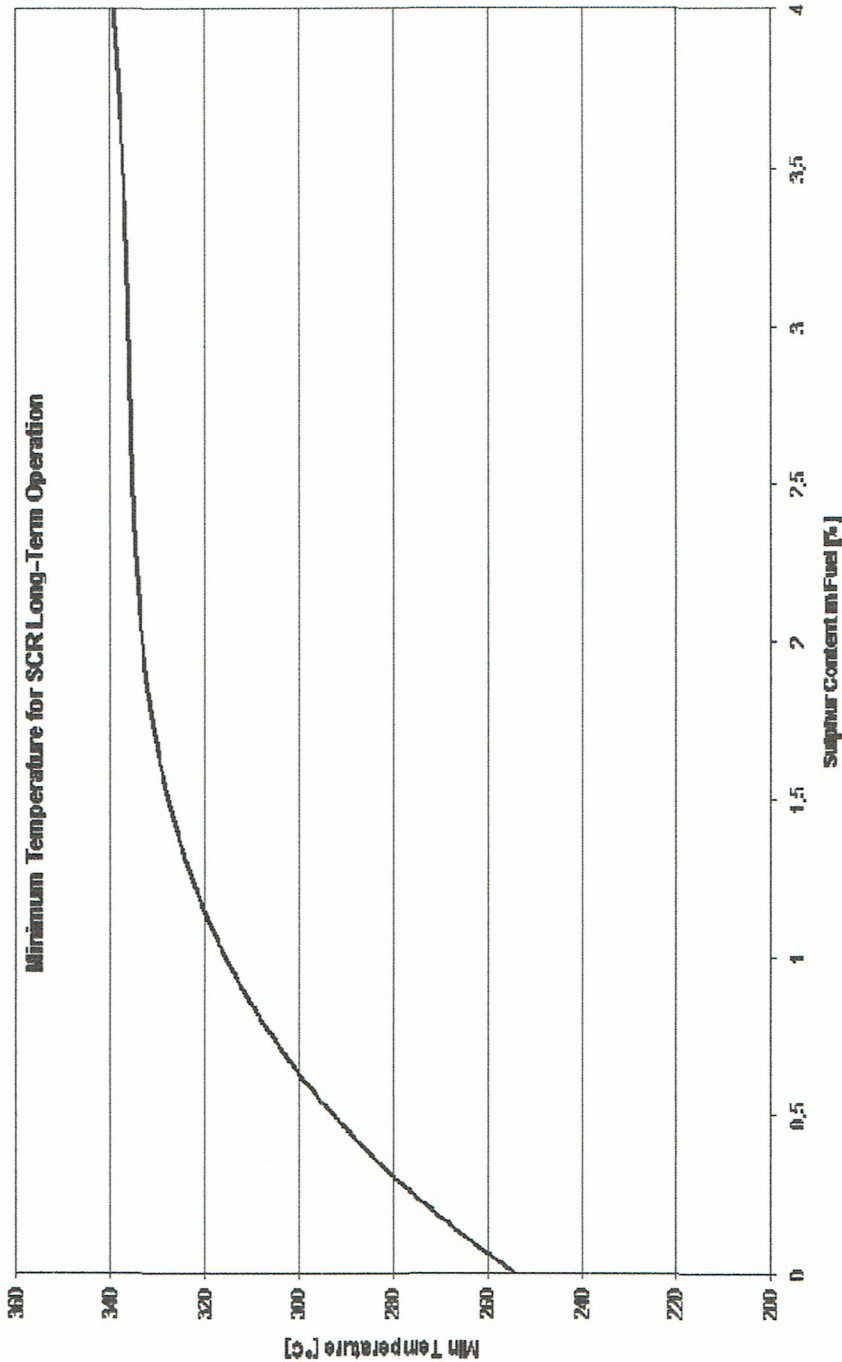


The reaction rate for the formation of (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> is much lower than that for NH<sub>4</sub>HSO<sub>4</sub>. This results in preferential formation of NH<sub>4</sub>HSO<sub>4</sub> at high cooling rates. This substance has the undesirable properties

of being viscous, adhesive and corrosive. All exhaust gas path components at or downstream of where ammonium bisulfate is generated are at risk.

These ammonia salts can condense in the catalyst pores, resulting in deactivation.

This effect can be prevented by maintaining a minimum temperature as a function of the concentrations of SO<sub>3</sub> and NH<sub>3</sub>.





#### 4. Design Data

The design of the SCR exhaust gas treatment system is based on the following data:

| Parameter = 100 % Load                       | Unit                                 | Engine 1-3<br>(Diesel) |
|--|--------------------------------------|------------------------|
| Type   |                                      | S12A2-Y2PTAW-2         |
| Power  | [kW]                                 | 900                    |
| Quantity                                     | [pcs]                                | 3                      |
| Fuel type                                    |                                      | ULSD                   |
| Flue gas volume (wet)                        | [kg/h]                               | ---                    |
|  | [m <sup>3</sup> .i.N./h]             | ---                    |
|  | [acfm]                               | 7344                   |
| Water content                                | Vol. %                               | 8                      |
| Oxygen content                               | Vol. %                               | 9                      |
| Exhaust-gas temperature (housing inlet)      | [°C]                                 | 472                    |
| NOx as NO <sub>2</sub> inlet catalyts , dry  | [g/kWh]                              | 5.36                   |
|  | mg/Nm <sup>3</sup> @5%O <sub>2</sub> | ---                    |
|  | [g/bhp hr]                           | ---                    |
| NOx as NO <sub>2</sub> outlet catalyts , dry | [g/kWh]                              | 0.67                   |
|  | mg/Nm <sup>3</sup> @5%O <sub>2</sub> | ---                    |
|  | [g/bhp hr]                           | ---                    |
| Aqueous urea solution                        | %                                    | 32.5                   |

m<sup>3</sup>.i.N = standard cubic meter (referenced to 0% humidity, 1013mbar absolute pressure, 0°C temperature)

#### Ambient conditions

|                           |              |  |    |
|---------------------------|--------------|--|----|
| SCR Control & Dosing Unit | +xCBC10      | +5...40  | °C |
| NOx Box                   | +xCBCx0      | +5...45  | °C |
| Pump station              | +xCBC40      | +5...45  | °C |
| Aqueous urea solution     |              | 8 °C < T < 35<br>(for details ref. to supplier MSDS) | °C |
| Atmospheric pressure:     | 700... 1.100 | mbar   |    |
| Rel. Humidity at 40 °C:   | 0...50       | %  |    |

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## 5. Utilities

| Electricity    |             |         |                |
|----------------|-------------|---------|----------------|
| Voltage        | 208V@60Hz   | Volt AC | (+/- 10%)      |
| Frequency      | 208V@60Hz   | Hz      | (+/- 2 %)      |
| Compressed air |             |         |                |
| Pressure       | 6...8       | bar     | (overpressure) |
| Quality        | Working air |         |                |
| Consumption    | ~9          | kg/h    | (at maximum)   |



Always keep compressed air pressure at or above 6 bar.  
Before turning off or reducing compressed air switch off the SCR on the main cabinet and wait for the procedure for cleaning the lance to finish.

Reducing agent: **Urea**  
Chemical formula:  $(\text{NH}_2)_2\text{CO}$   
Molar mass: 60,06 g/mol

### 5.1. 40 % aqueous urea solution

#### Physical properties:

| Parameter                              | Min.  | Max.  | Unit              |
|--|-------|-------|-------------------|
| Density                                | 1.105 | 1.115 | kg/m <sup>3</sup> |
| Urea content                           | 39.0  | 41.0  | % by weight       |
| Alkalinity (as NH <sub>3</sub> )       |       | 0.5   | % by weight       |
| Biuret                                 |       | 0.8   | % by weight       |
| Aldehydes                              |       | 100   | mg/kg             |
| Insoluble matter                       |       | 50    | mg/kg             |
| Total Phosphorus (as PO <sub>4</sub> ) |       | 1.0   | mg/kg             |
| Calcium                                |       | 1.0   | mg/kg             |
| Sodium                                 |       | 1.0   | mg/kg             |
| Potassium                              |       | 1.0   | mg/kg             |
| Iron                                   |       | 1.0   | mg/kg             |
| Magnesia                               |       | 1.0   | mg/kg             |

### 5.2. 32.5 % aqueous urea solution

#### Physical properties:

| Parameter                              | Min.   | Max.   | Unit              |
|--|--------|--------|-------------------|
| Density                                | 1.0870 | 1.0930 | kg/m <sup>3</sup> |
| Urea content                           | 31.5   | 33.5   | % by weight       |
| Alkalinity (as NH <sub>3</sub> )       |        | 0.5    | % by weight       |
| Biuret                                 |        | 0.8    | % by weight       |
| Aldehydes                              |        | 100    | mg/kg             |
| Insoluble matter                       |        | 50     | mg/kg             |
| Total Phosphorus (as PO <sub>4</sub> ) |        | 1.0    | mg/kg             |
| Calcium                                |        | 1.0    | mg/kg             |
| Sodium                                 |        | 1.0    | mg/kg             |
| Potassium                              |        | 1.0    | mg/kg             |
| Iron                                   |        | 1.0    | mg/kg             |
| Magnesia                               |        | 1.0    | mg/kg             |
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## 6. Technical Safety instructions

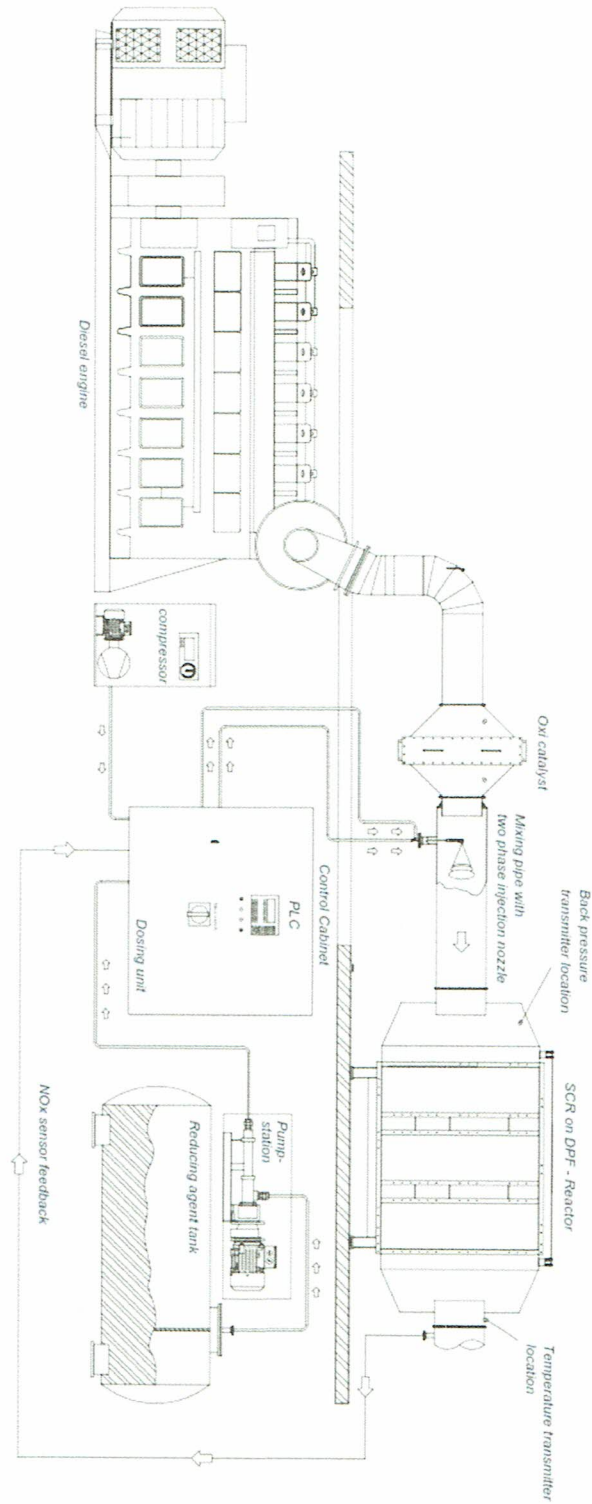


This technical description contains instructions on how to prevent property damage. These instructions are intended to complement general CLASSIFICATION and company safety instructions only. Please also refer to chapter 'General Safety Instructions'.

- To avoid damages to the engine or turbo by falling parts, we strongly recommend to install applicable arrangements (e.g. protection grill / or siphon).
- Protect hot parts (> 50°C) against contact!
- All temperature bonded threats must be treated with adequate antiseize paste
- Avoid temperature over 500°C for whole SCR – System, catalyst or material may be damaged!
- Install catalyst modules after the running in of the engines!
- We recommend installing catalysts only under supervision of H+H experts.
- All items and pipes that have contact with aqueous urea must be made of stainless steel.
- Pipes must be flushed after installation.
- Check voltages and frequency before connecting the electronic parts.

## 7. General description and arrangement

General arrangement instructions



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## 8. Main components of the SCR – System

The H+H SCR system is designed for 1 engine according to attached P&ID. The components shown in the process flow diagram are listed in the material safety and data sheet (MSDS).

The main components are:

- 1 Pump station (one per engine)
- 1 Control Cabinet and Dosing unit (one per engine)
- 1 Injection and mixing device (one per engine)
- 1 Oxidation Catalyst (one per engine)
- 1 Catalyzer housing (one per engine)
  - o Additional equipment as mentioned below at 8.4
    - Catalyst elements
    - 1xThermocouple
    - DeltaP
- 1 NOx Sensor (one per engine)



The operation of the H+H SCR system is controlled automatically by a programmable measurement- and control system. Active interference or supervision by operating personnel is not necessary.

The catalyzer housing is installed on a separate platform and is erected on a special steel support. The catalyzer housing must be disconnected from engine and exhaust gas system vibrations by means of flexible support elements and compensators. To cope with the heat extensions of components exposed to elevated temperatures, defined extension is allowed in certain places.



## 8.1. Pump station

### 8.1.1. Characteristics

Equipment for increasing the pressure of urea solution up to 7 bar.

### 8.1.2. Installation

Consider maximum suction lift of 4 m. In case of taking the reducing agent with a suction lance from the top of the tank (e.g. bottom tanks) a check valve must be provided inside the tank (not H+H scope). The maximum opening pressure for this check valve is 50 mbar. The check valve has to be made of stainless steel.

Before startup of the urea main pump make sure that:

- Aqueous urea solution is available inside the tank
- The pump is filled up with water (no dry run!)
- All signals and rotation direction checked
- Inlet and outlet ball valves on pump station are opened
- Inlet and outlet ball valves on pressure control and distribution unit (see following chapter) are opened
- Repair switch is not activated (not H+H scope)
- Leakage test of pipes is done
- Filter cartridge of pre filter (0.250 mm is installed)
- All pipes are connected in the right way and with the correct diameter (see P&ID).

### 8.1.3. Equipment

|                                  |                       |            |
|----------------------------------|-----------------------|------------|
| - 1 x Main filter with cartridge | (0HSJ10AT010/AT020)   | (see MSDS) |
| - 1 x Pressure transducer        | (0HSJ10CP050)         | (see MSDS) |
| - 1x Manometer Ø 63              | (0HSJ10CP010/020/025) | (see MSDS) |
| - 1 x Urea main pump             | (0HSJ10AP010/AP020)   | (see MSDS) |
| - 1 x Pressure control valve     | (0HSJ50AA030)         | (see MSDS) |

### 8.1.4. Set points of field devices:

|                         |     |     |
|-------------------------|-----|-----|
| Pressure control valve: | 7   | bar |
| Pressure transmitter:   | 6/8 | bar |



**Before any work on the pump station or the pump, please do set the repair switch to 'OFF'.**

**For more detailed information about urea main pump(s) see additional manual in our MSDS (material and safety data sheets).**

## 8.2. Dosing unit inside control cabinet (xCBC10)

### 8.2.1. Characteristics

- Cooling down the two-phase nozzle before dosing urea solution. (While cooling down the nozzle the solenoid valves xHSC10AA020 and xHSC10AA040 are open. The cooling process depends on the length and diameter of pipe between dosing unit and injection nozzle. Normally, the time of cooling is adjusted to 180 seconds).
- Measuring and adjusting the required urea flow (coming from polygon, see chapter SCR control cabinet (+xCBC10)).
- Cleaning and removal of the remaining urea solution from the system after shut down of the flow to stop or standby process (While cleaning the nozzle the solenoid valves xHSC10AA020 and xHSC10AA040 are open.). The purging process depends on the length and diameter of pipe between dosing unit and injection nozzle. Normally, the time of cooling is adjusted to 180 seconds.

### 8.2.2. Installation

The dosing unit should be installed in a way that the piping between the outlet of the dosing unit and the injection lance is no longer than 10 m.

Before commissioning make sure that:

- all pipes are connected in the right way with the right dimension (see P&ID)
- all pipes are cleaned (very important)
- leakage test of pipes is done
- pressurized air inlet ball valve is open
- dosing valve (xHSJ10AA020) is adjusted (see adjustment of dosing control valve, MSDS)
- set points of field devices are adjusted
- pressure regulator for compressed air (xHSC10CP010) is adjusted to 5,0 bar
- check valves (xHSC10AA030 and xHSC10AA050) are correctly installed (see arrowhead)
- flow meter (xHSJ10CF010) is adjusted
- flow switch compressed air (xHSC10CF010) is adjusted

### 8.2.3. Equipment

- |  |                       |            |
|--|-----------------------|------------|
| - 1 x Dosing valve   | (xHSJ10AA020/AA021)   | (see MSDS) |
| - 1 x Flow meter   | (xHSJ10CF010)         | (see MSDS) |
| - 1 x Fine filter compressed air with<br>Pressure control valve in combination | (xHSC10CP010)         | (see MSDS) |
| - 1 x Flow switch compressed air   | (xHSC10CF010)         | (see MSDS) |
| - 2 x Solenoid valves compr. air   | (xHSC10AA020/040)     | (see MSDS) |
| - 1 x Check valve compressed air   | (xHSC10AA015/030/050) | (see MSDS) |
| - 1 x Check valve urea   | (xHSJ10AA040)         | (see MSDS) |

### 8.2.4. Set point of field devices

Flow switch compressed air (xHSC10CF010): 60% of max flow.  
Max flow setpoint at 3,0 without dosing



### 8.3. DOC & SCR Catalyst and Equipment



SECTION 8.3.1 THROUGH SECTION 8.3.3 DESCRIBE THE CATALYST EQUIPMENT AND INSTALLATION. PLEASE REFERENCE SUPPLEMENTAL MANUAL "SCRonF Manual V 1.1" AND "X0001-0000-64 QUICK-LID IOM Manual" FOR SPECIFIC INFORMATION PERTAINING TO THE DCL SCRonF REACTOR AND DIESEL OXIDATION CATALYST SUPPLIED AS PART OF THE EMISSIONS CONTROL SYSTEM.

#### 8.3.1. Characteristics

- Please reference supplemental DCL manual supplied with this O&M manual: "SCRonF Manual V 1.1"
- Please reference supplemental DCL manual supplied with this O&M manual: "X0001-0000-64 QUICK-LID IOM Manual"

#### 8.3.2. Equipment (per catalyzer)

- Please reference supplemental DCL manual supplied with this O&M manual: "SCRonF Manual V 1.1"
- Please reference supplemental DCL manual supplied with this O&M manual: "X0001-0000-64 QUICK-LID IOM Manual"
  
- 1 x temperature measuring devices (xHSA20CT010/020) (see MSDS)
- 1 x differential pressure measuring device (xHSA20CP010) (see MSDS)
- 1x NOx distribution box (xCBC40) (see ECC)

#### 8.3.3. Installation

- Please reference supplemental DCL manual supplied with this O&M manual: "SCRonF Manual V 1.1"
- Please reference supplemental DCL manual supplied with this O&M manual: "X0001-0000-64 QUICK-LID IOM Manual"

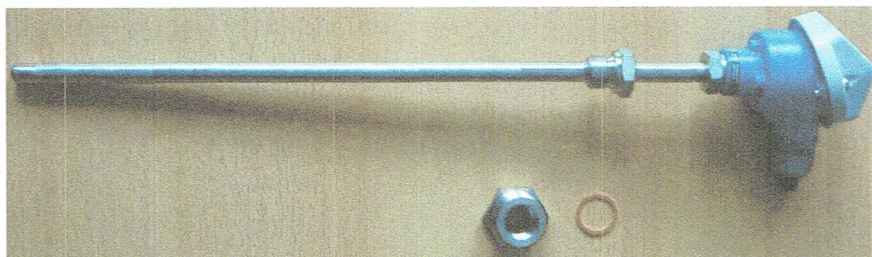
##### Installation of field devices

##### 8.3.3.1. Temperature sensors (xHSA20CT010/CT020)

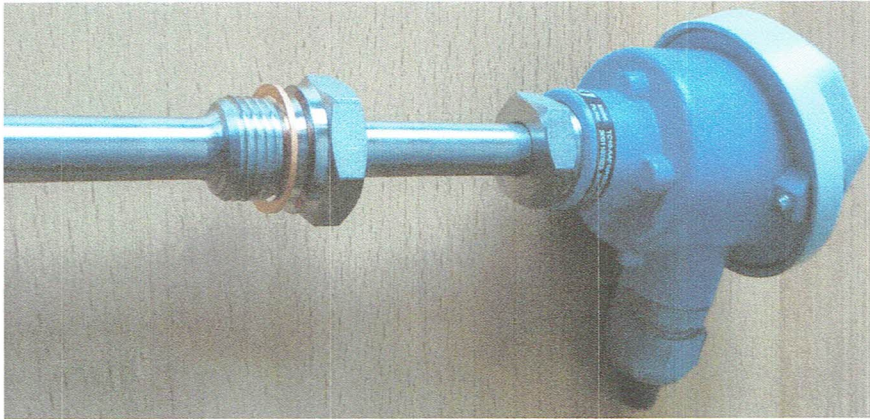
The sensors are prepared before delivery so that they can be screwed directly into the nozzles of the catalyzer housings (use PTFE tape to seal threads).

The following parts are needed for each temperature sensor:

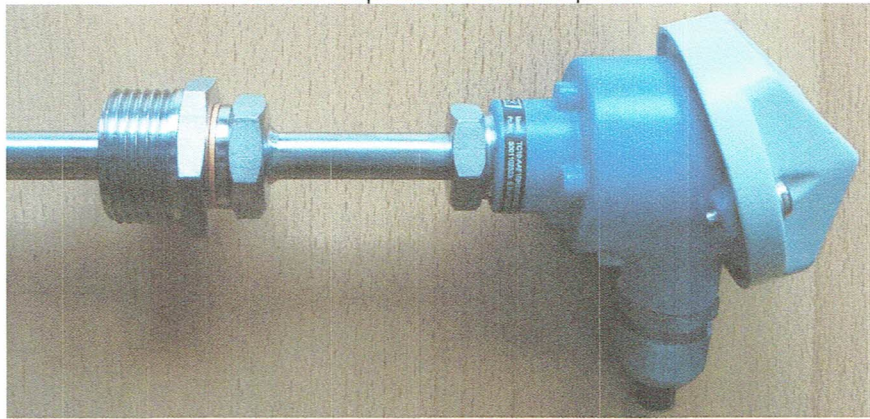
- 1 x connection piece 1" - 1/2" (H+H scope of supply)
- 1 x copper seal (H+H scope of supply)
- 1 x seal PTFE thread tape for sealing (not H+H scope)



First step: slip seal over connection thread



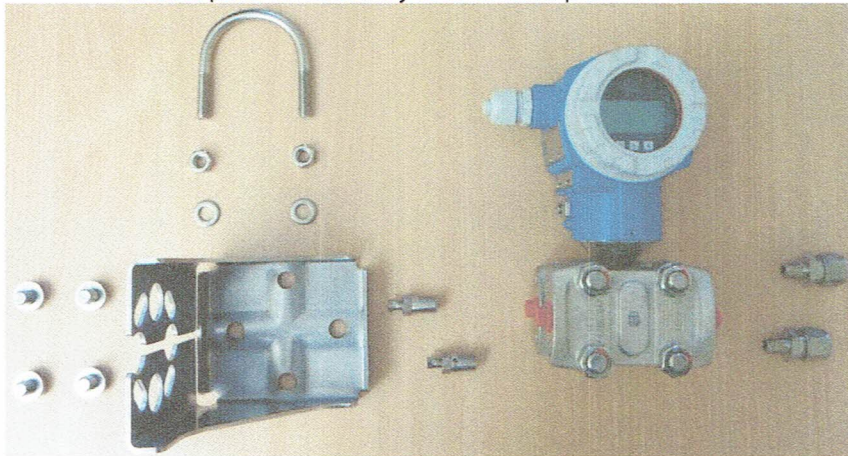
Second step: attach reduction piece



Sensor is now ready for mounting.

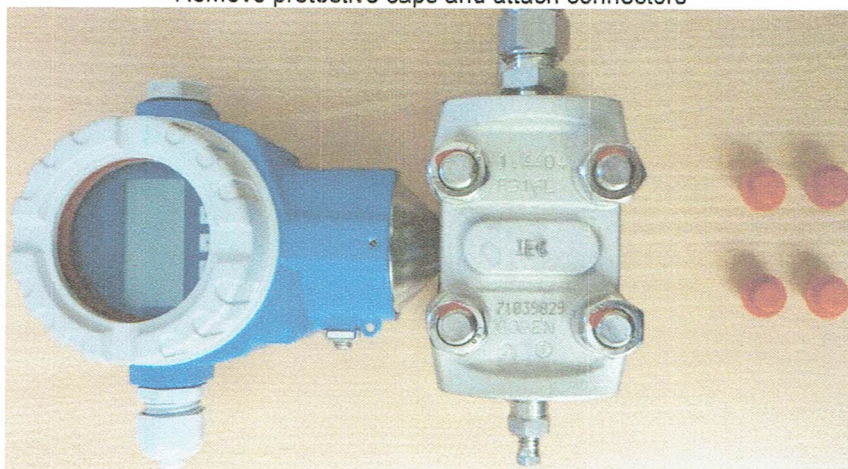
### 8.3.3.2. Differential pressure transmitter (xHSA20CP010)

Needed parts for assembly of differential pressure sensor





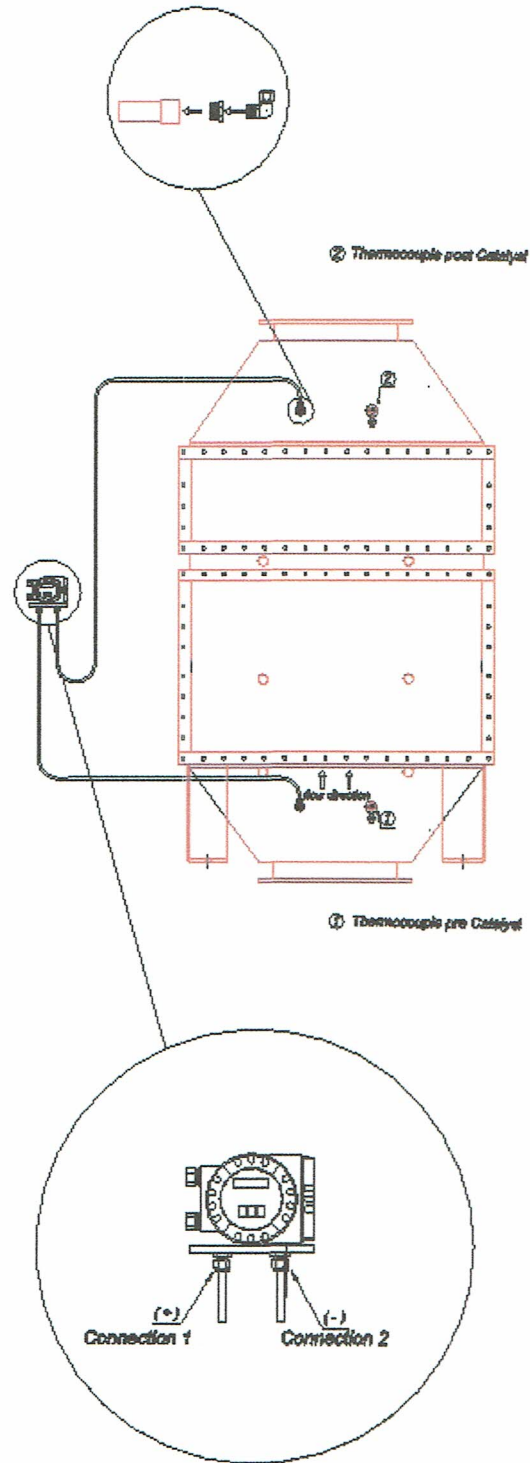
Remove protective caps and attach connectors



Fully assembled sensor with mounting plate but without Teflon tubes



Install differential pressure sensor above measuring points in order to avoid backflow of condensate water into the sensor. Alternatively the sample plug must point upwards with sample pipes installed as siphon.





## 8.4. Static mixer / mixing device

### 8.4.1. Characteristics

Inject urea mist into flue gas stream and mix

In order to achieve an optimum reaction at minimum reduction agent consumption, the reaction has to be prepared precisely.

This is done in a compact mixing element which essentially consists of the following elements:

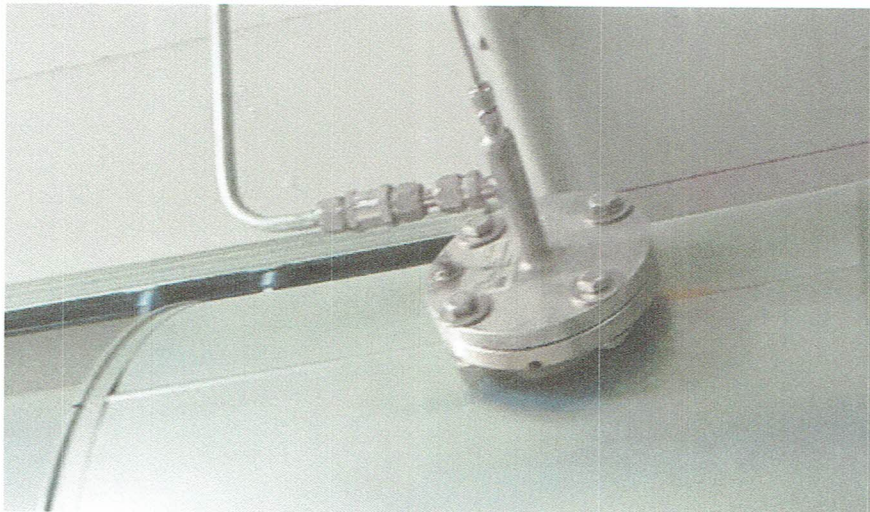
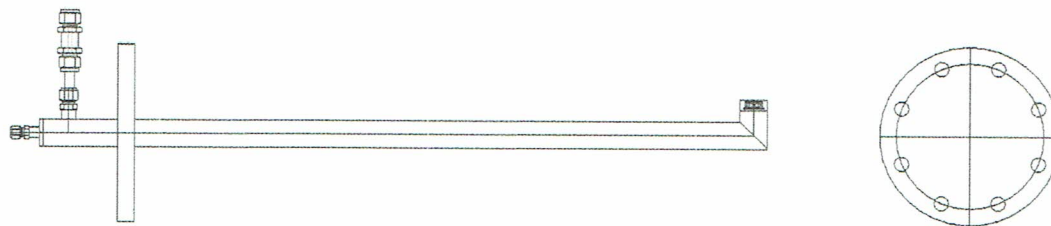
- Two phase nozzle
- Flow dynamically optimized mixing device
- Mixing distance

### 8.4.2. Two phase nozzle

Specially designed and adjusted reduction agent Injection with two phase nozzle. The liquid is supplied through the nozzles under pressure by a co-axial lance. In the nozzle, the reduction agent is mixed with air and a fine vaporized jet is produced.

In common operational conditions, double jet nozzles achieve the highest degree of vaporization. They generate extremely fine drops having a high specific surface thus permitting an intensive contact between reducing agent and waste gas. The operational pressure of the vaporized air is adapted to the reduction agent supply flow of the nozzle in such a way that the spraying properties remain constant in a large field of dosing

The nozzle system is dimensioned in such a way that a significant temperature increase of the reducing agent must only take place in the waste gas flow. When applying the reducing agent urea, this particular requirement has to be met. Otherwise polymolecular reaction products, such as biuret or melamine, can form in the nozzle system as a result of thermal urea decomposition and lead to clogging in this zone. Outside the nozzle, the urea is heated up quickly under release of  $\text{NH}_3$ , a process which is even reinforced by the large specific surface of the fine vaporized liquid.



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#### 8.4.2.1. Sequence of Operations

Remark: After every shut down, the lance has to be flushed with water/air at the liquid connection to avoid that urea remains in the lance! During this procedure the pressure at the pressurized air connection should remain stable.



All work on the lance should only be done by trained personnel.  
The parts of the lance inside the exhaust gas pipe can be very hot. Handle with care!

#### Tools

- Repair stand to put down the lance
- Wrench set (see drawing of static mixer for correct wrench size)
- Blind flange for covering the connection flange
- Spare sealing for the flange connection
- Heat resistant sealing paste for the nozzle thread (i.e. Molykote)
- Pressurized air, solvent, brushes and rags for cleaning the lance and the nozzle tips

#### 8.4.2.2. Removal of the lance

Again: The parts of the lance inside the exhaust gas pipe can be very hot. Handle with care!

- Check that the engine is STOPPED, don't remove the lance while engine is running
- protect the engine against accidental restart
- Check that the lance is flushed
- Close the ball valve (xHSJ10AA010) of the Urea line
- Close the ball valve (xHSC10AA010) of the pressured air line
- Make sure that the engine switch on the SCR Control Cabinet is set to "OFF"
- Disconnect the Urea line and pressurized air line at the lance
- Loosen the bolts at the mounting flange
- Remove the lance and put the lance on the repair stand
- Mount the blind flange at the connection flange

#### 8.4.2.3. Cleaning and Inspection

- Clean the lance surface and the flange
- Screw of the nozzle tips
- Clean the nozzle tips
- Carefully clean the holes of the nozzle tips
- Check the metal sealing surface of the nozzle tips
- The sealing surface should not be damaged apart from the sealing groove
- Check if the nozzle outlet is sharp-edged
- Replace the nozzle tips if the sealing surface or the nozzle outlet is damaged
- Clean the thread in the nozzle header and the nozzle head
- Put heat resistant sealing paste on the nozzle thread and the area below the mixing chamber
- Blow with the pressurized air through the pressured air connection
- Blow with the pressurized air through the Urea connection

#### 8.4.2.4. Testing

- Screw in the nozzle tip and tighten manually
- Connect the Urea and pressured air line with the lance
- Open the water and pressure air line

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- Adjust the operating values according to data sheet
- Use leak detection spray to check the sealing of the nozzle tip. If the nozzle tip is leaky retighten the nozzle tip. Replace the leaky nozzle tip if this is not successful and repeat the testing procedure
- Check whether the water spray is symmetric and smooth. Pay attention to fluctuations
- Don't install the lance when the spray is not o.k.
- Check whether the leakage and spray test can be performed at the mounting place. If this is not possible the lance must be tested at another place

If testing fails, please contact H+H for trouble shooting!

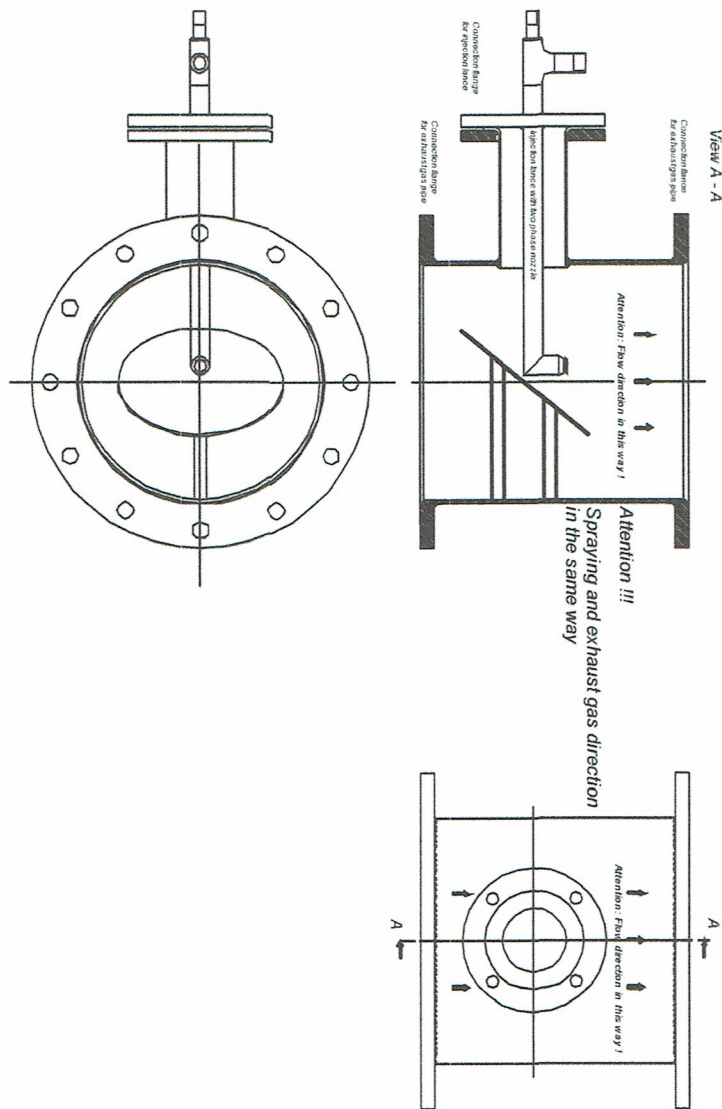
#### 8.4.2.5. Installation



Check that the engine is NOT running.  
Don't install the lance while the engine is running.

- Remove the blind flange from the connection flange
- Check the sealings on the mounting flange, pressurized air and Urea connection
- Replace the sealing in case of need
- Feed the lance into the exhaust gas pipe, see chapter [8.5.3](#) for nozzle orientation
- Tighten the bolts at the mounting flange
- Connect the Urea line and pressurized air line with the lance
- Open the ball valve (xHSJ10AA010) of the Urea line on the PCU
- Open the ball valve (xHSC10AA010) of the pressured air line on the Dosing Unit
- Check again that all shut-off valves are open after maintenance
- Put the engine switch on the SCR Control system to "ON"

### 8.4.3. Flow optimized static mixer



#### 8.4.3.1. Characteristics

This mixer is used to equally distribute the urea solution injected throughout the entire flow-in diameter of the catalyst. Thus, the clogging risk of the catalyst, the reduction agent consumption and NH<sub>3</sub> slip are reduced down to a minimum.

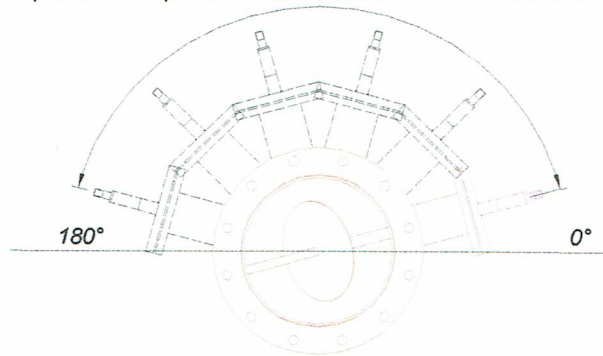
#### 8.4.3.2. Equipment for one mixing device

- 1 x Mixing device / Static mixer with connection flange for injection lance
- 1 x Injection lance with two phase nozzle and connecting flange
- Stainless steel screws and nuts for connecting injection lance with mixing element
- 1 x Flexible tube (OPTION) for compressed air connection with check valve xHSC20AA010 and tube fittings
- 1 x Flexible tube (OPTION) for reducing agent with check valve xHSJ20AA010 and tube fittings
- 1 x graphite sealing for connection flange

#### 8.4.3.3. Installation

The injection nozzle should be the highest point in the urea piping outlet from the dosing unit.

In horizontal pipes the lance connector should point upwards. The next image shows a radius of possible positions. The number of positions depends on the number of boreholes in the connection flange.

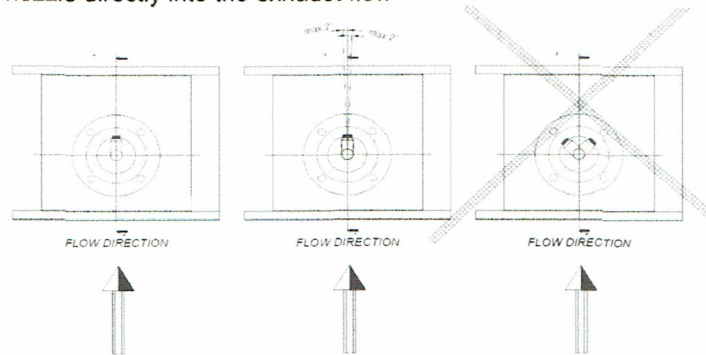


The mixing device is designed for horizontal and vertical installation.

For tight tube fitting consider installation instructions of Swagelok (see MSDS)

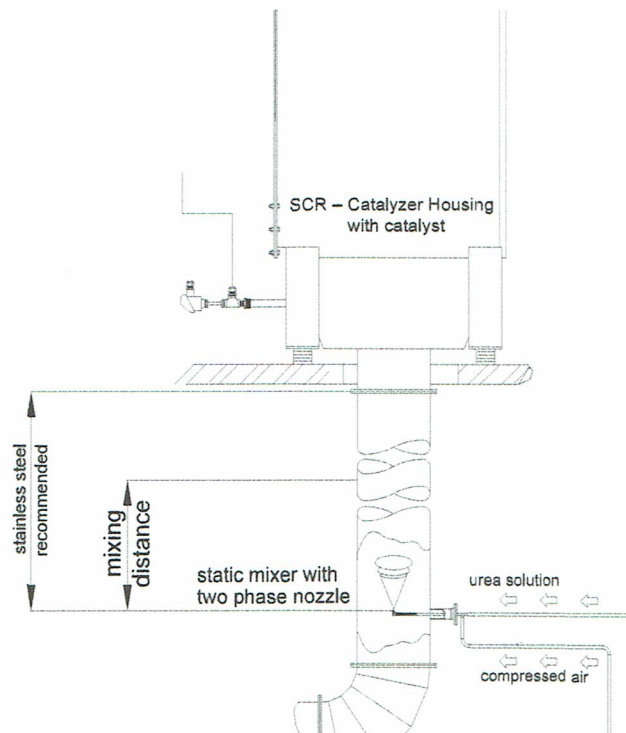
Make sure that all protective coverings have been removed before the injection lance is built into the mixing element.

Install the injection nozzle directly into the exhaust flow



#### 8.4.4. Mixing Distance

This distance is required for the complete disintegration of urea to ammonia and water and to homogeneously mix it with the flue gas.



The needed distance depends on the reducing agent flow, temperature, diameter of exhaust gas pipe (mixing device), compressed air consumption and exhaust gas flow.



Within this distance different decomposition products like **isocyanic acid** will appear. These products can lead to a higher risk of corrosion for all parts within this distance. **When constructing this area of the exhaust gas pipe the resistance to corrosion of all used materials has to be taken into account.**



**The static mixer should only be installed in straight pipes.**

**Rough reference values for the minimum straight pipe after the static mixer as function of the reducing agent flow are:**

| Urea Flow<br>[dm <sup>3</sup> per hour] | minimum straight pipe after mixer<br>[mm] |
|---|---|
| up to 20                                | 1800                                      |
| 20 to 50                                | 2500                                      |
| 50 to 220                               | 3200...4000                               |

Please refer to the PID or contact H+H for exact values.



**H+H strongly advises not to install bends of any kind within the mixing distance. If the technical situation forces the use of bends closer to the static mixer then the above given lengths please contact H+H.**

Should compensators be installed as part of this straight pipe they should have sleeves / inliners.

The final decision for the material depends on the reducing agent flow, exhaust gas temperature and flow, compressed air consumption, diameter and routing of the exhaust gas pipe.

**Neither the pipe routing nor the chosen materials have any influence on the disintegration of urea.**

Hint for a first approach for the design of the mixing distance:

H+H has made good experiences with 1.4301 for straight pipes and 1.4541 for all other parts.

Bends or compensators within the mixing distance should be avoided. If the technical situation forces the use of compensators within the mixing distance H+H gives the following recommendations:

- Bends and compensators have to be made out of stainless steel (see above)
- Compensators should have sleeves/inliners
- Place bends or compensators as far to the end of the mixing distance as possible
- All parts between static mixer and catalyzer housing should be made from stainless steel

## 8.5. NOx Analyzer

OPTION: NOx sensor with junction box +1CBC40/50.



### 8.5.1. Characteristics

This device measures the NOx concentration on the outlet side of the catalyzer. The engine with operational will be monitored continuously after the injection starts. The NOx sensor consists of a ceramic sensor element and an electronic control unit (ECU). The NOx sensor measures the NOx concentration and equilibrium oxygen partial pressure in the exhaust gas of combustion engines (gasoline and diesel) and can be used for diesel engines (SCR catalyts, NOx trap, closed-loop NOx control). The specified mounting position of the NOx Sensor is before the reducing agent injection point or after SCR catalyzt.

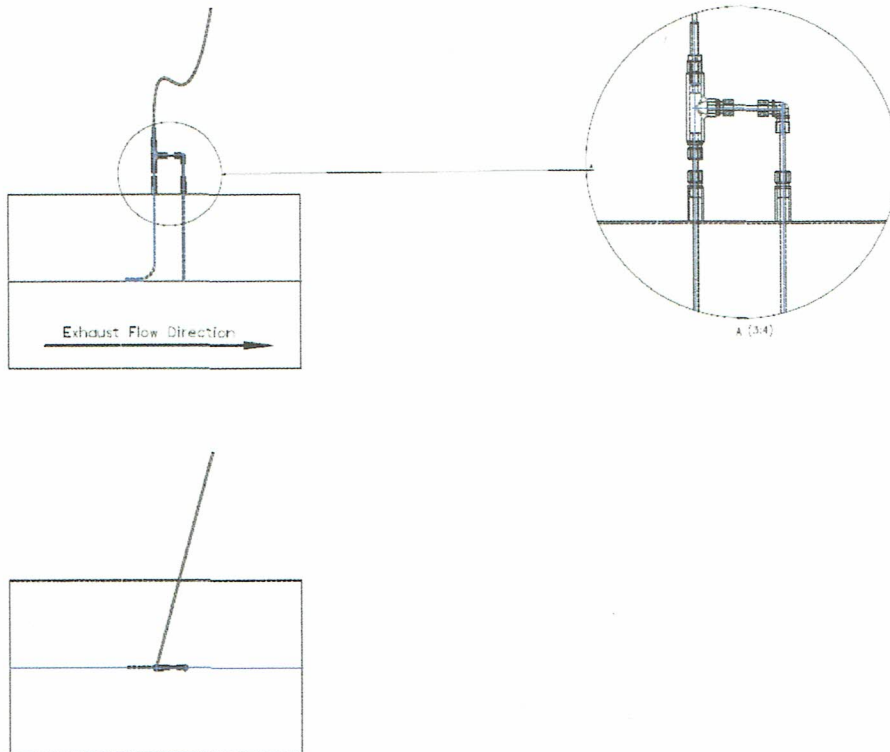
A ceramic sensor element made of zirconium electrolyte measures the oxygen concentration entering from the exhaust gas through a diffusion barrier into a first cavity. The oxygen concentration inside the cavity is controlled to a constant concentration of a few ppm O<sub>2</sub>. Other components of the exhaust gas like HC, CO and H<sub>2</sub> also enter the cavity and are oxidized at the first pumping electrode made of Pt. From the first cavity the test gas with a few ppm O<sub>2</sub> and NOx enters a second cavity, where gaseous oxygen is totally removed by an auxiliary pump. At the measuring electrode, the equilibrium of NO + N<sub>2</sub> + O<sub>2</sub> is changed by removing oxygen generated by the reduction of NO. The amperometric measurement IP2 of the generated oxygen represents the NOx concentration of the exhaust gas. An electronic control unit (ECU) provides power control for heating the sensor element to operating temperature. In an ASIC the control of amperometric operation of all pumping cells to determinate NOx concentration is realized. The ECU provides the measured gas concentrations digitally via CAN bus.



### 8.5.2. Standard Equipment

- 1 x NOx Sensor with junction box
- 1 x Set of fittings and pipes will be delivered. The fittings on the exhaust system should be ½" or 1" and they are not included.

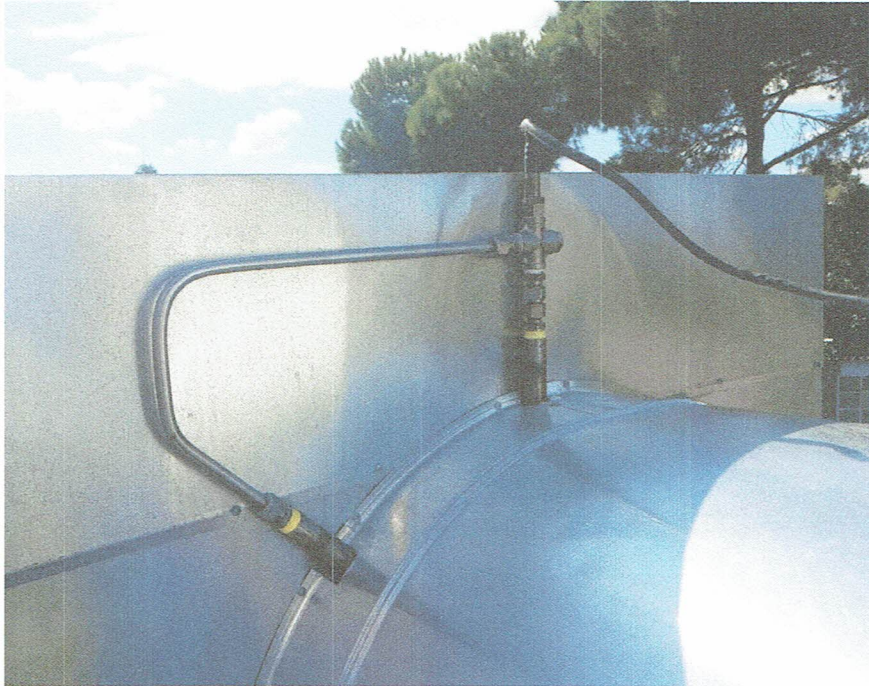
### 8.5.3. Installation



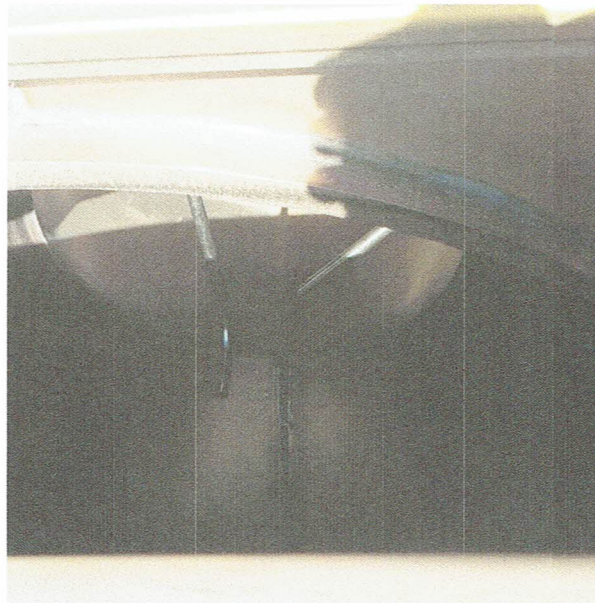
- The NOx sensor should be installed after the Catalyst and before a heatexchanger.
- In general, the sample pipe has a 90° bow, must point upstream of the exhaust flow and be placed in the middle. The return pipe, which is just a straight pipe, should also be placed towards the middle of the exhaust pipe.
- Note: All pipes outside of the exhaust pipe should be as short as possible! This will avoid condensation, which will damage the NOx Sensor.
- The cable between the sensor and the junction box is only 70cm long and cannot be extended. Therefore, a proper support for the junction box has to be made, near the sampling point.

#### 8.5.4. Example

Outside of the exhaust pipe



Inside of the exhaust pipe:



## 8.6. SCR Control Cabinet +xCBC10

### 8.6.1. Characteristics

The main function of the combined control and regulation system of the SCR plant is to keep the NO<sub>x</sub> emission behind the exhaust gas purification plant below a given nominal value - approx. 80 - 99 % of the admissible emission limit.

For this purpose, the functional relation between the NO<sub>x</sub> emission, the resulting reducing agent flow and the load of the engine is recorded in the digital control system (PLC) as an operational characteristic (polygon). With this operational characteristic, a delay-free pre-dosing of the reducing agent is carried out depending on the engine load.

In addition, a close loop control compares the reducing agent flow measured with the recorded nominal value of the reducing agent need, which depends on the engine load. Using a digital/analogous transformer, the output of the controller is transformed into an analogous signal (4...20mA).

In the emission measuring system (OPTION), the NO clean gas concentration is continuously recorded as additional control value. Depending on the deviation between the control value and the nominal value, the processor determines the reducing agent volume to be injected into the exhaust gas.

By means of the operational characteristic, a rapid pre-dosing of the reducing agent is possible. Furthermore, the additional loop to control the NO clean gas concentration minimizes the reducing agent consumption by precise dosing at any time of operation and independent from the catalyst age.



### 8.6.2. Control and Safety Functions

The reducing agent dosing system is released when:

- the engine is started AND
- the lower limit temperature for the catalyst elements is reached AND
- the limit of minimum request of urea or the engine load is reached

The following control functions are implemented:

- Evaluation of the NOx signal of the gas analyzer
- Release of urea dosing process after system check
- Pre-dosing of urea by operational characteristic control
- Control of the reducing agent flow
- Precise dosing of urea by NO-control (OPTION)
- Control of all security functions and of operational readiness of supply unit
- Control of automatic soot blower operation

To secure the fully automated plant operation the following safety elements are always included

- **Menu-Controlled Adjustment of Parameters**  
The operational parameters of the plant can be adjusted without modifying the program. This also applies to the calibration of the plant performance, the nominal reducing agent flow and the specific adjustment of the flow control system. The adjustments are done on a graphical display with easy to understand numerical inputs.
- **Password Protection for Service Staff**  
The parameterized functions are protected by passwords and are only accessible to service staff or **by H+H authorized and trained operators**. On-site program modifications e.g. for parameterizing the control system are not required. **Changes of parameters or settings by not authorized persons are strictly forbidden and will result in loss of warranty!!!!**
- **Display Error and Warning Messages**  
All error and warning signals are displayed with a detailed message on the touch panel of the control cabinet. In addition, a binary signal to ship control is set and a signal lamp on the SCR control cabinet indicates the event. Errors and Warnings are indicated by a permanent light.

### 8.6.3. Start up - SCR

- Turn main switch on SCR cabinet (1) to "ON"
- Push Operation switch on SCR control cabinet (2) of related plants to "ON".
- Condition: Motor load is higher than adjusted limit (will be adjusted at commissioning)
- Condition: Temperature at catalyst elements is higher than adjusted limit (ca. 310°C)
- Condition: Compressed air supply is connected and higher than 6 bar overpressure
- Condition: No fault
- Plant starts and stops automatically
- Maintenance switch on pumps station distribution panel (+xCBC40) is not activated

For deactivating turn all switches to "OFF" or "0"

### 8.6.4. Installation of SCR control cabinet and distribution boxes

- The ambient temperature for control cabinet +xCBC10 should not be higher than 40°C
- The junction boxes (+xCBCx0) for the SCR system should be installed with no more than 50m cable distance to sensors such as thermocouple or pressure transducers (Option).

## 8.7. Compressor station

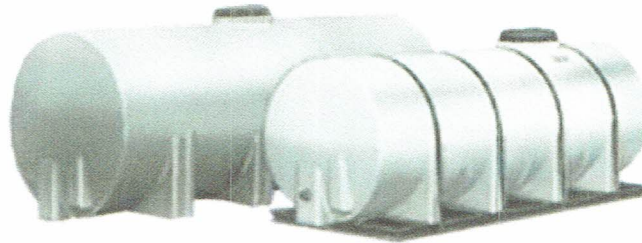


**SECTION 8.7 COVERS THE COMPRESSOR STATION. PLEASE REFERENCE SUPPLEMENTAL MANUAL "GD Hydrovane 2 - 10 HP V0 Series Operating and Service Manual" FOR SPECIFIC INFORMATION PERTAINING TO THE HYDROVANE 5HP HORIZONTAL COMPRESSOR .**

## 8.8. Tank station

### 8.8.1. Characteristics

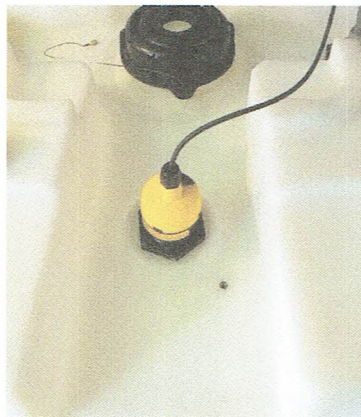
The main function of the urea tank station is the storage of the urea solution. The tank is delivered with a separate ultrasonic level transmitter which has to be installed on top of the storage tank. The fill level will be shown digitally on the control panel screen.



*General view of the tank*

### 8.8.2. Installation of the fill level transmitter

The fill level transmitter needs to be placed into one of the openings of the tank. The device will be simply screwed into a port in the top. The level indicator is a general-purpose ultrasonic transmitter that provides a 4-20 mA output to the SCR panel. The level transmitter is used as a safety shutdown to protect the pump and prevent it from running dry if the urea tank is empty.



*General view of a tank level transmitter, SFA*



## 9. Touch panel, Operation and operation modes

General:

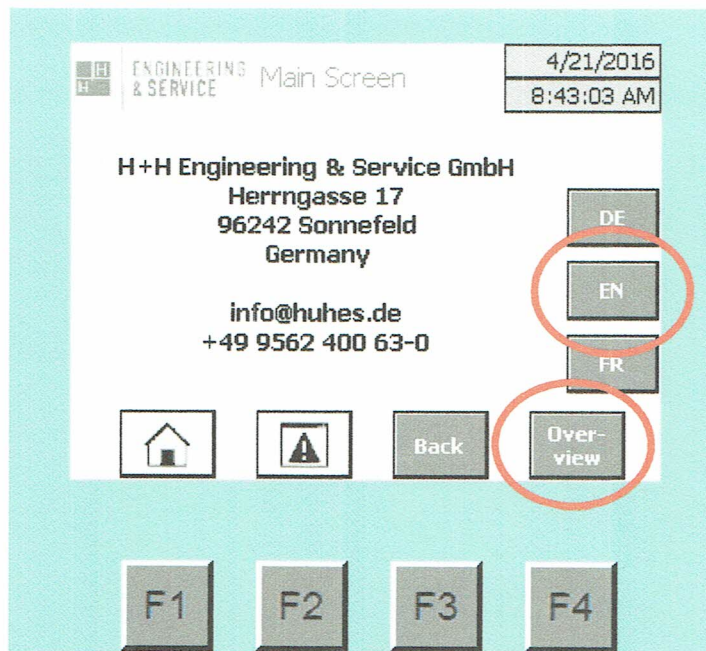
If soot blower systems are installed and the main switch of SCR control cabinet is activated, the relating blower valves will be activated automatically by PLC once the relating engine has been started

The operation of the H+H SCR system is only permitted for personal which was trained by H+H. The commissioning must be accepted or done by H+H personnel.

### 9.1. Touch Panel TP400 (visualization of SCR parameters and signals)

Main-Menu (Press "Home Button" (HUHES Logo) in the upper left corner to indicate the main menu)

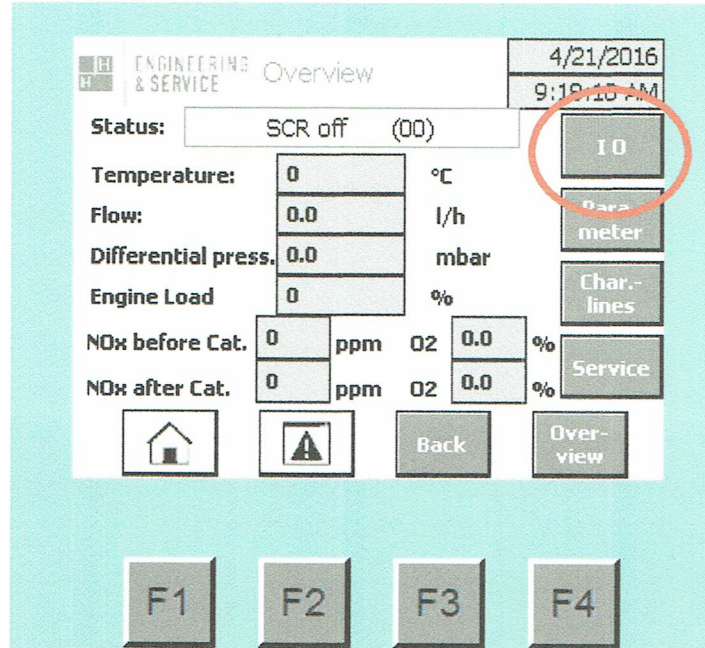
The HMI will show you the status of the System and the most important Parameters of the control logic. In Order to get started and find some information's you should select the language on the main screen as shown below. For the next step you should press the "Overview" button to open the Overview screen



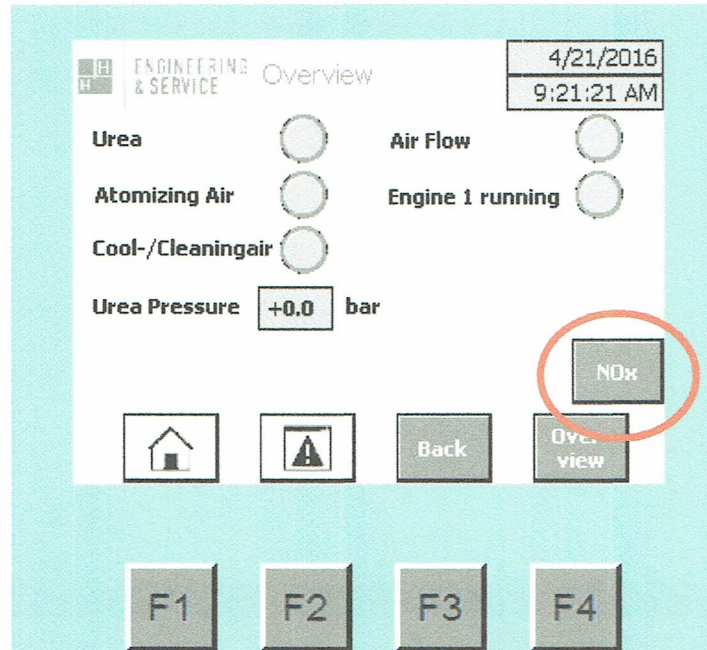


On the Overview screen you will find some information's about the System. Here you can find the temperature after the catalyst (Temperature), the differential pressure over the catalyst (Differential press.), The reducing agent flow (Flow), the Engine load signal (Load) and the Nox/O2 values from the before and after catalyst measurement.

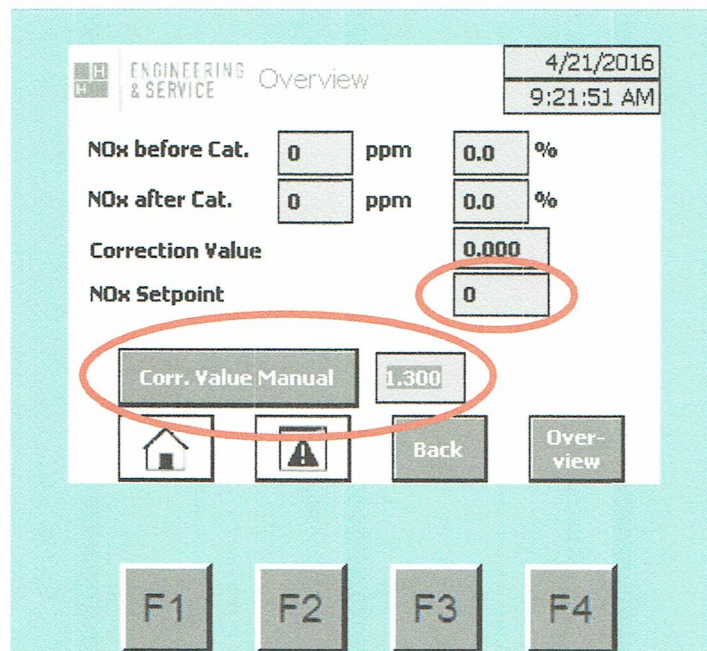
By pressing one of the buttons on the right site, you will open the next screen. By pressing the "IO" Button the IO overview screen will open



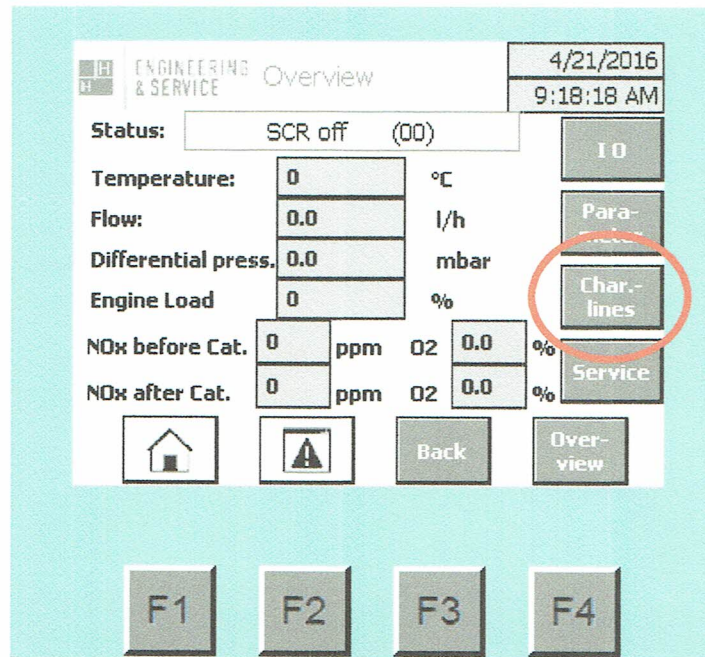
Here you can see the status of the digital inputs. By pressing the "NOx" Button you will get to NOx controller



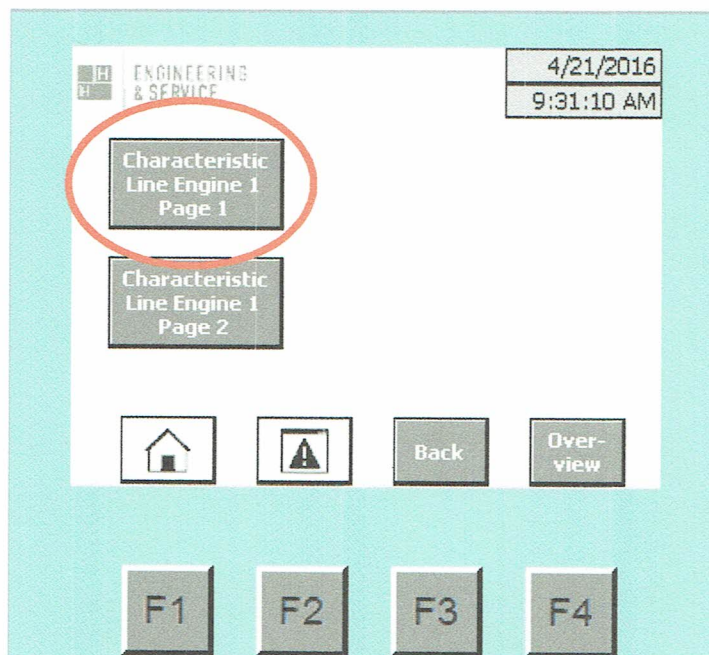
The actual values can be seen again. Further you will find NOx Set-point for the control and possibility to set a manual correction value for increasing the flow. By pressing the "Back" or "Overview" button you will get back to the previous or the Overview screen.



To see the reducing agent injection curve, the "Char.-lines" button needs to be pressed.

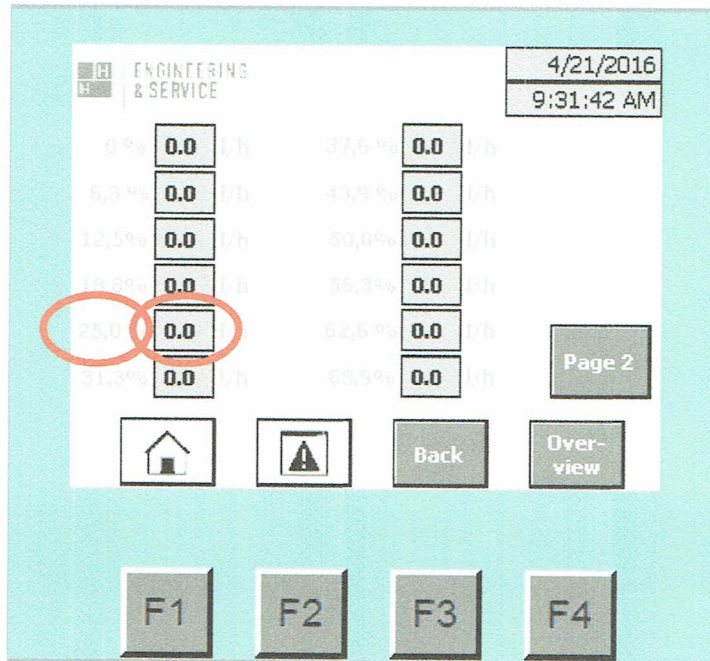


The values are shown on two pages.

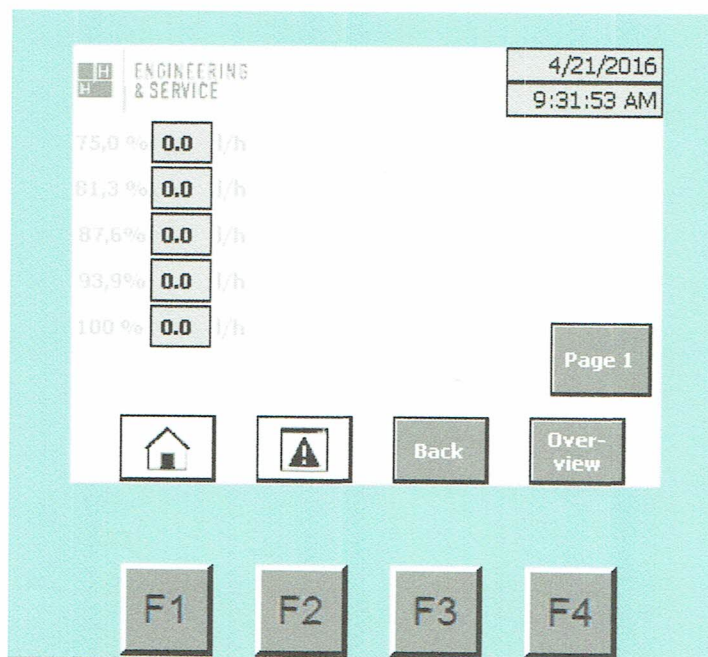




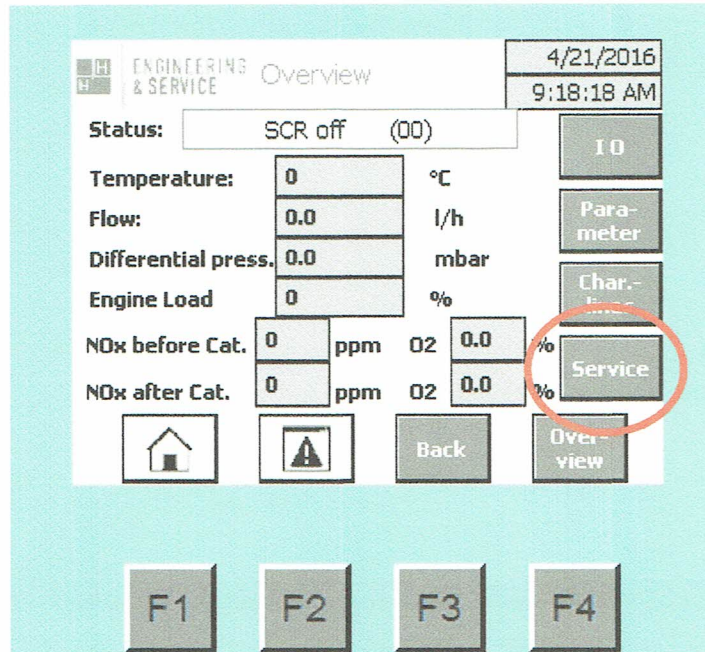
Here you can find the flow settings for the engine load. So for 25% Load the value on the right side will be injected. The values between each load step are calculated. For the load steps from 75 to 100% the "Page 2" Button has to be pressed.



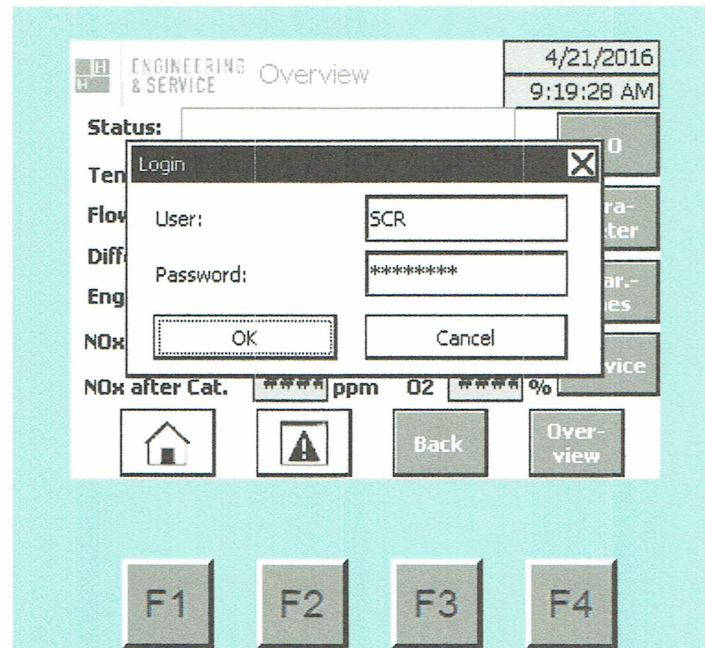
Here are the other values. Again, by pressing the "Overview" Button, the Overview screen will be shown.



Pressing the Service button will allow you to run the System in manual mode.  
!!! This should only be done by H+H Service personal !!!

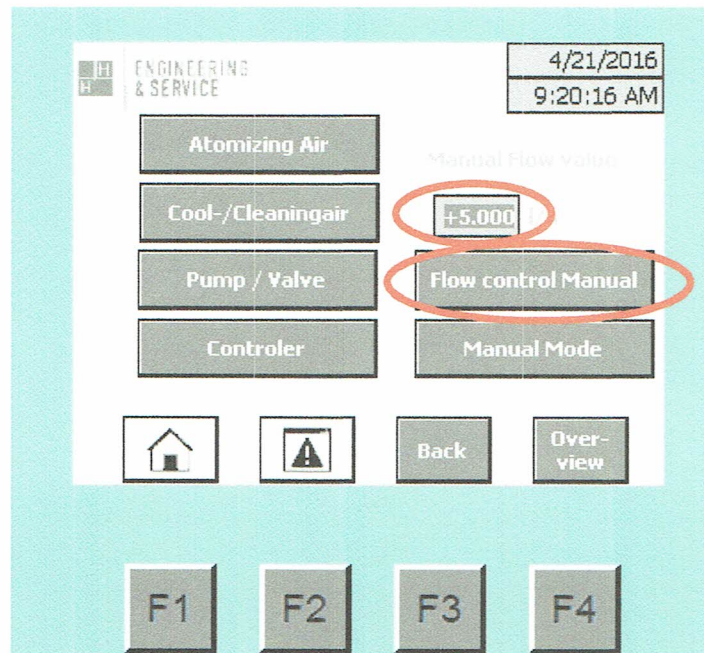


Please enter the Username and Password





Here are the Options to run the System in Manual mode. For test modes the flow can manually be entered (Manual Flow value) and activated ("Flow control Manual" Button). This will not affect the automatic run of the System. It just will overwrite the flow from the characteristic line. Pressing the "Manual Mode" Button will stop the automatic run. If this Button is pressed there is a high risk of blocking the nozzle and putting the System out of Service!



## 9.2. Operation mode "Stand by"

- Main switch on SCR cabinet "on"
- SCR operation switch "on"
- Engine signal "on"
- Alarm Light on the cabinet "off"

## 9.3. Operation mode Start up "Cooling / cleaning"

- Main switch on SCR cabinet "on"
- SCR operation switch "on"
- Engine signal "on"
- Urea request is higher than adjusted minimum (will be adjusted while commissioning).
- The temperature before and/or after catalyst elements is higher than adjusted minimum (will be adjusted while commissioning).
- No Alarm

The compressed air valves (xHSC10AA020/040) on relating dosing panel are opened. The injection nozzle will be cooled by compressed air for an adjusted minimum time (normally 3 minutes)

## 9.4. Operation mode "Dosing"

After cooling time of injection nozzle the cooling air valve (xHSC10AA040) will be closed. At the same time the urea valve (xHSJ10AA030) will open. The operation mode dosing will begin if:

- Main switch on SCR cabinet "on"
- SCR operation switch "on"
- Engine signal "on"
- Urea request is higher than adjusted minimum (will be adjusted while commissioning).
- The temperature before and/or after catalyst elements is higher than adjusted minimum (will be adjusted while commissioning).
- No Alarm
- The atomizing and cooling air pressure (xHSC10CP020(030)) is higher than 4.0 bar overpressure.
- Flow switch compressed air (xHSC10CF010) is higher than adjusted minimum
- Urea pressure (xHSJ10CP010) is higher than adjusted minimum.

The reducing agent will be injected into the exhaust gas before the catalyzer housing according to the adjusted polygon Urea flow = f(engine load).

If a NOx analyzer cabinet is installed the polygon will be fine regulated and corrected according to the adjusted NOx set point.

## 9.5. Operation mode "Shut down to Standby"

- Main switch on SCR cabinet "on"
- SCR operation switch "on"
- Engine signal "off" OR
- Urea request < minimum OR
- Temperature before catalyst elements < minimum OR
- Temperature after catalyst elements < minimum

The SCR control system will stop dosing process of the relating engine. Both air valves (xHSC10AA020(040)) are opened for cleaning the nozzle from urea for an adjusted time (normally 3 minutes). The urea valve (xHSJ10AA030) will be closed after opening the compressed air valves. After adjusted cleaning and cooling time the compressed air valve will be closed. The system is waiting for the next start up. No action of operator required.



### CAUTION!

While dosing or shut down procedure, never switch off the compressed air supply. Otherwise risk of clogging of injection nozzle or injection lance

## 9.6. Operation mode "Shut down to off"

- Hardware or supply error (e.g. atomizing air too low, wire break of field devices...)
- SCR operation switch = off

The system will shut down in the same way as "shut down to standby". The operator must eliminate the cause of errors. After eliminating the cause of error the operator must push the "fault accept" button.

For more information of errors see chapter "Errors and Alarms"



## 10. Pre Conditions for Commissioning

Commissioning of the SCR system consists of two parts, Cold and Hot commissioning. Cold commissioning has to take place before Hot commissioning can be done.



- To adjust the exhaust gas values, parameters and polygons, every engine with SCR System must be available for operation with 20% up to 100% of load (at minimum 5steps, approx. 20 minutes per step).
- Screws of hatches / doors have to be assembled using suitable copper free high temperature paste or spray
- Engines should only run when seals are installed and doors are closed.
- All Urea and air pipes are flushed and free of any dirt.

### 10.1. Mandatory Conditions for Cold Commissioning

To assure that the time of commissioning and adjustment of the SCR system is as short as possible, we kindly recommend the following points to be prepared and met prior to Cold Commission:

- The load area for the catalyzer housing must be freely accessible!
- Motors must be of and the catalyzer housing must be fully cooled down below 35°C.
- Two or three workers with necessary tools for installing the catalysts have to be available (installation is supervised by H+H).
- The catalyst modules should be available, near catalyzer housing.
- The doors for catalyst loading have to be open.



Make sure that the Motors are not started until all doors are closed again and engine operation is approved by the responsible H+H engineer.

- The wooden boxes with the catalyst elements should be nearby the catalyzer housings.
- For opening and closing of the doors copper free antiseize paste for the screws as well as all necessary tools (compressed air, electrical screwdriver, etc.) have to be available.
- Tank for the reducing agent (urea) has to be filled up to at least 1/4 of his full volume with the reducing agent.
- 6 bar air pressure (overpressure) are available.
- Power supply for the SCR control cabinet is available on request.
- Fresh water supply is nearby the pump station.
- Necessary tools are available (besom, ratchet (with bolt of lock), light).
- System is completely insulated.
- Weather protection, heating and sanitary installations have to be available for commissioning personnel.
- Platforms and ladders are available; all parts of the plant are attainable.
- Piping for reducing agent completely installed, flushed and pressure tested.
- Test reports are available at site.
- compressed air piping to dosing unit ready, flushed and pressure tested; air available, all pipes are cleaned, leakage test finished
- Soot blowing system is installed and ready (if part of project); compressed air is available.
- Start up / commissioning engineer for engines has to be available at site.
- Coupling / load signals and/or bus connection are connected with engine control system.
- Occasional warming up of the catalyst by exhaust gas flow is possible if needed.
- Pipes / tubes for measuring differential pressure over catalyst are installed and connected
- Electrical installation ready and steady tested; test report is available at site
- Current power supply for switch cabinets is available
- Desk is available close to SCR control cabinet +xCBC10 for programming device, printer etc.



## 10.2. Mandatory Conditions for Hot Commissioning

The following conditions have to be met prior to final Hot Commissioning:

- Cold Commissioning has to be successfully completed.
- Engine is running with constant NOx load
- Engine adjustments must be finished (cooling, air and temperature management, cooling water)
- Operation of engines is possible in different load conditions according to the request of H+H SCR commissioning personnel
- NOx analyzer system (if part of the order) is completely installed
- Span gas (100 ppm NO, rest N2) is available at site
- Tank for reducing agent is filled (if in doubt contact H+H for minimum needed amount)
- Responsible engineers of final owner as well as operators are available for training after commissioning.

## 10.3. Checklist for commissioning

This list is provided for information purposes only. The actual list will be filled out, signed and provided by an H+H engineer after Commissioning.

### General

| Checkpoint  | Remark |
|---|--------|
| All components according to device list and flow diagram    |        |
| All components mounted correctly and stable                 |        |
| All supply systems connected and marked (power, air, urea)  |        |
| All devices marked if necessary                             |        |
| General condition, painting, cleanness                      |        |
| All components accessible, platforms installed if necessary |        |
| All openings of the exhaust gas system closed               |        |

### Catalysts, Housing and Injection System

| Checkpoint   | Remark |
|--|--------|
| Housing mounted correctly and stable   |        |
| Housing and injection duct connected and tight welded  |        |
| All mounting openings and manholes accessible  |        |
| Reducing agent nozzle adjusted and mounted correctly   |        |
| Catalyst installed according plan  |        |
| Mounting openings of catalyzer housing tightened and closed                                  |        |
| Insulation of catalyzer housing completed  |        |
| Thermocouples and differential pressure transmitter installed according mounting instruction |        |
| Pressure transmitter connected according manual  |        |
| Differential pressure transmitter zero and span adjusted                                     |        |

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Electrical system

| Checkpoint  | Remark |
|---|--------|
| All electrical components connected correctly and according manuals |        |
| All cables according cable list                                     |        |
| All connections according drawings                                  |        |
| All signals available in switch gear cabinet                        |        |
| Hour meters in operation  |        |
| Connection and signal exchange to engine control system o.k.        |        |
| Power supply for all systems  |        |

Pipe work

| Checkpoint   | Remark |
|--|--------|
| All pipes according flow diagram   |        |
| Connections to dosing unit, pump station and injection nozzle according mounting instruction |        |
| Pipes cleaned and washed trough  |        |
| Marking of pipework  |        |
| Reducing Agent pipes pressure tested   |        |
| Air pipes pressure tested  |        |
|  |        |

Compressed air station (Option)

| Checkpoint   | Remark |
|--|--------|
| Compressor, buffer tank and condensate drain placed, connected and fixed according instruction |        |
| Oil level controlled, oil filled to air inlet port   |        |
| Door interlock switch tested   |        |
| Rotation of compressor in right direction  |        |
| Setting of timer relays and pressure switch  |        |
| Compressor set to operation according manual   |        |
| Condensate valve of buffer tank function tested  |        |

Pump station

| Checkpoint  | Remark |
|---|--------|
| Pump gearbox filled with oil  |        |
| Safety-repair-switches and emergency-stop-button mounted                              |        |
| Pump rotation checked   |        |
| Pump set to operate with water  |        |
| Overflow valve adjusted   |        |
| Dry running control (pressure-transmitter connected and software-set points adjusted) |        |



Dosing unit

| Checkpoint  | Remark |
|---|--------|
| Dosing valve adjustment (zero and maximum stroke) controlled according manual |        |
| Pressure transmitter output signal according to manometer at pump station     |        |
| Parameters of flow meter set  |        |
| Air pressure reducing valve set   |        |
| Air pressure switch set   |        |
| Air flow switch adjusted  |        |

Soot blowing system (Option)

| Checkpoint                         | Remark |
|------------------------------------|--------|
| Air pressure reducing valve set    |        |
| Pipework pressure tested           |        |
| Function of solenoid valves tested |        |
| Set of blowing times               |        |

NOx analyzer system (Option)

| Checkpoint   | Remark |
|--|--------|
| All Parts mounted according mounting instruction   |        |
| All parts mounted according flow diagram   |        |
| Exhaust gas probes mounted to catalyzer housing at correct place and in accordance with manual     |        |
| Heated exhaust gas pipes between single gas probe and analyzing cabinet mounted correctly and safe |        |
| All electrical connections ready   |        |
| All signals available in PLC   |        |
| NOx-(O2)-analyzer ready and in correct range   |        |

## **11. Alarmlist and Troubleshooting**

See separate Alarmlist BAN020Rxx "Alarm Messages".

## **12. Service & Maintenance**

See separate Service & Maintenance List BAN050Rxx  
(final version will be submitted after commissioning).

Additional spare parts can be prepared and offered upon request.  
For a detailed offer please contact our service department at [service@huhes.de](mailto:service@huhes.de)

## **13. Contact persons**

In case of problems with the SCR system or use of service, please contact the H+H or AeriNOx service department.

**H+H Engineering & Service GmbH**  
**Herrngasse 17**  
**D-96242 Sonnefeld,**  
**GERMANY**

[www.huhes.de](http://www.huhes.de)

Contact persons:

Jürgen Müller  
tel.: +49 (0) 9562 / 40063 – 11  
fax: +49 (0) 9562 / 40063 - 20  
mobile: +49 (0) 160 979 14 288  
[juergen.mueller@HuHES.de](mailto:juergen.mueller@HuHES.de)

André Hoppe  
tel.: +49 (0) 9562 / 40063 - 15  
fax: +49 (0) 9562 / 40063 - 20  
mobile: +49 (0) 171 684 48 41  
[andre.hoppe@HuHES.de](mailto:andre.hoppe@HuHES.de)

**AeriNOx Inc.**  
**100 Cherry Ave, Suite 6B**  
**Eaton, Colorado, 80615**  
**UNITED STATES**

[www.aerinox-inc.com](http://www.aerinox-inc.com)

Contact persons:

Loran Novacek  
tel.: +01 (970) 454 5639  
Mobile: +01 (970) 443 3868  
[lnovacek@aerinox-inc.com](mailto:lnovacek@aerinox-inc.com)

Andy Collins  
tel.: +01 (970) 454 5639  
Mobile: +01 (585) 943 5858  
[acollins@aerinox-inc.com](mailto:acollins@aerinox-inc.com)

| ID | Message   | Possible Cause   | Needed Action   | Location    |
|----|---|--|---|-------------|
| 1  | A Tank empty  | - Tank level low<br>- Tank level sensor broken   | - Refill red. Agent tank<br>- Check tank level sensor<br>- Call H+H Service Hotline   | 0HSJ01CL060 |
| 2  | W Tank level low                                    | - Tank level low<br>- Tank level sensor broken   | - Refill red. Agent tank<br>- Check tank level sensor<br>- Call H+H Service Hotline   | 0HSJ01CL060 |
| 24 | A Tank level signal underflow                       | - Analog Signal less than 3.5mA<br>- Under pressure in pipe<br>- Device is wrong calibrated  | - Check signal<br>- Check tank level<br>- Call H+H Service Hotline  | 0HSJ01CL060 |
| 25 | A Tank level signal overflow                        | - Analog Signal more than 20mA<br>- Device broken<br>- Analog input card broken  | - Check Signal<br>- Check tank level<br>- Change Analog input card  | 0HSJ01CL060 |
| 26 | A Tank level signal wirebreak                       | - Broken cable<br>- No power supply<br>- Device broken<br>- Broken Analog input card<br>- Broken Analog output at device                 | - Measuring cable<br>- Check Power supply<br>- Check Signal<br>- Replace Analog input card<br>- Replace tank level sensor<br>- Call the H+H Service Hotline   | 0HSJ01CL060 |
| 22 | W NOx sensor pre catalysts on error                 | - Broken cable<br>- No power supply<br>- Device broken<br>- Broken CAN-converter<br>- Communication to converter interrupted             | - Measuring cable<br>- Check Power supply<br>- Check ethernet connection<br>- Replace CAN-converter<br>- Replace sensor<br>- Call the H+H Service Hotline   |             |
| 23 | W NOx sensor post catalysts on error                | - Broken cable<br>- No power supply<br>- Device broken<br>- Broken CAN-converter<br>- Communication to converter interrupted             | - Measuring cable<br>- Check Power supply<br>- Check ethernet connection<br>- Replace CAN-converter<br>- Replace sensor<br>- Call the H+H Service Hotline   | 1HSA20CQ030 |
| 27 | W NOx sensor pre catalysts exceeds operation hours  | - NOx sensor is worn. Values are not longer valid.   | - Replace sensor<br>- Call the H+H Service Hotline  |             |
| 28 | W NOx sensor post catalysts exceeds operation hours | - NOx sensor is worn. Values are not longer valid.   | - Replace sensor<br>- Call the H+H Service Hotline  | 1HSA20CQ030 |
| 19 | W NOx correction factor high limit                  | - Wrong red. Agent concentration is used<br>- Raw emissions from engine have changed<br>- Catalysts are worn<br>- Urea leak at pipe work | - Check red. Agent concentration<br>- Check raw emissions of engine<br>- Check engine for temporary malfunction<br>- Check pipe work for leaks<br>- Analyze activity of catalysts<br>- Call the H+H Service Hotline | 1HSA20CQ030 |
| 20 | W NOx correction factor low limit                   | - Wrong urea concentration<br>- Raw emissions from engine have changed   | - Check red. Agent concentration<br>- Check raw emissions of engine<br>- Check engine for temporary malfunction<br>- Call the H+H Service Hotline   | 1HSA20CQ030 |
| 3  | A Atomizing Air flow too low                        | - Defect / Blocked solenoid valves<br>- Fine filter blocked<br>- Blocked nozzle<br>- Device broken                                       | - Check valves<br>- Clean filter<br>- Clean nozzle<br>- Check power supply<br>- Change device   | 1HSC10CF010 |



| ID | Message                                       | Possible Cause  | Needed Action   | Location    |
|----|---|---|---|-------------|
| 4  | W Reducing agent leakage                      | <ul style="list-style-type: none"> <li>- Urea flow to the engine</li> <li>- Dosing valve and Ball valve open.</li> <li>- Air in measuring area of the flow meter</li> </ul>   | <ul style="list-style-type: none"> <li>- Change the valve</li> <li>- Tight the valves</li> <li>- Release the air</li> </ul>   | 1HS110CF010 |
| 5  | A Flowmeter wirebreak                         | <ul style="list-style-type: none"> <li>- Broken cable</li> <li>- No power supply</li> <li>- Device broken</li> <li>- Broken Analog input card</li> <li>- Broken Analog output at device</li> </ul>  | <ul style="list-style-type: none"> <li>- Measuring cable</li> <li>- Check Power supply</li> <li>- Check Signal</li> <li>- Replace Analog input card</li> <li>- Replace flow meter</li> <li>- Call the H+H Service Hotline</li> </ul>  | 1HS110CF010 |
| 9  | W Reducing agent flow deviation               | <ul style="list-style-type: none"> <li>- Red. Agent pressure is too low</li> <li>- Injection nozzle is clogged</li> <li>- Atomizing air pressure too high</li> <li>- Dosing valve membran is clogged</li> <li>- Fine filter blocked</li> <li>- Pipes before dosing panel blocked</li> <li>- Urea leakage before dosing panel</li> <li>- Ball valve closed</li> <li>- If dosing is controlled by pump frequency</li> <li>- Not enough back pressure from Air system</li> </ul> | <ul style="list-style-type: none"> <li>- Check air and red. Agent pressure</li> <li>- Check and clean injection lance</li> <li>- Check and clean dosing valve membran</li> <li>- Call the H+H Service Hotline</li> <li>- Clean filter</li> <li>- Clean / check pipes- Check Compressed Air system</li> <li>- Check pipes from Dosing panel to nozzle for leakages</li> <li>- Check nozzle if nozzle head is broken</li> </ul> | 1HS110CF010 |
| 11 | A Reducing agent low pressure                 | <ul style="list-style-type: none"> <li>- Temperature of the engine is way too high!!!</li> <li>- The catalyst will be damaged !!!</li> <li>- Soot on the exhaust gas pipe catches fire</li> </ul>   | <ul style="list-style-type: none"> <li>- Stop the engine</li> </ul>   | 1HSA20CT020 |
| 7  | A Temperature sensor post Catalysts wirebreak | <ul style="list-style-type: none"> <li>- Broken cable</li> <li>- No power supply</li> <li>- Device broken</li> <li>- Broken Analog input card</li> <li>- Broken Analog output at device</li> </ul>  | <ul style="list-style-type: none"> <li>- Measuring cable</li> <li>- Check Power supply</li> <li>- Check Signal</li> <li>- Replace Analog input card</li> <li>- Replace temperature sensor</li> <li>- Call the H+H Service Hotline</li> </ul>  | 1HSA20CT020 |
| 12 | A Engine load signal underflow                | <ul style="list-style-type: none"> <li>- Analog Signal less than 3.5mA</li> <li>- Under pressure in pipe</li> <li>- Device is wrong calibrated</li> </ul>   | <ul style="list-style-type: none"> <li>- Check signal</li> <li>- Check load signal</li> <li>- Call H+H Service Hotline</li> </ul>   |             |
| 13 | A Engine load signal overflow                 | <ul style="list-style-type: none"> <li>- Analog Signal more than 20mA</li> <li>- Device broken</li> <li>- Analog input card broken</li> </ul>   | <ul style="list-style-type: none"> <li>- Check Signal</li> <li>- Check load signal</li> <li>- Change Analog input card</li> </ul>   |             |
| 10 | A Engine load signal wirebreak                | <ul style="list-style-type: none"> <li>- Broken cable</li> <li>- No power supply</li> <li>- Device broken</li> <li>- Broken Analog input card</li> <li>- Broken Analog output at device</li> </ul>  | <ul style="list-style-type: none"> <li>- Measuring cable</li> <li>- Check Power supply</li> <li>- Check Signal</li> <li>- Replace Analog input card</li> <li>- Call the H+H Service Hotline</li> </ul>  |             |

# SCR System - Service & Maintenance

| Item                   | Designation                                       | Activities  | Interval | Needed part                          | H+H Order no. | Quantity | Used on Service | On Site | Order / Quote |
|------------------------|---|---|----------|--------------------------------------|---------------|----------|-----------------|---------|---------------|
| <b>Injection Lance</b> |   |   |          |                                      |               |          |                 |         |               |
| xHSJ10BN110            | Injection Lance                                   | Clean Lance / Nozzle (check Gasket before remounting) | 6 Month  | Gasket DN65                          | 22020         | 8        |                 |         |               |
|                        |   | Change Nozzle Tip                                     | 2 Year   | Nozzle Tip 3.0 Typ S PA2016_361      | 22011         | 2        |                 |         |               |
| xHSC10AA067            | Compressed Air Check Valve                        | Change Valve  | Yearly   | Check Valve 12mm                     | 27225         | 4        |                 |         |               |
| <b>Dosing Unit</b>     |   |   |          |                                      |               |          |                 |         |               |
| xHSC10CP010            | Compact Control Valve Compr. Air incl. Air Filter | Change Filter Element                                 | 6 Month  | Air Filter Cartridge                 | 13092         | 8        |                 |         |               |
|                        |   | Change Membran / O-Ring / Conical Nipple              | Yearly   | Wear Part Set Pressure Control Valve | 13091         | 4        |                 |         |               |
|                        |   | ---   | ---      | ---                                  | 13090         | 1*       |                 |         |               |
| xHSC10AA020            | Atomizing Air Valve                               | Check Function  | 6 Month  |                                      | 14025         | 1*       |                 |         |               |
|                        |   | Change Wear Part Set                                  | Yearly   | Wear Part Set Valve ½"               | 14021         | 4        |                 |         |               |
| xHSC10AA050            | Check Valve Cool/Clean Air                        | Clean/Check Function                                  | 6 Month  | ---                                  | ---           | ---      |                 |         |               |
|                        |   | Change Valve  | Yearly   | Check Valve 6mm                      | 27210         | 4        |                 |         |               |
| xHSC10AA040            | Cool/Clean Air Valve                              | Check Function  | 6 Month  | ---                                  | 14025         | ---      |                 |         |               |
|                        |   | Change Wear Part Set                                  | Yearly   | Wear Part Set Valve ½"               | 14021         | 4        |                 |         |               |
| xHSC10CF010            | Flow Switch Compr. Air                            | Clean Sensor / Recalibrate                            | Yearly   | (H+H Annual Service)                 | 15010         | 1*       |                 |         |               |
| xHSJ10AA020            | Urea Dosing Valve                                 | Clean/Check Function                                  | Yearly   | Dosing Valve 1.5                     | 21235         | 1*       |                 |         |               |
|                        |   | Check Settings / Tune                                 | Yearly   | E-Controller                         | 21239         | 1*       |                 |         |               |
| xHSJ10AA040            | Urea Check Valve                                  | Clean/Check Function                                  | 6 Month  | ---                                  | ---           | ---      |                 |         |               |
|                        |   | Change Valve  | 2 Year   | Check Valve 6mm                      | 27210         | 2        |                 |         |               |
| xHSJ10CF010            | Urea Flow Meter                                   | Clean Sensor / Recalibrate                            | 2 Year   | ---                                  | 15030         | 1*       |                 |         |               |





# SCR System - Service & Maintenance

| Item                | Designation                   | Activities            | Interval | Needed part                           | H+H Order no. | Quantity | Used on Service | On Site | Order / Quote |
|---------------------|-------------------------------|-----------------------|----------|---------------------------------------|---------------|----------|-----------------|---------|---------------|
| <b>Pump Station</b> |                               |                       |          |                                       |               |          |                 |         |               |
| xHSJ10AT010         | Urea Filter                   | Clean Filter          | 6 Month  | Urea Filter Gasket                    | 26027         | 8        |                 |         |               |
|                     |                               | Change Filter Element | Yearly   | Urea Filter Element                   | 26026         | 4        |                 |         |               |
| xHSJ10CP010         | Manometer Suction Side        | Check Function        | 6 Month  | ---                                   | 27701         | 1*       |                 |         |               |
| xHSJ10CP020         | Pressure Switch Pressure Side | Check Function        | 6 Month  | ---                                   | 15021_1       | 1*       |                 |         |               |
| xHSJ10CP030         | Overflow Valve                | Check Function        | Yearly   | ---                                   | 25110         |          |                 |         |               |
|                     |                               | Change Wear Parts     | 2 Years  | Wear Part Set                         | 25111         | 2        |                 |         |               |
| xHSJ10AP010         | Urea Pump 1.5                 | Change Part           |          | Pin 5M6 x 16 [Drawaing No. 301]       | 2x 19331      | 1*       |                 |         |               |
|                     |                               | Change Part           |          | Rotor [Drawaing No. 401]              | 19332         |          |                 |         |               |
|                     |                               | Change Part           |          | Stator [Drawaing No. 402]             | 19333         |          |                 |         |               |
|                     |                               | Change Part           |          | Special Joint Grease                  | 19334         |          |                 |         |               |
|                     |                               | Change Part           |          | O-Ring [Drawaing No. 313]             | 2x 19335 E    |          |                 |         |               |
|                     |                               | Change Part           |          | Slide Ring Sealing [Drawaing No. 219] | 19336         |          |                 |         |               |
|                     |                               | Change Part           |          | Joint Shaft [Drawaing No. 307]        | 19339         |          |                 |         |               |
|                     |                               | Change Part           |          | Pump complete                         | 19330         |          |                 |         |               |
| <b>Reactor</b>      |                               |                       |          |                                       |               |          |                 |         |               |
| xHSA20CT020         | Temperature Sensor            | Check Function        | Yearly   | (H+H Annual Service)                  | 16010         | 1*       |                 |         |               |
| xHSA20CP010         | Diff. Pressure Sensor         | Check Function        | Yearly   | (H+H Annual Service)                  | 16031         | 1*       |                 |         |               |
|                     | Sealing Tape                  | Catalyst Inspection   | Yearly   | (H+H Annual Service)                  | 17011         | 50m      |                 |         |               |
|                     | Sealing Rope                  | Catalyst Inspection   | Yearly   | (H+H Annual Service)                  | 17010         | 50m      |                 |         |               |
| <b>Analyzer</b>     |                               |                       |          |                                       |               |          |                 |         |               |
| xHSA20CQ050         | NOx Sensor                    | Change Sensor         | Yearly   | NOx Sensor                            | 31110         | 4        |                 |         |               |

\* = Spare Part (all other parts are wear parts); x=1,2

**Quantity is based on an operation time of 2 years!**

Please quote order number and item number together with the designation of the part when ordering. Maintenance intervals may decrease due to ambient and operating conditions.

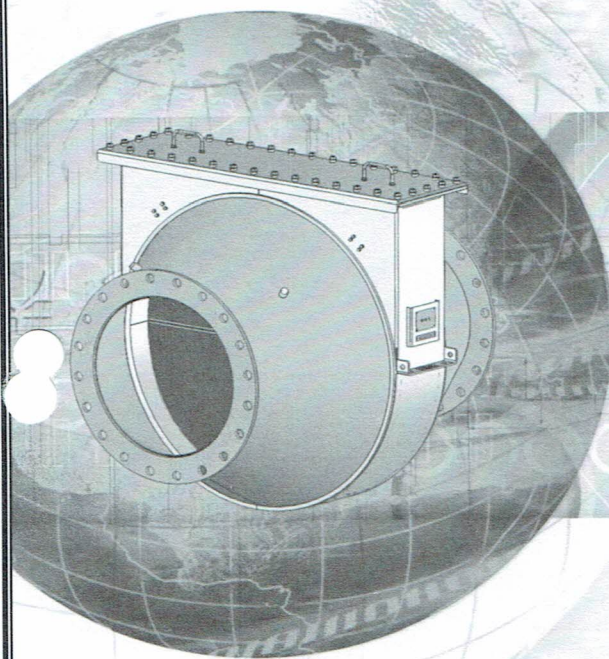
For further information about the SCR process and for placing an order, please send e-mail to [service@huhes.de](mailto:service@huhes.de) or contact:

**H+H Engineering & Service GmbH**  
**Herrngasse 17**  
**D-96242 Sonnefeld**  
**Germany**

tel.: +49 (0) 9562 / 40063 - 0  
 fax: +49 (0) 9562 / 40063 - 20  
[info@HuHES.de](mailto:info@HuHES.de)



# QUICK-LID<sup>®</sup> CATALYTIC CONVERTER INSTALLATION, OPERATION AND MAINTENANCE



## QUICK-LID<sup>®</sup>

DCL International Inc.  
P.O. Box 90,  
Concord, ON, Canada  
L4K 1B2

Phone: 905-660-6450  
Toll Free: 1-800-872-1968  
Fax: 905-660-6435  
[www.dcl-inc.com](http://www.dcl-inc.com)



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## 1.0 GENERAL

**Important Note: Before any work, consult your company health and safety officer for details of safe working practices. Safety requirements include but are not limited to: proper engine shut down; personal protection (gloves, coveralls, safety glasses etc.); and safe handling temperature of converter.**

The QUICK-LID<sup>®</sup> catalytic converter is designed for emission control of industrial internal-combustion engines used in the following applications:

- Power generation and co-generation
- Gas compression
- Chillers
- Irrigation and pumping stations
- Air compressors
- CNG refuelling

This manual contains instructions on installation, maintenance and operation of the converter\*, as well as operating limits and restrictions.

For lean-burn spark-ignited or compression ignited engines, the converter promotes the oxidation reactions of carbon monoxide (CO), hydrocarbons (C<sub>x</sub>H<sub>y</sub>) and partially oxidized hydrocarbons (C<sub>x</sub>H<sub>y</sub>O) into carbon dioxide (CO<sub>2</sub>) and water (H<sub>2</sub>O). For these reactions to take place the catalyst element must have a coating designed for oxidation reactions.

For rich-burn or stoichiometric spark-ignited engines, the converter promotes the three-way reactions of oxides of nitrogen (NO<sub>x</sub>), carbon monoxide (CO) and hydrocarbons (C<sub>x</sub>H<sub>y</sub>) into nitrogen (N<sub>2</sub>), carbon dioxide (CO<sub>2</sub>) and water (H<sub>2</sub>O). For these reactions to take place the catalyst element must have a coating designed for three-way reactions, and it is necessary for the engine to operate with a closed loop air-fuel ratio control system.

The converter is normally used for allowing a site to comply with air quality requirements. The design conversion efficiency and/or design post-converter emissions are provided in the Quotation. The conversion of any of substance across the converter shall be the difference of the inlet quality of the substance minus the quantity of the substance divided by the inlet quantity of the substance.

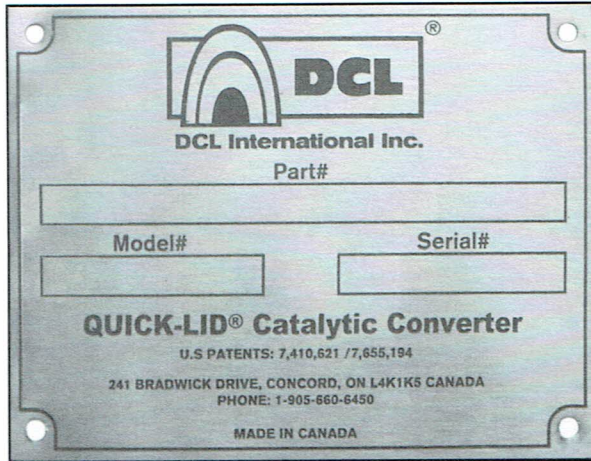
In some cases the converter is combined with a muffler or silencer to provide sound attenuation.

\*The term "converter" (unless otherwise specified) will be used in this manual to include both QUICK-LID<sup>®</sup> catalytic converters and QUICK-LID<sup>®</sup> catalytic silencers installed with either oxidation or three-way catalysts.

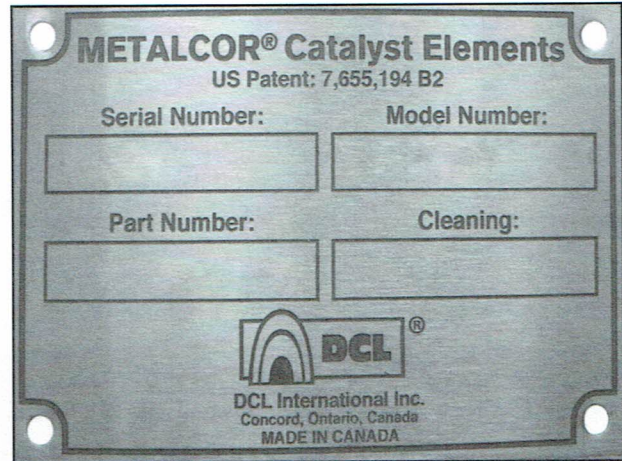


## 2.0 NAMEPLATE INFORMATION

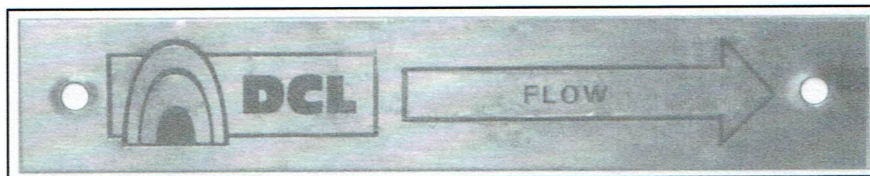
Refer to the nameplate for the part, model and serial numbers. Nameplates are located on both the housing and the catalyst element. Record this information for reference. Affixed to the converter will also be a warning label and a flow direction arrow as depicted below.



Housing Nameplate



Element Nameplate



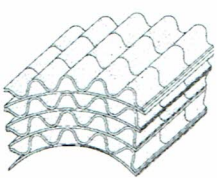
Flow Direction Arrow



Warning Label

# 3.0 PRODUCT DESCRIPTION

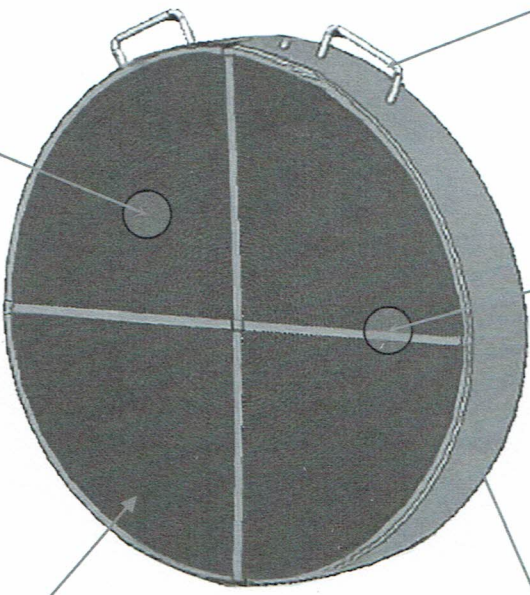
## 3.1 Catalyst Element Specifications



High-temperature-resistant steel foils of alternating layers of corrugated and flat strips 100, 200, 300 or 400 cpsi (cells per square inch).

Catalytic materials coated onto the channel surfaces consist of a refractory inorganic oxide, various substances that act as chemical promoters and stabilizers and a combination of platinum group metals that can include platinum, palladium and rhodium.

Options: Catalyst element can be Brazed or Non-brazed.



Handles for installation and maintenance.

Stiffening bars are inserted across the diameter of the element to maintain element rigidity.

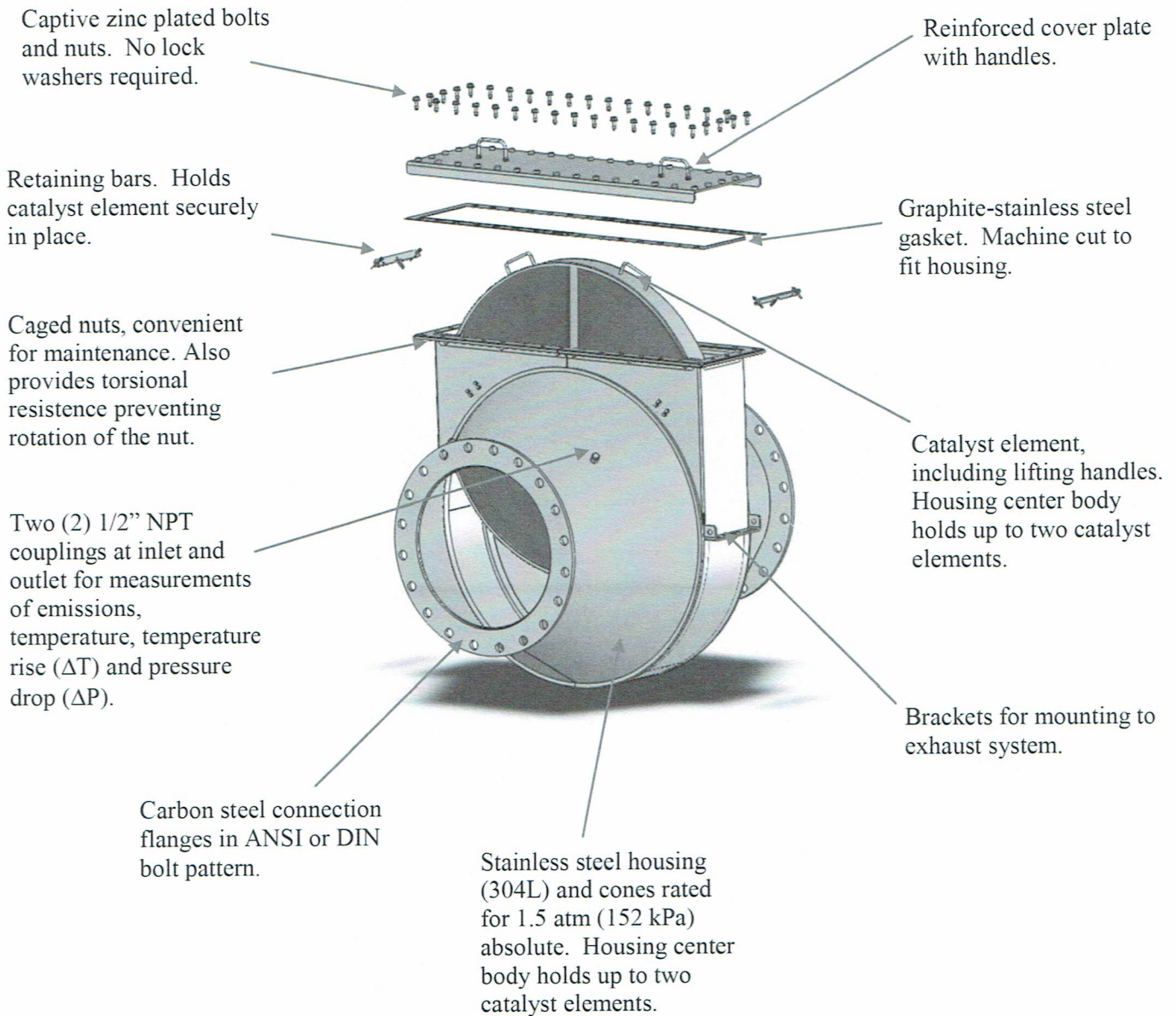
C-channel band of 304 stainless steel to provide rigidity and protect operators from foil abrasions.





### 3.2 Converter Housing Specifications

The following section contains general specifications for the QUICK-LID<sup>®</sup> catalytic converter housing. For any special customer specifications, refer to the sales drawing.

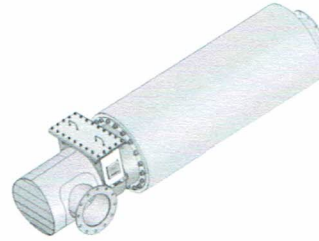


### 3.3 Housing Configurations

The QUICK-LID<sup>®</sup> converter comes in several configurations. The converter housing is primarily 304L stainless steel. In some cases the converter center body is integrated with a silencer. Where silencer components are integrated with the converter, the silencer jacket and silencer internal baffle components are mild steel unless specified otherwise by the customer. Where applicable, the sales drawing and/or quotation will indicate the sound attenuation or grade for the silencer.



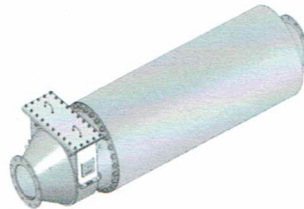
**QUICK-LID<sup>®</sup> Q6 Catalytic Converter.**  
Holds up to two catalyst elements.



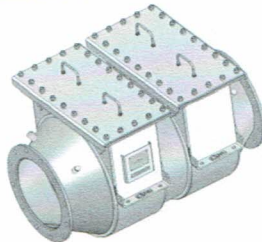
**QUICK-LID<sup>®</sup> QM6 Catalytic Silencer.**  
Holds up to two catalyst elements.  
(Custom Inlet)



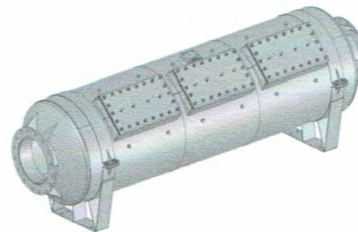
**QUICK-LID<sup>®</sup> QM6 Vertical Catalytic Converter.** Holds up to two catalyst elements.



**QUICK-LID<sup>®</sup> QM6 Catalytic Silencer.**  
Holds up to two catalyst elements.



**QUICK-LID<sup>®</sup> Q6 Catalytic Converter.** Holds up to four catalyst elements.



**QUICK-LID<sup>®</sup> Q6 Lateral Catalytic Silencer.**  
Holds up to six catalyst elements.

### 3.4 Paint and Coating Specifications

Catalytic converter housings are almost entirely stainless steel and therefore are supplied without paint or coating.

Catalytic silencer housings are supplied with high heat black paint. Under normal high temperature operation, peeling and other imperfections may occur. Higher grades of paint and protective coatings are available upon request.

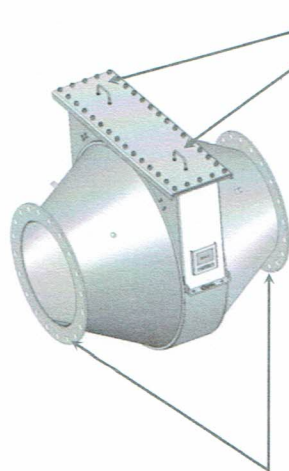


## 4.0 INSTALLATION

### 4.1 General Mounting Guidelines

- The converter should be mounted by overhead supports or base supports as shown in Sections 4.3 and 4.4.
- Mount the converter according to the flow direction sticker on the housing.
- Always isolate the converter from engine vibration (i.e. use expansion joint between the engine and the beginning of the exhaust piping).
- Ensure the converter does not support the weight of the exhaust pipe or any other exhaust system components.
- Avoid long piping runs before the converter that will thermally expand into the housing.
- Ensure that the converter location is easily accessed for inspection and removal of the catalyst element(s). Where necessary, install non-slip walking grids and/or safety railings for accessing the catalyst element.
- The converter should be located close to the exhaust manifold or turbocharger outlet, as the higher exhaust gas temperatures will increase the destruction efficiency of pollutants.
- Where the exhaust temperature exceeds the design temperature for the converter, short lengths of un-insulated pipe upstream of the converter are acceptable for outdoor applications.

### 4.2 Lifting and Handling of Housing



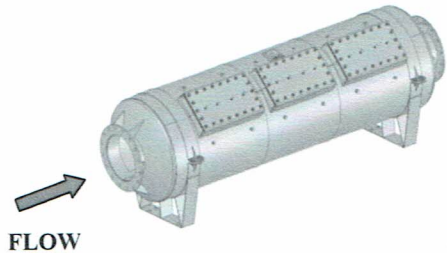
**NOTE:** Do not use the cover plate lifting handles to support the converter.

Use slings and properly sized shackles to lift from both ends for installation. Flange holes may be used as lifting lugs.

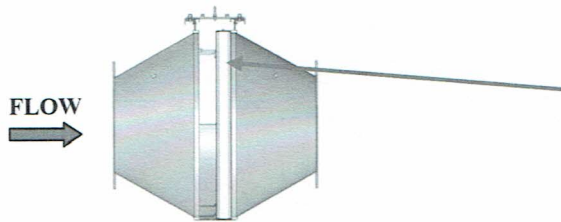
## 4.3 Mounting Orientation

### Horizontal Flow Orientation

For best mechanical durability of the catalyst element it is recommended the housing be positioned so that the exhaust flow direction is parallel with the ground. It is important to install the catalytic converter so that the housing cover is facing away from the ground and the catalyst element is held in place mostly by gravity.



**NOTE:** If installing only one catalyst element for the lateral design, it is recommended to follow the vertical installation guidelines. Refer to Appendix A.

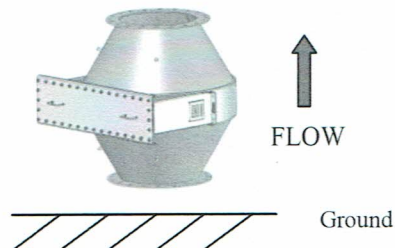


**NOTE:** If installing only one catalyst element, it is recommended the slot furthest from the inlet be used first. Refer to Appendix A.

### Vertical Flow Orientation

Positioning the housing so that the exhaust flow direction is perpendicular to ground level is acceptable only for engines running at speeds 1000 rpm or higher.

**Important Note:** Mounting a catalytic silencer in the vertical orientation may involve structural components such as trunnions, wind load and seismic zone standards and the need to support a stack. Design details for vertically mounted catalytic silencers must be discussed with DCL at the proposal stage and incorporated into the sales drawing.

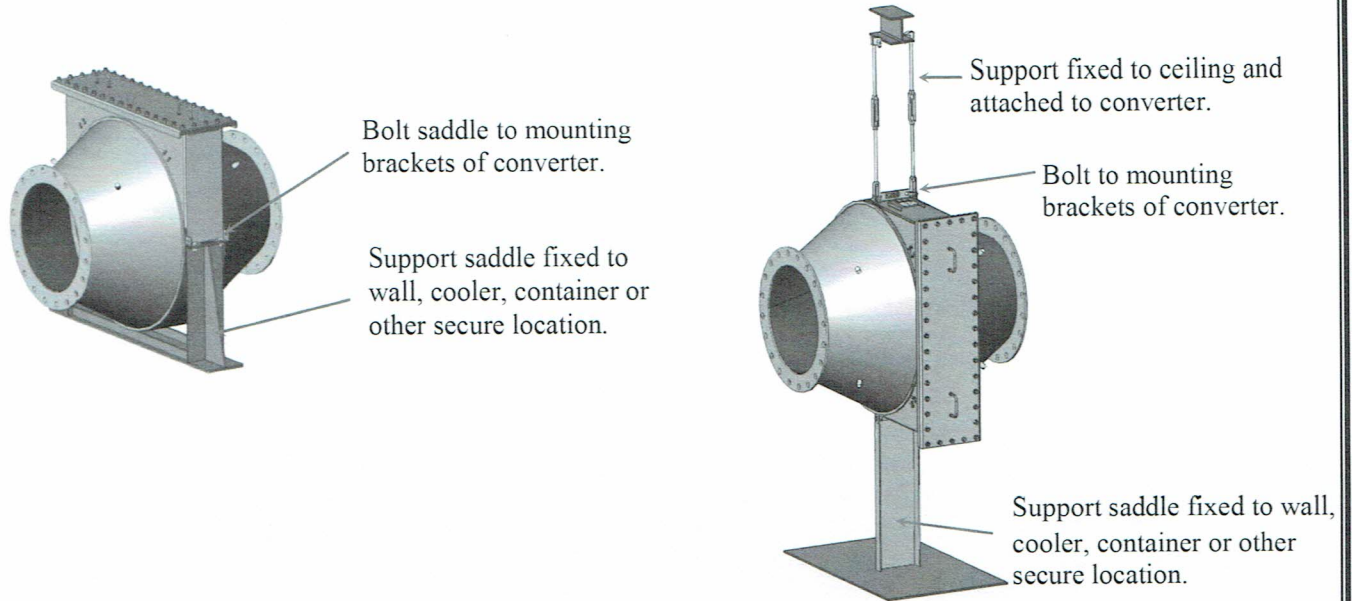


**NOTE:** Refer to Appendix A for catalyst installation instructions.

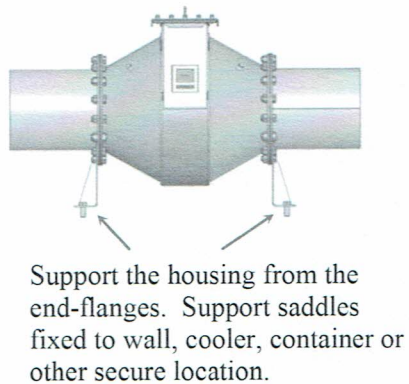


## 4.4 Mounting Examples

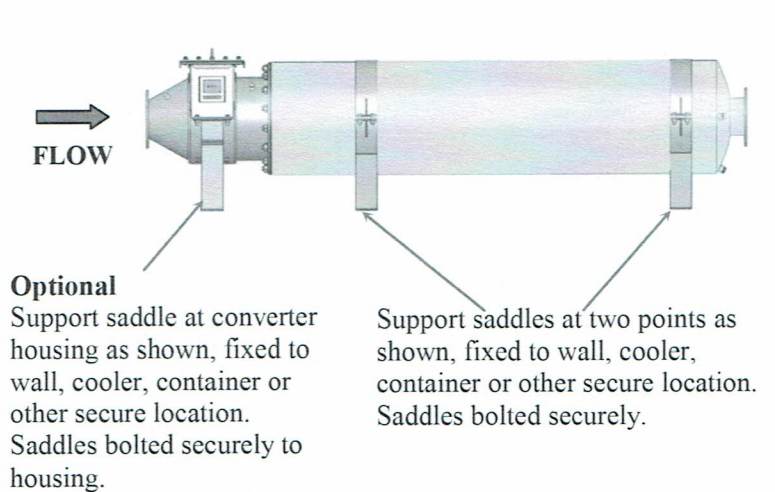
### Horizontal Flow – Catalytic Converter Q6



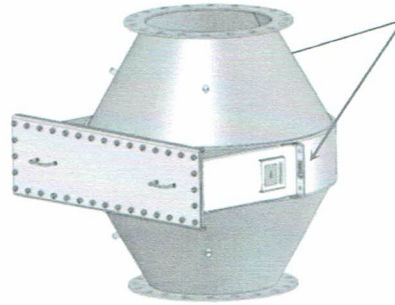
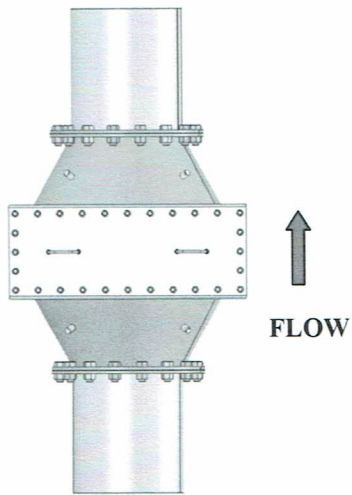
### Horizontal Flow – Catalytic Converter Q6



### Horizontal Flow – Catalytic Silencer QM6



## Vertical Flow – Catalytic Converter Q6



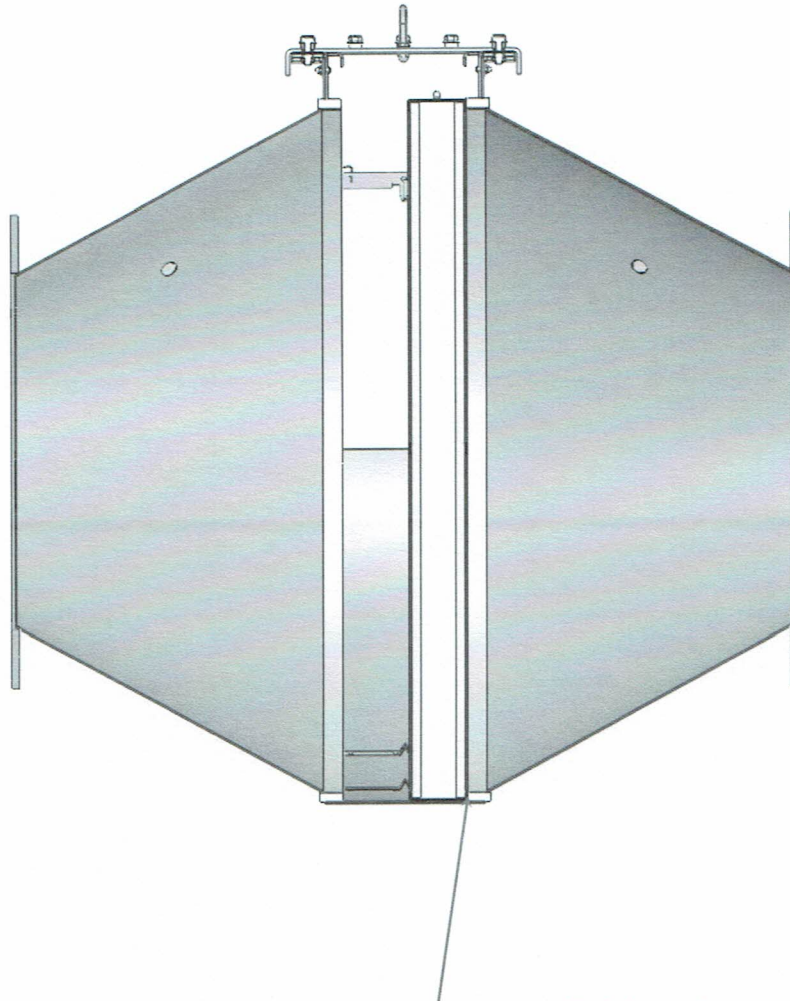
Bolt to mounting brackets on both sides of the converter and support at two points fixed to wall, cooler, container or other secure location

## 4.5 Inspection for Exhaust Gas Blow-By

Inspection for exhaust gas blow-by is recommended after a backfire, explosion or if a leak is suspected. Inspection is done by using gap feelers in the following manner:

Remove cover plate and check accessible areas of the catalyst element. Using a 0.125" (3.2 mm) gap feeler, check to make sure it does not fit between the catalyst element and the housing at any point around the catalyst element. There should be no localized gap of 0.125" (3.2 mm) or greater at any point around the catalyst element.

Using a 0.06" (1.5 mm) gap feeler, check to make sure it does not fit between the catalyst element and the housing and slide for the entire accessible area of the catalyst element. The gap around the catalyst element should not be greater than 0.06" (1.5 mm) for any extended area.



Maximum localized gap anywhere [ 0.125" (3.2 mm)].  
Maximum gap < 0.06" (1.5 mm) for up to 300 degrees.



## 4.6 Safety, Storage and Handling of Elements

Handling the DCL metal element does not pose any particular health or safety hazard related to catalyst composition or formulation (see Appendix B for MSDS sheets). If elements are stacked together for shipping, use a layer of cardboard, plywood or other suitable material between each element to prevent them from rubbing against each other and causing damage.

The metal foils are sharp and abrasion of the hands or other body parts may occur if the elements are handled without gloves or other protective clothing. The elements should be packed in bubble wrap or other suitable packing material. The thin metal foils on the element are prone to damage if handled improperly. The element foils can be easily crushed if struck with a hard object, resulting in plugging of the channels.

To store DCL elements, pack the element in a plastic or bubble wrap and store at normal room temperature in a dry area away from direct sunlight. If stored under these conditions, DCL elements have an indefinite shelf life. It is recommended that parts stored in excess of two years be tested for activity before use. DCL should be contacted if activity testing is required.

After prolonged storage some dust may accumulate at the bottom of the element. This dust will contain high levels of alumina and platinum group metals. This dust does not pose any health or safety hazard but should be disposed of properly.

## 5.0 OPERATION

### 5.1 Operating Requirements for Three-Way (NSCR) Catalysts

The operating requirements below are necessary to achieve the emission targets indicated in the quote. Failure to meet these operating requirements may result in lower than expected emission destruction efficiencies.

|   |   |
|---|---|
| Exhaust Flowrate                          | ✓ As indicated in quote.  |
| Exhaust Temperature                       | ✓ Minimum 752 °F (400 °C) at inlet to converter.<br>✓ Maximum 1250 °F (677 °C) at inlet to converter.<br>✓ Maximum 1350 °F (732 °C) at outlet of converter.   |
| Engine Power                              | ✓ As indicated in quote.  |
| Engine Speed                              | ✓ As indicated in quote.  |
| Lube Oil Specification                    | ✓ Sulfated ash < 0.6 wt%.<br>✓ Zinc < 900 ppm.<br>✓ Phosphorus < 400 ppm.   |
| Lube Oil Consumption Rate                 | ✓ Manufacturer's normal lube oil consumption rate or 0.5 g/bhp-hr (0.67 g/kW-h), whichever is lower.  |
| Crank Case Ventilation                    | ✓ Crank case ventilation should be routed either back to the air intake or downstream of the converter.   |
| Fuel Quality                              | ✓ Pipeline quality natural gas or commercial grade LPG or gasoline is preferred but not required.<br>✓ Unprocessed wellhead gas is acceptable if all other specifications are maintained and measures are taken to ensure the engine can run on the fuel without misfires.<br>✓ Biogas, landfill gas and digester gas are acceptable if all other specifications are maintained.<br>✓ For gaseous fuels the energy content should be > 750 BTU/ft <sup>3</sup> LHV.<br>✓ Sulfur < 100 ppm.<br>✓ Chlorinated compounds < 10 ppm.<br>✓ Siloxane compounds < 40 ppb (scrubbing of the fuel is normally required to achieve this level for landfill gas). |
| Exhaust Gas Oxygen (EGO) Sensor Set-Point | ✓ For air-fuel ratio controllers that operate using a pre-converter EGO sensor and setpoint voltage, the optimum setpoint is typically between 700 and 800 mV. The optimum voltage setpoint may vary according to the engine load. The signal from the EGO sensor is somewhat biased by CO, H <sub>2</sub> and HC levels, exhaust gas temperature and age of the sensor.<br>✓ For air-fuel ratio controllers that use a dithering strategy, follow the operating  |



|                           |  |
|---------------------------|--|
|                           | instructions provided by the manufacturer.   |
| Oxygen                    | <ul style="list-style-type: none"> <li>✓ 0.2-0.5% at inlet to converter.</li> </ul>  |
| Air-Fuel Ratio Controller | <ul style="list-style-type: none"> <li>✓ After installation of the converter, use a portable analyzer to measure pre and post converter NO<sub>x</sub>, CO, O<sub>2</sub> emissions and determine the correct setpoints for operation. Note: the setpoints may change depending on engine load, EGO sensor age and other operating conditions; it is recommended that emissions are checked periodically with a portable analyser to see if adjustments to the setpoints are necessary.</li> <li>✓ Engine and air-fuel controller must operate at a steady condition, with air-fuel ratio swings not exceeding +/- 0.005 lambda.</li> <li>✓ The EGO sensor at inlet to the converter should not deviate by more than 50 mV from its setpoint during steady operation.</li> <li>✓ All operation and maintenance procedures for the air-fuel ratio controller must be followed, including scheduled replacement of thermocouples and EGO sensors.</li> </ul> |
| Ash Deposits              | <ul style="list-style-type: none"> <li>✓ Ash deposits should not exceed 50 g per liter of catalyst element (1400 g/ft<sup>3</sup>).</li> <li>✓ High levels of ash on the catalyst element will result in higher pressure restrictions and reduce conversion efficiency.</li> <li>✓ It is recommended that an authorized cleaning facility is contacted if cleaning of the catalyst element is necessary.</li> <li>✓ Cleaning procedures are available from DCL upon request.</li> </ul>  |
| Exhaust System            | <ul style="list-style-type: none"> <li>✓ Ensure the exhaust system is free of leaks, particularly before the converter.</li> </ul>   |
| Ignition System           | <ul style="list-style-type: none"> <li>✓ Replace spark plugs at scheduled intervals. Never allow a spark plug to fail before replacing it.</li> <li>✓ Check spark gap, wiring harness and secondary leads as well as coils and magnetos.</li> <li>✓ Proper grounding of the ignition system is essential to proper combustion.</li> <li>✓ Timing must be adjusted to the manufacturer's recommended setting for the given site fuel and engine conditions.</li> <li>✓ Digital ignition systems are recommended for combustion stability, but are not required.</li> <li>✓ The ignition coils should not be painted. Painting of the coils has been known to cause incomplete combustion.</li> </ul>  |
| Fuel System               | <ul style="list-style-type: none"> <li>✓ Ensure the fuel system is properly maintained and functioning according to manufacturer's specifications.</li> <li>✓ Ensure a stable fuel supply, proper fuel pressures and balanced regulators and carburetors.</li> <li>✓ Eliminate the risk of backfires, due to purging of the exhaust system with fuel, by equipping the fuel supply system with a safety shut off valve triggered by the ignition or annunciator panel.</li> </ul> <p style="text-align: center;">Start up sequence: air – ignition – fuel<br/>Shut down sequence: fuel – ignition – air</p>  |



### Back-Pressure

- ✓ High back-pressure may indicate excessive build-up of ash deposits.
- ✓ When the catalyst bed is new, measure pressure before and after the converter during full load operation. The difference in before and after pressure is the baseline back-pressure for the converter.
- ✓ Re-measure the converter back-pressure under the same operating conditions periodically.
- ✓ Should the converter back-pressure increase by more than 2" wc (0.5 kPa) over the baseline back-pressure, the catalyst element should be removed for cleaning.
- ✓ Should the converter back-pressure decrease from baseline back-pressure, the catalyst element should be removed and inspected for damage.

### High Temperature Shutdown

- ✓ A functioning high temperature shut-down system is required to prevent the catalyst element from over-heating due to misfires.
- ✓ The thermocouple located on an outlet port of the converter should be set to 150 °F (83 °C) above the normal outlet temperature of the converter but should never exceed 1,350°F (732 °C).

### Catalyst Poisons

- ✓ Catalyst poisons build up on the catalyst element over time, due to their presence in the fuel or lube oil. The presence of certain contaminants may also indicate excessive engine wear or a coolant breach.
- ✓ If there is a suspected problem, the catalyst element may be returned to DCL where a small amount of washcoat is removed and analyzed for contaminants and activity.
- ✓ For acceptable performance, catalyst poisons as a fraction of washcoat shall not exceed the following:
  - Sulfur < 1%
  - Calcium < 1%
  - Phosphorus < 1%
  - Zinc < 0.5%
  - Iron < 1%
  - Sulfur, Calcium, Phosphorus, Zinc, Iron < 2% (collectively)
  - Lead, Mercury, Arsenic, Antimony, Copper, Tin, Nickel, Chromium < 200 ppm (collectively)

### Compliance Assurance Monitoring

- ✓ It is recommended that the site operator establish a Compliance Assurance Monitoring (CAM) plan.
- ✓ A CAM plan should be tailored to the site specific or company specific needs.

Unless stated otherwise in the quote, the following are the assumed pre-catalyst emissions after calibration of the air-fuel ratio controller. Should pre-catalyst emissions fall outside the ranges below, lower than expected emission destruction efficiencies may result.

| Species                               | g/bhp-h | ppmvd (15% O <sub>2</sub> ) | mg/Nm <sup>3</sup> (5% O <sub>2</sub> ) |
|---------------------------------------|---------|-----------------------------|---|
| NO <sub>x</sub> (as NO <sub>2</sub> ) | 8 – 14  | 530 – 940                   | 3000 – 5200                             |
| CO                                    | 10 – 16 | 1100 – 1800                 | 3700 – 6000                             |
| NMHC                                  | < 0.5   | < 100 (C1)                  | < 190                                   |
| NMNEHC                                | < 0.3   | < 60 (C1)                   | < 110                                   |
| VOCs                                  | < 0.3   | 39 (C1)                     | < 110                                   |
| CH <sub>2</sub> O                     | < 0.2   | 29                          | < 75                                    |

The product warranty shall be voided if the following occurs:

- Engine misfire, backfire or exhaust system explosion.
- Excess unburned fuel entering the catalyst, such as when the engine operates beyond its lean limit or if an ignition failure occurs.
- Turbocharger failure.
- Exhaust temperature in excess of the maximum.
- Catalyst poisons in excess of the maximum.
- Fuel quality not meeting the specifications in this manual.
- Mechanical damage to the converter due to improper mounting.
- Mis-handling or improper storage of catalyst elements.
- Improper cleaning of the catalyst element.
- Failure to conduct normal maintenance.



## 5.2 Operating Requirements for Oxidation Catalysts

The operating requirements below are necessary to achieve the emission targets indicated in the quote. Failure to meet these operating requirements may result in lower than expected emission destruction efficiencies.

|  |   |
|--|---|
| Exhaust Flowrate                                 | ✓ As indicated in quote.  |
| Exhaust Temperature                              | <ul style="list-style-type: none"> <li>✓ No lower than 54 °F (30 °C) than the temperature indicated in quote.</li> <li>✓ At inlet and outlet of the converter the temperature must never exceed a maximum 1,112 °F (600 °C).</li> </ul>   |
| Engine Power                                     | ✓ As indicated in quote.  |
| Engine Speed                                     | ✓ As indicated in quote.  |
| Lube Oil Specification                           | <ul style="list-style-type: none"> <li>✓ Sulfated ash &lt; 0.6 wt% (Spark ignited engines).</li> <li>✓ Sulfated ash &lt; 1.0 wt% (Compression ignited engines).</li> <li>✓ Zinc &lt; 900 ppm.</li> <li>✓ Phosphorus &lt; 400 ppm.</li> </ul>  |
| Lube Oil Consumption Rate                        | ✓ Manufacturer's normal lube oil consumption rate or 0.5 g/bhp-hr (0.67 g/kW-h), whichever is lower.  |
| Crank case ventilation                           | ✓ Crank case ventilation should be routed either back to the air intake or downstream of the converter.   |
| Fuel Quality for Gaseous Fuels, Gasoline and LPG | <ul style="list-style-type: none"> <li>✓ Pipeline quality natural gas or commercial grade LPG or gasoline is preferred but not required.</li> <li>✓ Unprocessed wellhead gas is acceptable if all other specifications are maintained and measures are taken to ensure the engine can run on the fuel without misfires.</li> <li>✓ Biogas, landfill gas and digester gas are acceptable if all other specifications are maintained.</li> <li>✓ Sulfur &lt; 100 ppm.</li> <li>✓ Chlorinated compounds &lt; 10 ppm.</li> <li>✓ Siloxane compounds &lt; 40 ppb (scrubbing of the fuel is normally required to achieve this level for landfill gas).</li> </ul> |
| Fuel Quality for Diesel, LFO or Biodiesel Blends | <ul style="list-style-type: none"> <li>✓ Fuel must conform to ASTM D975, ASTM D6751, EN590 or EN14214 standards, plus the following additional standards:</li> <li>✓ Sulfur &lt; 500 ppm.</li> <li>✓ Chlorinated compounds – must be Nil.</li> <li>✓ Siloxane compounds – must be Nil.</li> <li>✓ Phosphorus &lt; 1 ppm.</li> </ul>   |
| Oxygen   | ✓ > 2% at inlet to converter.   |
| Ash Deposits                                     | <ul style="list-style-type: none"> <li>✓ Ash deposits should not exceed 50 g per liter of catalyst element (1400 g/ft<sup>3</sup>).</li> <li>✓ High levels of ash on the catalyst element will result in higher pressure restrictions</li> </ul>  |

|   |  |
|---|--|
|   | <ul style="list-style-type: none"> <li>and reduce conversion efficiency.</li> <li>✓ It is recommended that an authorized cleaning facility is contacted if cleaning of the catalyst element is necessary.</li> <li>✓ Cleaning procedures are available from DCL upon request.</li> </ul>   |
| Exhaust System                            | <ul style="list-style-type: none"> <li>✓ Ensure the exhaust system is free of leaks, particularly before the converter.</li> </ul>   |
| Ignition System (Spark Ignited Engines)   | <ul style="list-style-type: none"> <li>✓ Replace spark plugs at scheduled intervals. Never allow a spark plug to fail before replacing it.</li> <li>✓ Check spark gap, wiring harness and secondary leads as well as coils and magnetos.</li> <li>✓ Proper grounding of the ignition system is essential to proper combustion.</li> <li>✓ Timing must be adjusted to the manufacturer's recommended setting for the given site fuel and engine conditions.</li> <li>✓ Digital ignition systems are recommended for combustion stability, but are not required.</li> <li>✓ The ignition coils should not be painted. Painting of the coils has been known to cause incomplete combustion.</li> </ul>  |
| Fuel System (Spark Ignited Engines)       | <ul style="list-style-type: none"> <li>✓ Ensure the fuel system is properly maintained and functioning according to manufacturer's specifications.</li> <li>✓ Ensure a stable fuel supply, proper fuel pressures and balanced regulators and carburetors.</li> <li>✓ Eliminate the risk of backfires, due to purging of the exhaust system with fuel, by equipping the fuel supply system with a safety shut off valve triggered by the ignition or annunciator panel.</li> </ul> <p style="text-align: center;">Start up sequence: air – ignition – fuel<br/>Shut down sequence: fuel – ignition – air</p>  |
| Fuel System (Compression Ignited Engines) | <ul style="list-style-type: none"> <li>✓ Repair and replace fuel injectors at intervals required by the engine manufacturer's maintenance schedule.</li> <li>✓ Fix worn hydraulic injectors to stop lube oil leaks into the fuel.</li> </ul>   |
| Back-Pressure                             | <ul style="list-style-type: none"> <li>✓ High back-pressure may indicate excessive build-up of ash deposits.</li> <li>✓ When the catalyst bed is new, measure pressure before and after the converter during full load operation. The difference in before and after pressure is the baseline back-pressure for the converter.</li> <li>✓ Re-measure the converter back-pressure under the same operating conditions periodically.</li> <li>✓ Should the converter back-pressure increase by more than 2" wc (0.5 kPa) over the baseline back-pressure, the catalyst element should be removed for cleaning.</li> <li>✓ Should the converter back-pressure decrease from baseline back-pressure, the catalyst element should be removed and inspected for damage.</li> </ul> |
| High Temperature Shutdown                 | <ul style="list-style-type: none"> <li>✓ For spark ignited engines a functioning high temperature shut-down system is required to prevent the catalyst element from over-heating due to misfires.</li> <li>✓ The thermocouple located on an outlet port of the converter should be set to 150 °F (83 °C) above the normal outlet temperature of the converter but should never</li> </ul>  |



exceed 1,112 °F (600 °C).

#### Catalyst Poisons

- ✓ Catalyst poisons build up on the catalyst element over time, due to their presence in the fuel or lube oil. The presence of certain contaminants may also indicate excessive engine wear or a coolant breach.
- ✓ If there is a suspected problem, the catalyst element may be returned to DCL, where a small amount of washcoat is removed and analyzed for contaminants and activity.
- ✓ For acceptable performance, catalyst poisons as a fraction of washcoat shall not exceed the following:
  - Sulfur < 1%
  - Calcium < 1%
  - Phosphorus < 1%
  - Zinc < 0.5%
  - Iron < 1%
  - Sulfur, Calcium, Phosphorus, Zinc, Iron < 2% (collectively)
  - Lead, Mercury, Arsenic, Antimony, Copper, Tin, Nickel, Chromium < 200 ppm (collectively)

#### Compliance Assurance Monitoring

- ✓ It is recommended that the site operator establish a Compliance Assurance Monitoring (CAM) plan.
- ✓ A CAM plan should be tailored to the site specific or company specific needs.

Where post-catalyst emissions statements are provided in the quote, temperature at the inlet to the converter is assumed to be as shown in the table below, unless explicitly stated otherwise in the quote.

| Fuel        | Pollutant   | Min. Temperature at Inlet | Limits to Exhaust Compositions    |
|-------------|---|---------------------------|-----------------------------------|
| Natural Gas | Non-methane hydrocarbons (NMHCs), including formaldehyde      | 797 °F<br>(425 °C)        | Ethane < 37.5 wt.% of NMHC        |
| Natural Gas | Non-methane, non-ethane hydrocarbons (NMNEHC) – EPA Method 18 | 797 °F<br>(425 °C)        | Propane < 20 wt.% of NMNEHC       |
| Natural Gas | Volatile Organic Compounds – SCAQMD Method 25                 | 797 °F<br>(425 °C)        | Propane < 20 wt.% of NMNEHC       |
| Natural Gas | Formaldehyde (CH <sub>2</sub> O)                              | 572 °F<br>(300 °C)        | -                                 |
| LPG         | Total Hydrocarbons (THCs)                                     | 797 °F<br>(425 °C)        | Propane < 30 wt.% of exhaust THCs |
| Diesel      | Total Hydrocarbons (THCs)                                     | 572 °F<br>(300 °C)        | -                                 |
| All fuels   | Carbon Monoxide   | 752 °F<br>(300 °C)        | -                                 |

**The product warranty shall be voided if the following occurs:**

- **Engine misfire, backfire or exhaust system explosion.**
- **Excess unburned fuel entering the catalyst, such as when the engine operates beyond its lean limit or if an ignition failure occurs.**
- **Turbocharger failure.**
- **Exhaust temperature in excess of the maximum.**
- **Catalyst poisons in excess of the maximum.**
- **Fuel quality not meeting the specifications in this manual.**
- **Mechanical damage to the converter due to improper mounting.**
- **Mis-handling or improper storage of catalyst elements.**
- **Improper cleaning of the catalyst element.**
- **Failure to conduct normal maintenance.**



## 6.0 MAINTENANCE

DCL's recommended monitoring and maintenance schedule during operation is given below. Due to large variations in operating conditions, the schedule may change depending on the specifics of the application. In addition to this schedule, additional monitoring and reporting may be needed according to the requirements of your environment permit.

It is recommended that a maintenance log be maintained. Measurements and records of temperature difference ( $\Delta T$ ) and pressure difference ( $\Delta P$ ) should always be made under the same operating conditions (e.g. engine load, speed, ignition timing and exhaust oxygen concentration).

### Monitoring and Maintenance Schedule

| Item No. | Description                             | > 4000 hours operation per year   | 500 – 3999 hours operation per year   | < 500 hours operation per year  | Directions   |
|----------|---|---|---|---|--|
| 1        | Check back-pressure ( $\Delta P$ )      | <ul style="list-style-type: none"> <li>At time of installation</li> <li>Every 3 months</li> </ul> | <ul style="list-style-type: none"> <li>At time of installation</li> <li>Every 6 months</li> </ul> | <ul style="list-style-type: none"> <li>At time of installation</li> <li>Every year</li> </ul> | If the ( $\Delta P$ ) is more than 55 mm H <sub>2</sub> O (2" H <sub>2</sub> O) higher than the initial ( $\Delta P$ ), inspect catalyst for excessive ash build-up. See Section 7 (Troubleshooting).          |
| 2        | Check temperature change ( $\Delta T$ ) | <ul style="list-style-type: none"> <li>At time of installation</li> <li>Every 3 months</li> </ul> | <ul style="list-style-type: none"> <li>At time of installation</li> <li>Every 6 months</li> </ul> | <ul style="list-style-type: none"> <li>At time of installation</li> <li>Every year</li> </ul> | If the ( $\Delta T$ ) is more than 25°F (14°C) higher than the initial ( $\Delta T$ ), check the engine for misfiring and /or inspect catalyst element for damage or fouling. See Section 7 (Troubleshooting). |
|          | Conduct emissions test                  | As required by operating permit   | As required by operating permit   | As required by operating permit   | As required by operating permit.   |
| 4        | Visual inspection of catalyst element   | Every 2 years   | Every 3 years   | Every 3 years   | See Section 7 (Troubleshooting).   |
| 5        | Chemical cleaning of catalyst element   | Every 2 years   | Every 3 years   | N/A   | Contact DCL or authorized dealer for assistance.   |

**Note: Items 1, 2 and 3 can be conducted by utilizing the ports on the inlet and outlet side of the converter.**

## 7.0 TROUBLESHOOTING

### 7.1 General Troubleshooting

Inspecting the appearance of the catalyst can sometimes provide enough information to determine possible failure modes. The table below provides a guide for catalysts inspection.

#### Troubleshooting by Element Appearance

| Element Appearance  | Converter Operation   | Possible Cause  | Action  |
|---|---|---|---|
| Tan or light brown to dark brown element. Little amount of gray/white ash | <ul style="list-style-type: none"> <li>Normal back-pressure</li> <li>0-72 °F (0 – 40 °C) temperature rise across converter</li> </ul> | <ul style="list-style-type: none"> <li>Normal operation</li> </ul>  | <ul style="list-style-type: none"> <li>None</li> </ul>  |
| Carbon fouling – soft black sooty deposits on element                     | <ul style="list-style-type: none"> <li>High back-pressure</li> <li>Low conversion efficiencies</li> </ul>                             | <ul style="list-style-type: none"> <li>Clogged air filter</li> <li>Very low cylinder compression</li> <li>Weak ignition voltage</li> </ul>  | <ul style="list-style-type: none"> <li>Check air filter</li> <li>Check carburetor and ignition system</li> <li>Check rings and valves</li> <li>Chemical wash of catalyst element</li> </ul>   |
| Large amounts of powdery gray/white ash covering the element              | <ul style="list-style-type: none"> <li>High back-pressure</li> <li>Low conversion efficiencies</li> </ul>                             | <ul style="list-style-type: none"> <li>Ash originating from sulfated ash content and zinc and phosphorus compounds in the lube oil</li> </ul>   | <ul style="list-style-type: none"> <li>Correct engine lube oil consumption rate to &lt; 0.5 g/bhp-hr (0.67 g/kW-h)</li> <li>Use lube oil with &lt; 0.6% sulfated ash content; &lt; 900 ppm zinc and &lt; 400 ppm phosphorus</li> <li>Contact DCL for chemical wash of catalyst element</li> </ul> |
| Dark bronze to black in color   | <ul style="list-style-type: none"> <li>Low conversion efficiencies</li> </ul>   | <ul style="list-style-type: none"> <li>Oil fouling. Too much oil entering combustion chamber; possible worn rings or cylinder walls</li> <li>Excessive clearance of valve stem guides</li> <li>Build-up of crank-case pressure</li> </ul> | <ul style="list-style-type: none"> <li>Correct engine</li> <li>Contact DCL for chemical wash catalyst element</li> </ul>  |
| Pinholes, burnt element foil and/or white powdery appearance              | <ul style="list-style-type: none"> <li>Little or no conversion</li> </ul>   | <ul style="list-style-type: none"> <li>Ignition misfire</li> </ul>  | <ul style="list-style-type: none"> <li>Correct engine</li> <li>Contact DCL for replacement catalyst element</li> </ul>  |



## 7.2 Troubleshooting for Three-Way Catalysts

In order to achieve high conversion efficiency of NO<sub>x</sub>, CO and HCs simultaneously, it is necessary for the engine, air-fuel controller and converter to all function properly as a system. If any one of these components in the system malfunctions, the emissions may exceed the desired levels. In order to isolate the source of a problem to the engine, AFRC or converter, the following is recommended:

- Step 1 Deactivate the AFRC and allow the engine to operate at open loop.
- Step 2 Manually adjust the air-fuel ratio of the engine to the point for optimum simultaneous conversion efficiencies of CO and NO<sub>x</sub> by means of trial and error, and with the use of a portable analyzer.

### Troubleshooting by Catalyst Performance

|        |  |  |
|--------|--|--|
| Case 1 | High conversion efficiencies are achieved simultaneously for both NO <sub>x</sub> and CO (i.e. > 90%). | Refer to operating manual of AFRC for further troubleshooting assistance.            |
| Case 2 | High conversion efficiencies are achieved for CO or NO <sub>x</sub> , but not both simultaneous.       | Refer to possible engine or converter related problems in tables on pages 24 and 26. |
| Case 3 | High conversion efficiencies cannot be achieved at all for either CO or NO <sub>x</sub> .              | Refer to possible engine or converter related problems in tables on pages 24 and 26. |

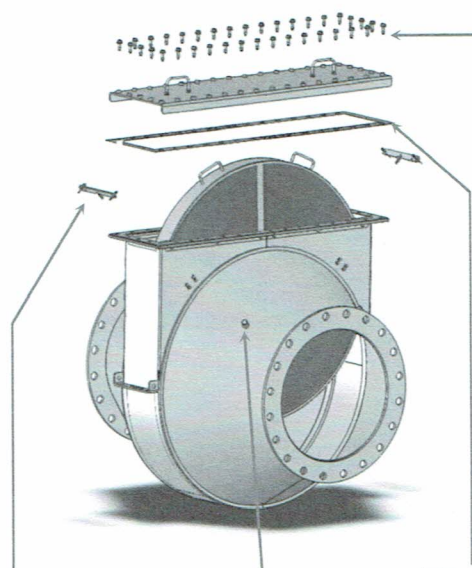
## Engine and Converter Related Problems

| Problem   | Possible Cause   | Action   |
|---|--|--|
| Little or no back-pressure and little or no conversion efficiency   | <ul style="list-style-type: none"> <li>Mechanical damage to element, possibly caused by excess vibration or engine backfires</li> </ul>  | <ul style="list-style-type: none"> <li>Correct engine</li> <li>Contact DCL for replacement catalyst element</li> </ul>   |
| High temperature alarm triggered and low conversion efficiency  | <ul style="list-style-type: none"> <li>Ignition and/or plugs failure</li> <li>Detonation</li> </ul>  | <ul style="list-style-type: none"> <li>Check timing and fuel heating values</li> </ul>   |
| High oxygen level (>0.5%) prior to converter and other parameters normal  | <ul style="list-style-type: none"> <li>Exhaust leak</li> </ul>   | <ul style="list-style-type: none"> <li>Check all exhaust components</li> <li>Crankcase ventilation should be routed to the atmosphere or intake air</li> </ul>   |
| Simultaneous high oxygen level (O <sub>2</sub> > 0.5%) and high CO level (> 7,000 ppm) prior to converter. High exhaust temperature               | <ul style="list-style-type: none"> <li>Ignition misfire</li> </ul>   | <ul style="list-style-type: none"> <li>Correct engine</li> </ul>   |
| Simultaneous high oxygen level (O <sub>2</sub> > 0.5%) and high CO level (> 7,000 ppm). Prior to converter. Normal exhaust temperature            | <ul style="list-style-type: none"> <li>Leaking exhaust valves</li> </ul>   | <ul style="list-style-type: none"> <li>Check exhaust valves</li> </ul>   |
| Simultaneous high oxygen level (O <sub>2</sub> > 0.5%) and high CO level (> 7,000 ppm). Prior to converter. Erratic swings in EGO sensor readings | <ul style="list-style-type: none"> <li>Low compression ratio or load conditions</li> </ul>   | <ul style="list-style-type: none"> <li>Correct engine</li> </ul>   |
| High conversion efficiency for CO and low for NO <sub>x</sub> (or visa versa); engine operating correctly   | <ul style="list-style-type: none"> <li>Improper air fuel controller calibration or operation</li> </ul>  | <ul style="list-style-type: none"> <li>Check instructions for air fuel controller</li> </ul>   |
| High conversion efficiency for CO and low for NO <sub>x</sub> (or visa versa); engine operating correctly   | <ul style="list-style-type: none"> <li>Damaged catalytic coating, i.e. lost oxygen storage capacity (possibly due to short term high temperature from ignition misfire)</li> </ul> | <ul style="list-style-type: none"> <li>Check engine ignition system.</li> <li>Replace catalyst element (high temperature damage can be assessed by chemical analysis of element)</li> </ul>                            |
| Low simultaneous conversion efficiencies of NO <sub>x</sub> and CO; AFRC and engine operating correctly   | <ul style="list-style-type: none"> <li>Exhaust by-passing catalyst element</li> <li>Possible catalyst activity problem</li> </ul>  | <ul style="list-style-type: none"> <li>Inspect catalyst element for gaps. Inspect and replace gasket material</li> <li>Add additional layer of gasket if necessary</li> <li>Contact DCL if problem persists</li> </ul> |

**Note: Typical exhaust values for good three-way conversion are provided on the table in page 15.**



## 8.0 SPARE PARTS



Retaining Bar and  
Quick Release  
Lock Pins

Brass Plug

|                      |   |            |
|----------------------|---|------------|
| <b>Item</b>          | Captive Bolts*                          |            |
| <b>Specification</b> | 1/2"-13 UNC X 1.50L WHIZ<br>- LOCK bolt |            |
| <b>Part Number</b>   | X0400-Q500-04                           |            |
| <b>Quantities</b>    | <b>Model</b>                            | <b>Qty</b> |
|                      | DC63 or DC73                            | 22         |
|                      | DC64 or DC74                            | 24         |
|                      | DC64.5 or DC74.5                        | 24         |
|                      | DC65 or DC75                            | 26         |
|                      | DC66 or DC76                            | 26         |
|                      | DC68 or DC78                            | 26         |
|                      | DC68.1 or DC78.1                        | 34         |
|                      | DC69.5 or DC69.5                        | 34         |

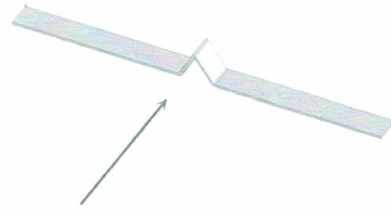
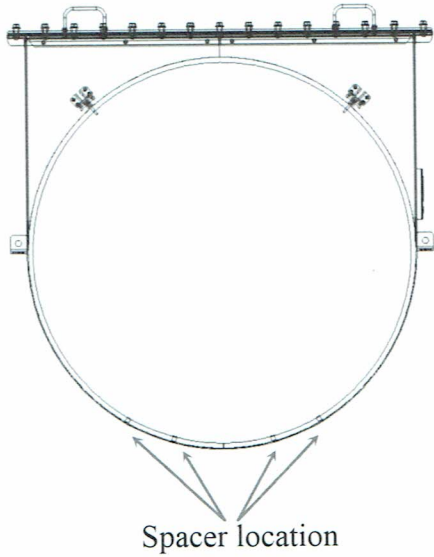
\* Non-captive bolts/nuts also available  
Bolt P/N X0400-Q500-03 Nut P/N X4008-NUTC-IS

|                            |                                      |               |
|----------------------------|--------------------------------------|---------------|
| <b>Item</b>                | Cover Plate Gasket                   |               |
| <b>Specification</b>       | Machine cut graphite-stainless steel |               |
| <b>Qty per cover plate</b> | 2                                    |               |
| <b>Part Numbers</b>        | <b>Model</b>                         | <b>P/N</b>    |
|                            | DC63 or DC73                         | X1963-Q502-09 |
|                            | DC64 or DC74                         | X1964-Q502-09 |
|                            | DC64.5 or DC74.5                     | X1967-Q502-09 |
|                            | DC65 or DC75                         | X1965-Q502-09 |
|                            | DC66 or DC76                         | X1966-Q502-09 |
|                            | DC68 or DC78                         | X1968-Q502-09 |
|                            | DC68.1 or DC78.1                     | X19C4-Q502-09 |
|                            | DC69.5 or DC79.5                     | X19C9-Q502-09 |

| Item                   | P/N           | Qty per cover plate |
|------------------------|---------------|---------------------|
| Retaining Bar          | X0500-Q502-35 | 2                   |
| Quick Release Lock Pin | X0400-Q500-01 | 4                   |
| 1/2" NPT Brass Plug    | X0702-0028-02 | 4                   |

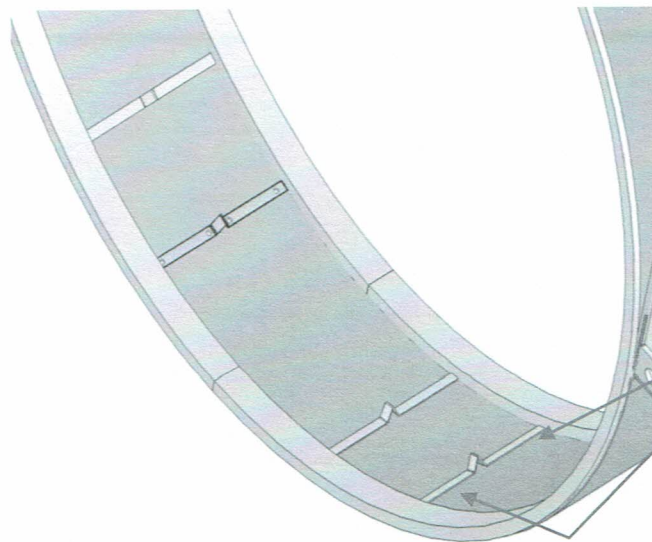
**Note: For spare elements, or for part information from older QUICK-LID® models, contact a DCL representative.**

## Horizontal Mount QUICK-LID®



|                 |               |
|-----------------|---------------|
| Item            | Spacer        |
| P/N             | X0500-Q5XX-02 |
| Qty per housing | 4             |

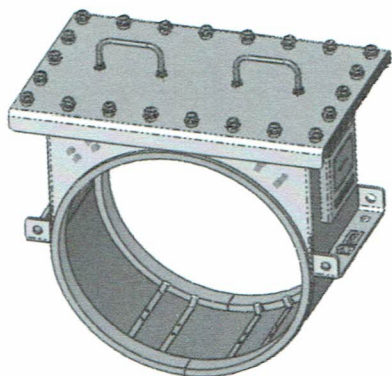
**Note:** In the case of a high pressure event, such as engine backfire, the four spacers supporting the catalyst element(s) may break. This breakage will help to minimize damage to the catalyst element(s). The four brackets can be welded back in place by following the instructions below.



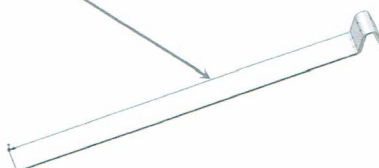
Use the GMAW (MIG) process with ER308L wire to apply two 1/4" dia spot welds on each side of the spacers



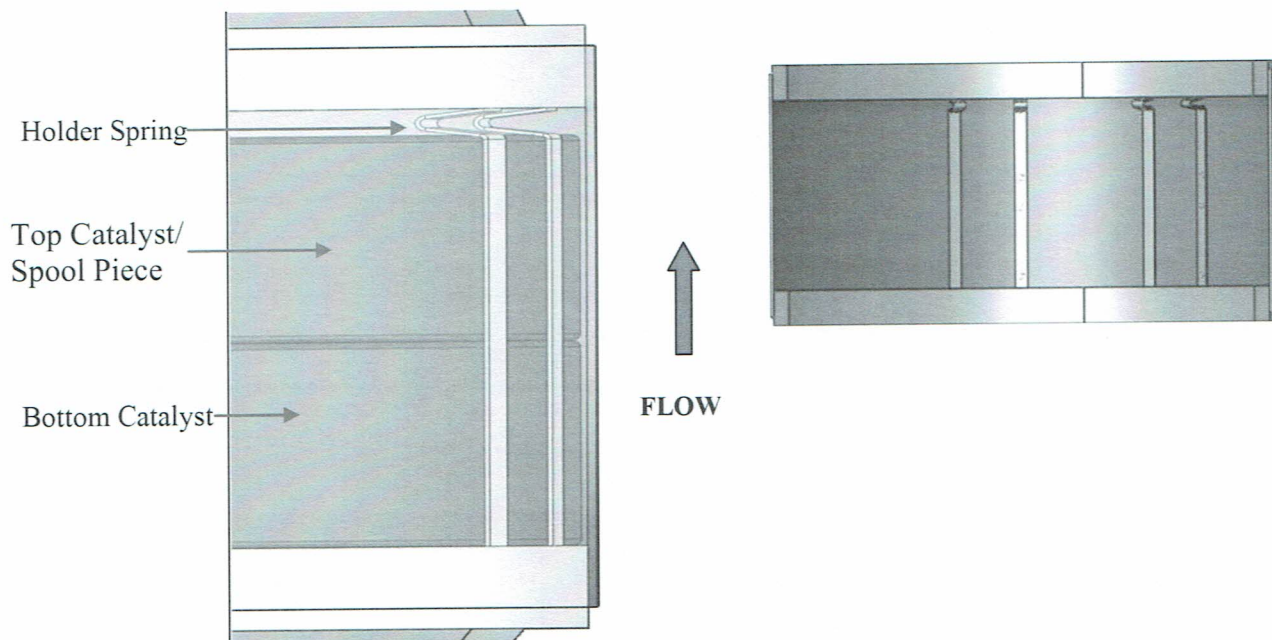
## Vertical Mount QUICK-LID®



| Item                   | P/N           | Qty per cover plate |
|------------------------|---------------|---------------------|
| Retaining Bar          | X4600-A9C7-01 | 2                   |
| Quick Release Lock Pin | X0400-Q500-01 | 4                   |
| Spacer                 | X4600-A9CT-02 | 4                   |



**Note:** When installing the catalyst element(s), the end of the spacer with the bend (holder spring) should always be on top of the catalyst as shown below. Its purpose is to provide a tight fit and to minimize damage to the catalyst element(s) in the case of a high pressure event such as an engine backfire.



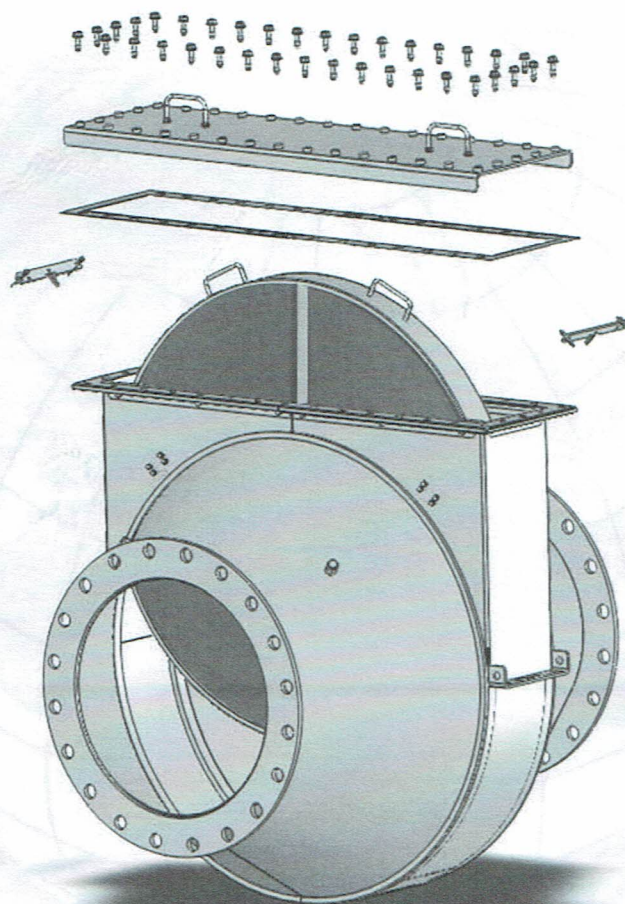
# Appendix A

## Installation and Removal of Catalyst Elements



# QUICK-LID®

## Catalyst Installation Guide

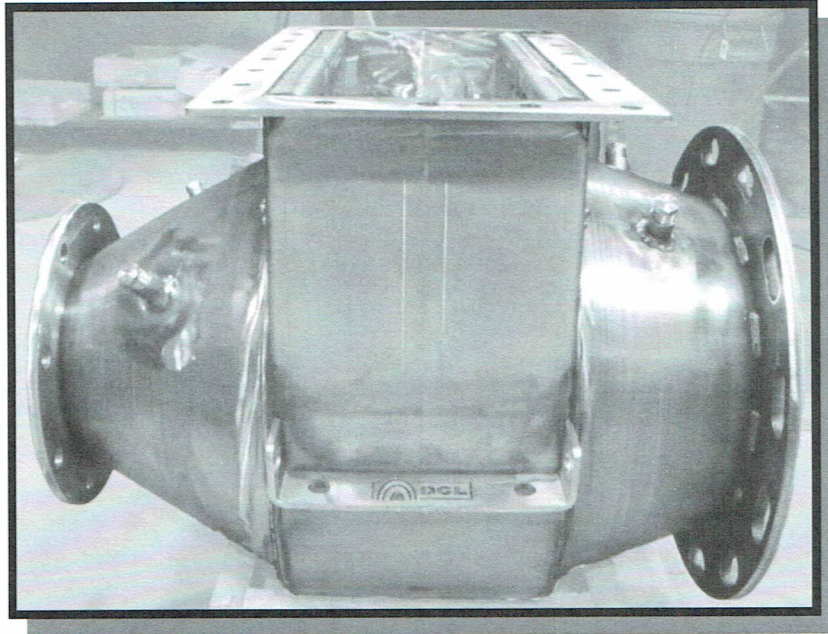


**DCL International Inc.**

241 Bradwick Drive, Concord, Ontario, Canada L4K 1K5  
Toll Free: 1-800-872-1968 • Fax: 905-660-6435 • E-mail: [sales@dcl-inc.com](mailto:sales@dcl-inc.com)  
[www.dcl-inc.com](http://www.dcl-inc.com)



## Case A – Horizontal Installation



### STEP 1: (Horizontal Installation)

Insert catalyst element into empty housing. If installing only one catalyst element, it is recommended to use the slot furthest from the inlet first.

#### WHY:

The pressure from the flow will push against the catalyst element, reinforcing the seal between the catalyst element and housing.

Flow Direction

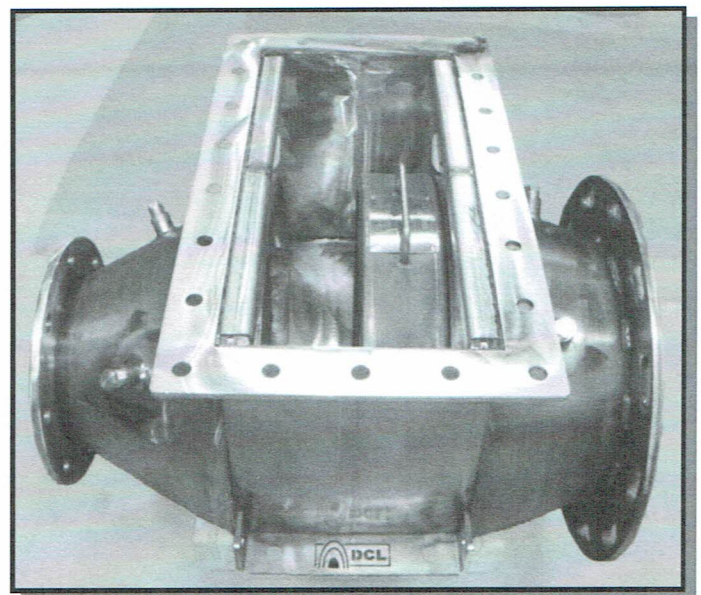


Fig. 1: Horizontal Installation



## Horizontal Installation

### STEP 2: (Horizontal Installation)

Insert both retaining bars into the slots located on the inside of the housing and secure them with the retaining pins as shown in Fig. 3.

#### For Applications Using Only One Catalyst Element:

**Horizontal Installation:** The retaining bars must be positioned such that the numeral "1" is located in the same slot as the catalyst element.

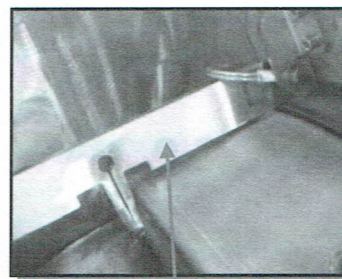
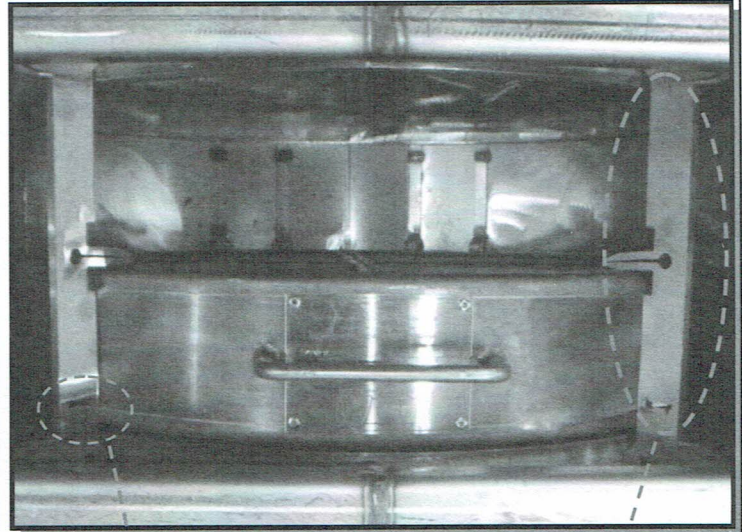
#### For Applications Using Two Catalyst Elements:

**Horizontal Installation:** Orient the retaining bars such that the numeral "1" (on both bars) are located above the catalyst closest to the outlet.

#### WHY:

The slotted ends on the retaining bar are oriented differently at each end. The slot located on the same side as the numeral "1" is vertical, thus preventing any lateral movement, while the slot on the opposite end of the retaining bar is horizontal to prevent any vertical movement of the element.

Fig. 3: Installing the Retaining Bars



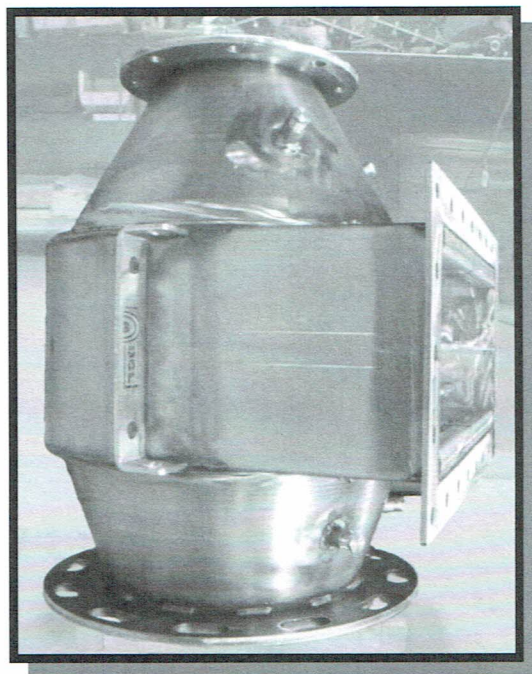
Retaining Bar for Horizontal Installation



Retaining Pins



## Case B – Vertical Installation



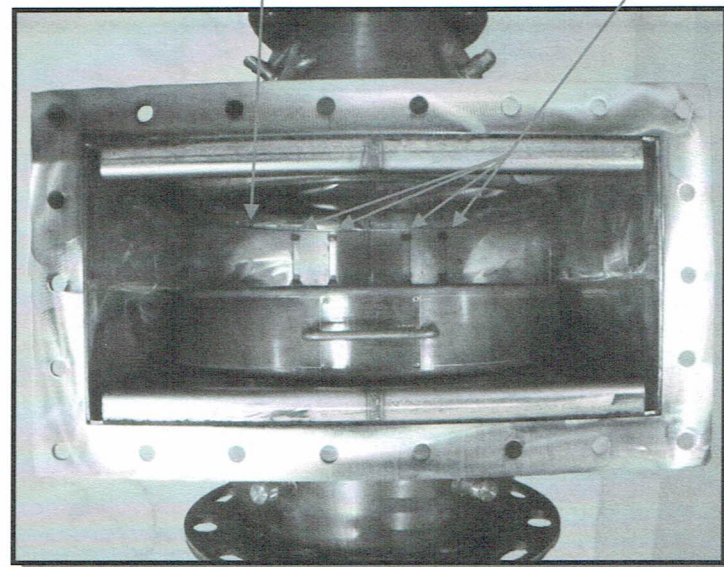
### STEP 1: (Vertical Installation)

Insert catalyst element(s) into empty housing. When installing the catalyst element(s), the end of the spacer with the bend (holder spring) should always be on top of the catalyst as shown in fig. 2. **If installing only one catalyst element**, install the element in the lowest slot first (**regardless of flow direction**). Use a spool piece above the catalyst element to fill the empty slot.

**WHY:** The gravitational force will provide pressure on the catalyst element creating a tight seal between the catalyst element and housing. The spool piece will keep the elements from moving around vertically.

Holder Spring

Use a spool piece to fill this empty slot



**Fig. 2: Lowest Slot Vertical Installation**



## Vertical Installation

### STEP 2: (Vertical Installation)

Insert both retaining bars into the slots located on the inside of the housing and secure them with the retaining pins as shown in Fig. 4.

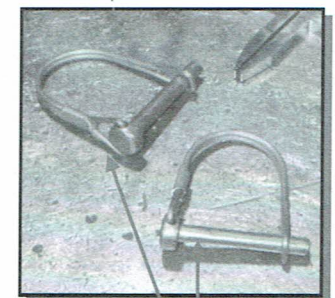
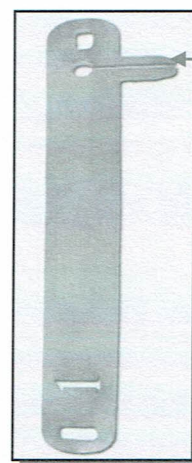
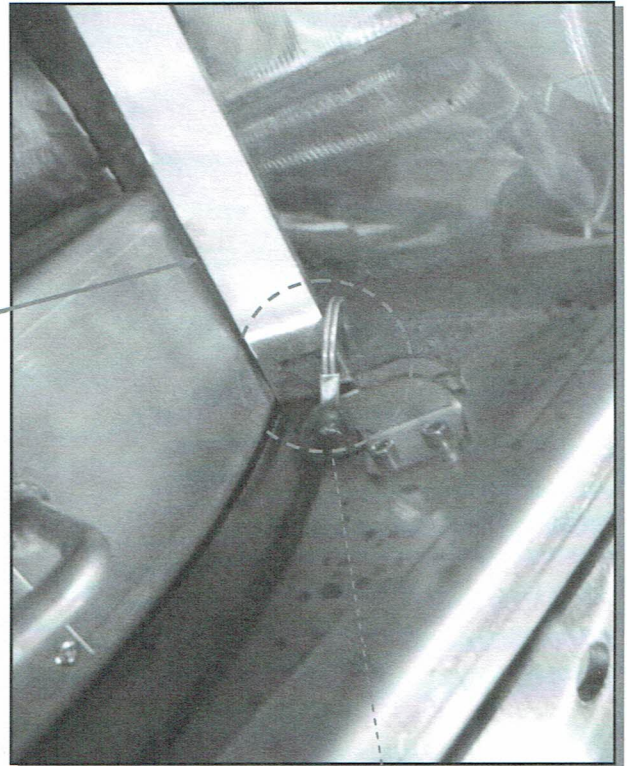
**NOTE: The following procedure is for vertical installations using one or two Catalyst Element(s):**

**Vertical Installation:** Orient the retaining bars such that the numeral "1" (on both bars) are located above the lower catalyst.

### WHY:

The retaining bars for vertical installations are different than the retaining bars for horizontal installations. The peg on the retaining bar for vertical installations is located on the opposite side to the numeral "1" creating a tight fit for the catalyst element(s) thus preventing vertical movement.

Fig. 4: Installing the Retaining Bars



Retaining Bar for Vertical Installation

Retaining Pins



**NOTE:** The following procedures are for both horizontal and vertical installations

**STEP 3: (Horizontal & Vertical Installation)**

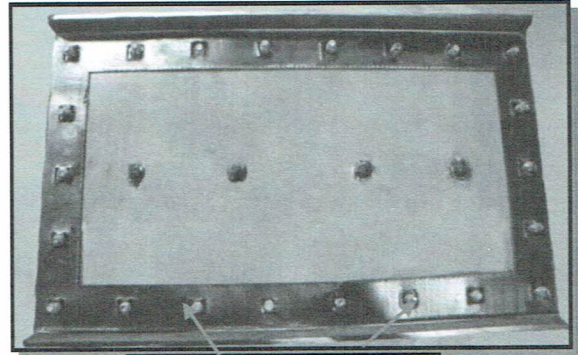
If necessary, replace the gasket by installing a new gasket on the lid.

**Step 4: (Horizontal & Vertical Installation)**

Install bolts so that the housing cover is pushed down and sealed to the housing. Use an anti-seizing compound on the bolt threads when installing. Nuts should be chased and bolts lubricated at each service.

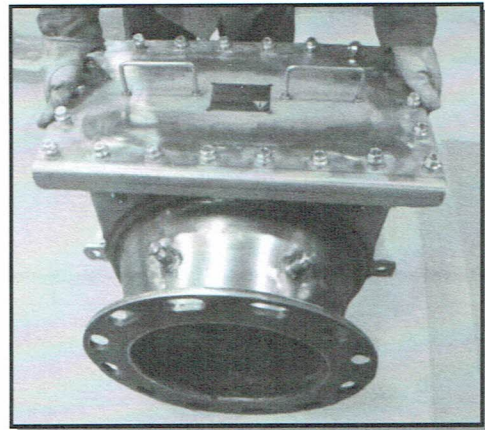
To supply a sufficient positive seal, follow the torque sequence provided in Fig. 7. Tightening torque should be 40-50lb-ft.

**Fig. 5: Installing the Gasket**

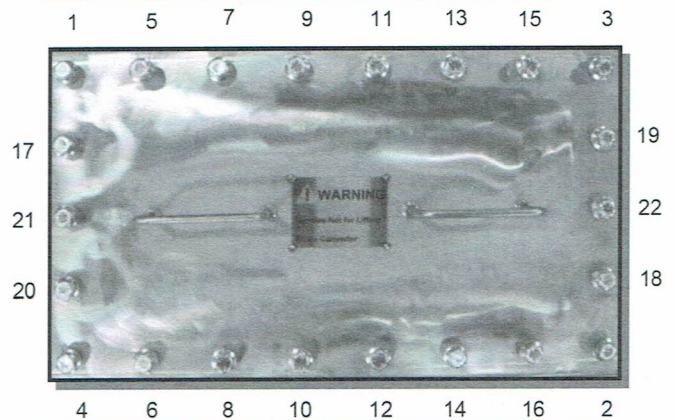


Two Piece Gasket

**Fig. 6: Setting the Lid**



**Fig. 7: Tightening Torque for Top Lid**



# Appendix B

## MSDS





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Toll free: 1-800-872-1968 or (905)-660-6450 Fax: (905)-660-6435 E-mail: info@dcl-inc.com

## MATERIAL SAFETY DATA SHEET

### Section 1 – General Information

Product Name: Oxidation or Three Way Catalyst  
Hazardous Material Description: N.A.  
Chemical Family: N.A.  
Formula: N.A.

### Section 2 – Ingredients

These ingredients are listed in TSCA inventory:

| CAS Registry No. | %W          | Chemical Names  | Listed as a carcinogen in NTP, IARC or OSHA |
|------------------|-------------|-----------------|---|
|                  | 75 to 85    | Metal Substrate | Not listed                                  |
| 1344-28-1        | 15 to 25    | Aluminum Oxide  | Not listed                                  |
| 1306-38-3        | 0 to 10     | Cerium Oxide    | Not listed                                  |
| 7440-06-4        | Less than 1 | Platinum        | Not listed                                  |
| 7440-16-6        | Less than 1 | Rhodium         | Not listed                                  |

### Section 3- Physical Data

|                          |  |                             |           |
|--------------------------|--|-----------------------------|-----------|
| Boiling Point:           | Not Known  | Specific Gravity:           | Not Known |
| Vapour Pressure:         | Not Known  | Percent Volatile by Volume: | Not Known |
| Vapour Density:          | N.A.   | Evaporation Rate:           | N.A.      |
| Percent Solid by Weight: |  | pH:                         | N.A.      |
| Solubility in Water:     | Not Known  |                             |           |
| Appearance and Odor:     | Honeycombed metal, no odor, reddish brown to black in color.<br>Material is a solid. |                             |           |

### Section 4 – Fire and Explosion Hazard Data

|                                     |   |
|-------------------------------------|---|
| Flash Point:                        | N.A.  |
| Extinguishing Media:                | Water, CO <sub>2</sub> , Dry Chemical, Foam |
| Unusual Fire and Explosion Hazards: | None  |
| Special Fire Fighting Procedures:   | None  |



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## Section 5 – Health Hazard Data

### Threshold Limit Value:

None established for this product. See value for components below.

### Hazardous Ingredients

| Material       | ACGIH – TLV<br>mg/m <sup>3</sup><br>unless otherwise noted | OSHA PEL<br>mg/m <sup>3</sup><br>unless otherwise noted |
|----------------|--|---|
| Aluminum Oxide | 10 (as aluminum)   | 10 (total dust)<br>5 (respirable fraction)              |
| Cerium Oxide   | 10 (total dust)  | 15 (total dust)<br>5 (respirable fraction)              |
| Platinum       | 1 (as platinum)  | 1 (as platinum)   |
| Rhodium        | 1 (as rhodium)   | 0.1 (as rhodium)  |

### Effects of Overexposure:

No adverse health effect would be expected during normal handling of this product. Health effects should be considered if this product is further worked such as cutting, grinding or crushing.

#### ***Inhalation:***

Short term exposure: May cause irritation to the nose, throat and respiratory tract.  
Long-term exposure: May cause damage to the respiratory tract and respiratory diseases.

#### ***Eye Contact:***

Short term exposure: May cause irritation and conjunctivitis.  
Long-term exposure: No additional effects known.

#### ***Skin Contact:***

Short term exposure: May cause skin dehydration and irritation.  
Long-term exposure: No additional effects known.

#### ***Ingestion:***

Short term exposure: None known.  
Long-term exposure: None known.

The health effects associated with the individual component of this product are listed below. It is important that actual exposures be determined by industrial hygiene monitoring.

#### Aluminum Oxide:

General: Aluminum Oxide is not listed by OSHA, IARC or NTP as a carcinogen. Repeated over-exposure has been linked to emphysema and other respiratory diseases.



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**Cerium Oxide:**

General: Cerium Oxide is not listed by OSHA, IARC or NTP as a carcinogen.

**Platinum:**

General: Platinum is not listed by OSHA, IARC or NTP as a carcinogen. Metallic platinum is considered to have minimal adverse health effect. Some platinum compounds are sensitizers. This should be taken into consideration for any process or procedure, which could result in the formation of other platinum compounds.

**Rhodium:**

General: Rhodium is not listed by OSHA, IARC or NTP as a carcinogen. Metallic rhodium is considered to have minimal adverse health effect. There are no documented health effects to humans due to overexposure to rhodium. Certain rhodium compounds (chloride) caused cancer in mice in one laboratory study.

**Medical Conditions Aggravated By Exposure:**

Dusts may aggravate pre-existing respiratory or allergic conditions in some workers if this product is further worked.

**Recommended First Aid Treatment:**

- Eyes:** Flush with water for 15 minutes. Seek medical attention immediately to ensure particles are removed from eyes.
- Skin:** Flush area with plenty of water. Cleanse wounds thoroughly to remove any particles. If irritation of skin occurs, seek medical attention.
- Inhalation:** Remove person to fresh air. If breathing has stopped, perform artificial respiration. If breathing is difficult, qualified personnel should give oxygen. Keep person warm and at rest. Seek medical attention immediately.
- Ingestion:** If material is swallowed, induce vomiting by giving large amounts of water and sticking fingers on the back of the throat. NEVER give anything by mouth to an unconscious person or make an unconscious person vomit. Seek medical attention immediately.

---

**Section 5 – Reactivity Data**

|                                       |                                       |
|---------------------------------------|---------------------------------------|
| Stability:                            | Stable                                |
| Incompatibility (materials to avoid): | Strong Acids and Bases                |
| Hazardous Decomposition Products:     | Contained elements or metallic oxides |
| Hazardous Polymerization:             | Will not occur                        |





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---

## **Section 6 – Spill or Leak Procedures**

### **Steps to be taken in case material is released or spilled:**

Clean up and accumulate any spilled residues. If cleaning up with a vacuum cleaner, the vacuum cleaner should be equipped with a high efficiency particulate filter (HEPA). Store collected material in DOT approved drums (see Section 8 - Special Protection Information and Section 9 - Special Precautions, for additional information).

### **Waste Disposal Method:**

Follow local, state and federal regulations for packaging, labeling, manifesting, transporting and disposal. Collected material should be recycled for its precious metals content.

CERCLA Reportable Quantity: N.A.

RCRA Hazardous Waste No. (40 CFR 261.33): N.A.

Volatile Organic Compounds (VOC): N.A.

---

## **Section 8 – Social Protection Information**

### **Respiratory Protection:**

Not normally required. If there is a possibility that the TLVs or PELs may be exceeded, a NIOSH/MSHA approved full-face piece respirator with high efficiency dust filters represents the minimum level of respiratory protection.

### **Local Exhaust Ventilation:**

Not normally required. If dusts are produced, local exhaust ventilation with HEPA filtration at point of dust generation should be provided.

### **Protective Gloves:**

Minimum of cotton gloves is recommended to avoid abrasion. If dust is present, gloves made of natural rubber, neoprene or nitrile are acceptable.

### **Eye Protection:**

Safety glasses should be worn to avoid contact with eyes. If dust is generated, chemical goggles should be worn.

### **Other Protective Equipment:**

If dust is present, wear disposable clothes to avoid getting material on clothing.

---



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---

## **Section 9 – Special Precautions**

### **Precautions to be taken in Handling and Storing:**

Store in a dry area. Avoid damaging, crushing or creating dust form this material.

### **Other Precautions:**

Follow good industrial hygiene and housekeeping practices. Do not eat, drink or smoke while working with this material. Wash hands before eating, drinking, smoking, applying cosmetics and at the end of the work shift. Avoid contact with eyes, skin or clothing. Do not ingest. Avoid breathing dust form this material. Use with adequate ventilation.

If uncontrolled dust is present, protective clothing, chemical resistant gloves, eye protection and respirator should be worn (see Special Protection Information).

---

**Disclaimer:** This information is furnished without warranty, and any use of the product not in conformance with this Material Data Sheet, or in combination with any other product or process, is the responsibility of the user.



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## MATERIAL SAFETY DATA SHEET

### Section 1 – General Information

Product Name: Oxidation Catalyst  
Hazardous Material Description: N.A.  
Chemical Family: N.A.  
Formula: N.A.

### Section 2 – Ingredients

| CAS Registry No. | %W          | Chemical Names  | Listed as a carcinogen in NTP, IARC or OSHA |
|------------------|-------------|-----------------|---|
| 1344-28-1        | 75 to 85    | Metal Substrate | Not listed                                  |
| 7440-06-4        | 15 to 25    | Aluminum Oxide  | Not listed                                  |
|                  | Less than 1 | Platinum        | Not listed                                  |

### Section 3- Physical Data

|                          |  |                             |           |
|--------------------------|--|-----------------------------|-----------|
| Boiling Point:           | Not Known  | Specific Gravity:           | Not Known |
| Vapour Pressure:         | Not Known  | Percent Volatile by Volume: | Not Known |
| Vapour Density:          | N.A.   | Evaporation Rate:           | N.A.      |
| Percent Solid by Weight: |  | pH:                         | N.A.      |
| Solubility in Water:     | Not Known  |                             |           |
| Appearance and Odor:     | Honeycombed metal, no odor, reddish brown to black in color.<br>Material is a solid. |                             |           |

### Section 4 – Fire And Explosion Hazard Data

|                                     |   |
|-------------------------------------|---|
| Flash Point:                        | N.A.  |
| Extinguishing Media:                | Water, CO <sub>2</sub> , Dry Chemical, Foam |
| Unusual Fire and Explosion Hazards: | None  |
| Special Fire Fighting Procedures:   | None  |



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## Section 5 – Health Hazard Data

### Threshold Limit Value:

None established for this product. See value for components below.

### Hazardous Ingredients

| Material       | ACGIH – TLV<br>mg/m <sup>3</sup><br>unless otherwise noted | OSHA PEL<br>mg/m <sup>3</sup><br>unless otherwise noted |
|----------------|--|---|
| Aluminum Oxide | 10 (as aluminum)   | 10 (total dust)<br>5 (respirable fraction)              |
| Platinum       | 1 (as platinum)  | 1 (as platinum)   |

### Effects of Overexposure:

No adverse health effect would be expected during normal handling of this product. Health effects should be considered if this product is further worked such as cutting, grinding or crushing.

#### **Inhalation:**

Short term exposure: May cause irritation to the nose, throat and respiratory tract.  
Long-term exposure: May cause damage to the respiratory tract and respiratory diseases.

#### **Eye Contact:**

Short term exposure: May cause irritation and conjunctivitis.  
Long-term exposure: No additional effects known.

#### **Skin Contact:**

Short term exposure: May cause skin dehydration and irritation.  
Long-term exposure: No additional effects known.

#### **Ingestion:**

Short term exposure: None known.  
Long-term exposure: None known.

The health effects associated with the individual component of this product are listed below. It is important that actual exposures be determined by industrial hygiene monitoring.

#### Aluminum Oxide:

General: Aluminum Oxide is not listed by OSHA, IARC or NTP as a carcinogen. Repeated over-exposure has been linked to emphysema and other respiratory diseases.





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---

**Platinum:**

General: Platinum is not listed by OSHA, IARC or NTP as a carcinogen. Metallic platinum is considered to have minimal adverse health effect. Some platinum compounds are sensitizers. This should be taken into consideration for any process or procedure, which could result in the formation of other platinum compounds.

**Medical Conditions Aggravated By Exposure:**

Dusts may aggravate pre-existing respiratory or allergic conditions in some workers if this product is further worked.

**Recommended First Aid Treatment:**

- Eyes:** Flush with water for 15 minutes. Seek medical attention immediately to ensure particles are removed from eyes.
- Skin:** Flush area with plenty of water. Cleanse wounds thoroughly to remove any particles. If irritation of skin occurs, seek medical attention.
- Inhalation:** Remove person to fresh air. If breathing has stopped, perform artificial respiration. If breathing is difficult, qualified personnel should give oxygen. Keep person warm and at rest. Seek medical attention immediately.
- Ingestion:** If material is swallowed, induce vomiting by giving large amounts of water and sticking fingers on the back of the throat. NEVER give anything by mouth to an unconscious person or make an unconscious person vomit. Seek medical attention immediately.
- 

**Section 5 – Reactivity Data**

|                                       |                                       |
|---------------------------------------|---------------------------------------|
| Stability:                            | Stable                                |
| Incompatibility (materials to avoid): | Strong Acids and Bases                |
| Hazardous Decomposition Products:     | Contained elements or metallic oxides |
| Hazardous Polymerization:             | Will not occur                        |

---

**Section 6 – Spill or Leak Procedures**

**Steps to be taken in case material is released or spilled:**

Clean up and accumulate any spilled residues. If cleaning up with a vacuum cleaner, the vacuum cleaner should be equipped with a high efficiency particulate filter (HEPA). Store collected material in DOT approved drums (see Section 8 - Special Protection Information and Section 9 - Special Precautions, for additional information).



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---

**Waste Disposal Method:**

Follow local, state and federal regulations for packaging, labeling, manifesting, transporting and disposal.  
Collected material should be recycled for its precious metals content.

|   |      |
|---|------|
| CERCLA Reportable Quantity:               | N.A. |
| RCRA Hazardous Waste No. (40 CFR 261.33): | N.A. |
| Volatile Organic Compounds (VOC):         | N.A. |

---

**Section 8 – Special Protection Information**

**Respiratory Protection:**

Not normally required. If there is a possibility that the TLVs or PELs may be exceeded, a NIOSH/MSHA approved full-face piece respirator with high efficiency dust filters represents the minimum level of respiratory protection.

**Local Exhaust Ventilation:**

Not normally required. If dusts are produced, local exhaust ventilation with HEPA filtration at point of dust generation should be provided.

**Protective Gloves:**

Minimum of cotton gloves is recommended to avoid abrasion. If dust is present, gloves made of natural rubber, neoprene or nitrile are acceptable.

**Eye Protection:**

Safety glasses should be worn to avoid contact with eye. If dust is generated, chemical goggles should be worn.

**Other Protective Equipment:**

If dust is present, wear disposable clothes to avoid getting material on clothing.

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---

## **Section 9 – Special Precautions**

### **Precautions to be taken in Handling and Storing:**

Store in a dry area. Avoid damaging, crushing or creating dust form this material.

### **Other Precautions:**

Follow good industrial hygiene and housekeeping practices. Do not eat, drink or smoke while working with this material. Wash hands before eating, drinking, smoking, applying cosmetics and at the end of the work shift. Avoid contact with eyes, skin or clothing. Do not ingest. Avoid breathing dust form this material. Use with adequate ventilation.

If uncontrolled dust is present, protective clothing, chemical resistant gloves, eye protection and respirator should be worn (see Special Protection Information).

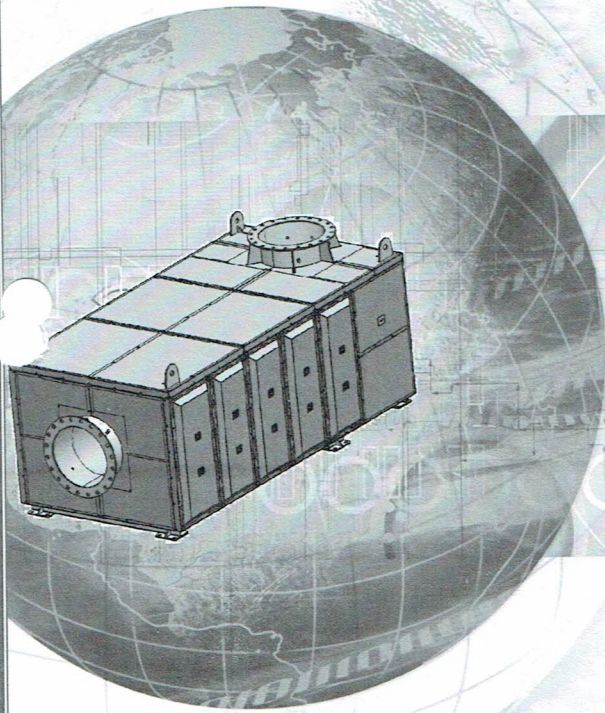
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### **Disclaimer:**

This information is furnished without warranty, and any use of the product not in conformance with this Material Data Sheet, or in combination with any other product or process, is the responsibility of the user.



# INSTALLATION, OPERATION & MAINTENANCE MANUAL



# *DCL SCR on F*



---

P.O. Box 90, Concord, Ontario, Canada L4K 1B2

Call Free: 1-800-872-1968 | Fax: 905-660-6435 | Email: [info@dcl-inc.com](mailto:info@dcl-inc.com) | [www.dcl-inc.com](http://www.dcl-inc.com)

Last Revised March 16, 2017



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**Important Note:** Before any work, consult your company health and safety officer for details of safe working practices. Safety requirements include but are not limited to: proper engine shut down; personal protection (gloves, coveralls, safety glasses etc.); and safe handling temperature of filter.

This manual provides instructions on the installation, maintenance and operation of DCL's SCRonF combination of Diesel Particulate Filter (DPF) and Selective Catalytic Reduction (SCR) catalyst.

The SCRonF contains wall-flow diesel particulate filter bricks that simultaneously promote passive soot regeneration and reduction of NO<sub>x</sub>. Heat from the engine exhaust burns off the particulates in a continuous manner, requiring no auxiliary exhaust heating components. Simultaneously, the SCR catalyst provides NO<sub>x</sub> reduction when urea is injected upstream using standard SCR urea dosing and mixing strategy. The housing is project-specific designed according to the engine and emission reduction requirements. In some designs a secondary layer of SCR catalyst is combined with the wall-flow DPF module.

This manual provides general concept and arrangements of the SCRonF housing. As project-specific designs may differ, refer to the Sales Drawing supplied with the project proposal for specific design information.



Figure 1.1 Example of SCFonF Brick

#### *Applications:*

The SCRonF is suitable for stationary diesel engines used for power generation and meet the additional criteria described in the Operation section below.

#### *Removal Efficiencies:*

|  |   |
|--|---|
| Particulate Matter - by particle count | >99% (ultra-fine and fine particles diameter 10–500 nm) |
| Particulate Matter - by mass           | 85-95% (ISO8178 or CARB Method 5 front half)            |
| Carbon Monoxide                        | Nil   |
| Hydrocarbons / (VOCs)                  | Nil   |
| Oxides of Nitrogen (NO <sub>x</sub> )  | Project-specific. Refer to quote for details.           |

*Sound Attenuation and Silencing:*

The sound attenuation of the standard SCRonF is 10-20 dBA unless stated otherwise on the Sales Drawing. Additional sound attenuation properties can be incorporated into the housing on a project specific basis.

*Exhaust Monitor/Logger:*

DCL requires that a **customer supplied** exhaust monitor and logger be installed on all applications. As a minimum, the device must measure the pressure drop across the inlet and outlet of the SCRonF housing and temperature at the inlet of the housing. The customer shall allow DCL access to this data in order to monitor overall system performance and in the event that troubleshooting is necessary.

Minimum specifications

|                              |            |
|------------------------------|------------|
| Pressure drop:               | +/- 1 mbar |
| Temperature:                 | +/- 1°C    |
| Measure/Recording Frequency: | 10 seconds |
| Time stamp:                  | Required   |
| Capacity:                    | 1000 hours |



## 2

## INSTALLATION

### 2.1 Filter Installation

It is necessary to install the SCRonF assembly as close to the exhaust manifold of the engine as possible, due to the SCRonF's requirement for heat. In addition, the SCRonF should be mounted so that it is isolated from engine vibration and external loads from the exhaust system.

If an installation case arises that does not fall under one of the above installation types, or if installation assistance is required, please contact DCL Technical Support (905) 660-6450 or toll free, 1-800-872-1968.

### 2.2 Installation Type – SCRonF Housing

Please follow the instructions below to install the standard SCRonF Housing.

- 1) If applicable, the SCRonF Housing is to be mounted upstream of the original equipment muffler.
- 2) Determine a suitable horizontal space as close to the engine exhaust outlet as possible.
- 3) Allow adequate space (~30" (762 mm)) for loading and unloading the individual filter units.
- 4) Secure the SCRonF Housing feet to a concrete foundation or structural steel.
- 5) Use a flex pipe to isolate the SCRonF Housing from vibrations from the engine or exhaust stream.
- 6) Eight ½" test ports are provided to allow installation of pressure and temperature at the inlet and outlet.

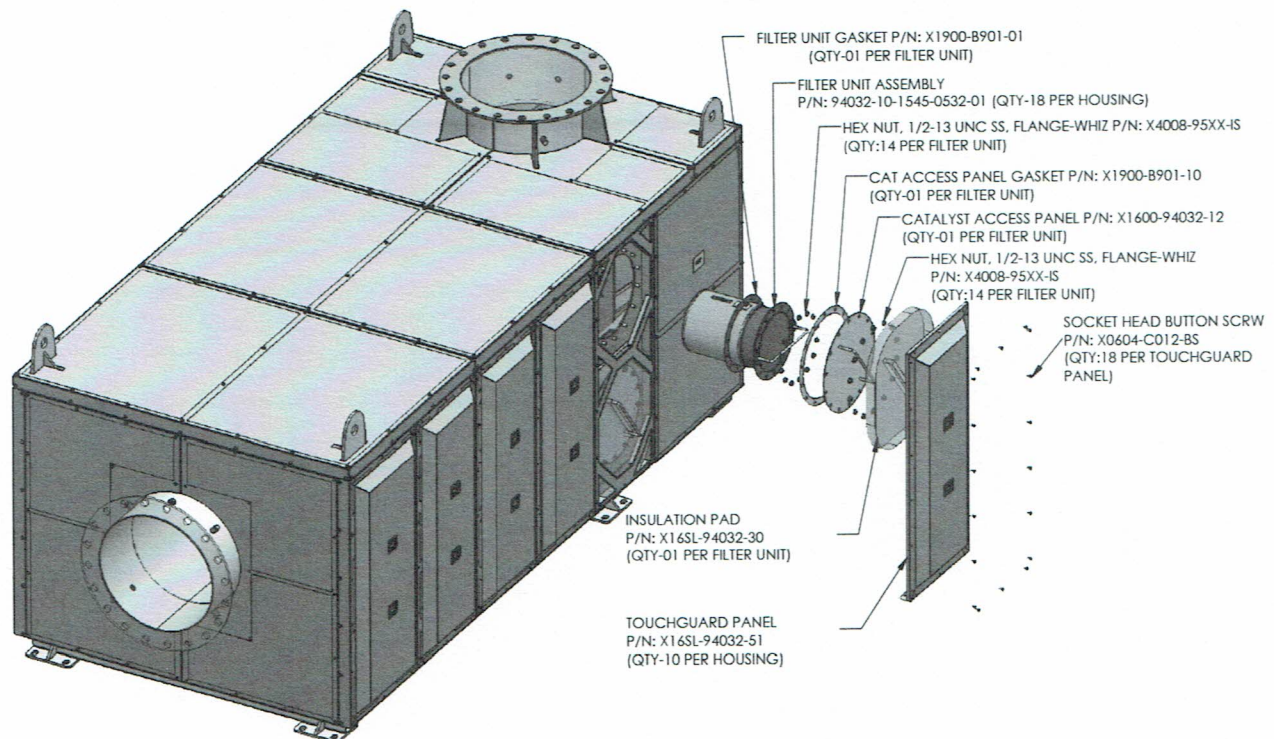


Figure 2.1 – Example of SCRonF Housing with Filter Unit Exploded View



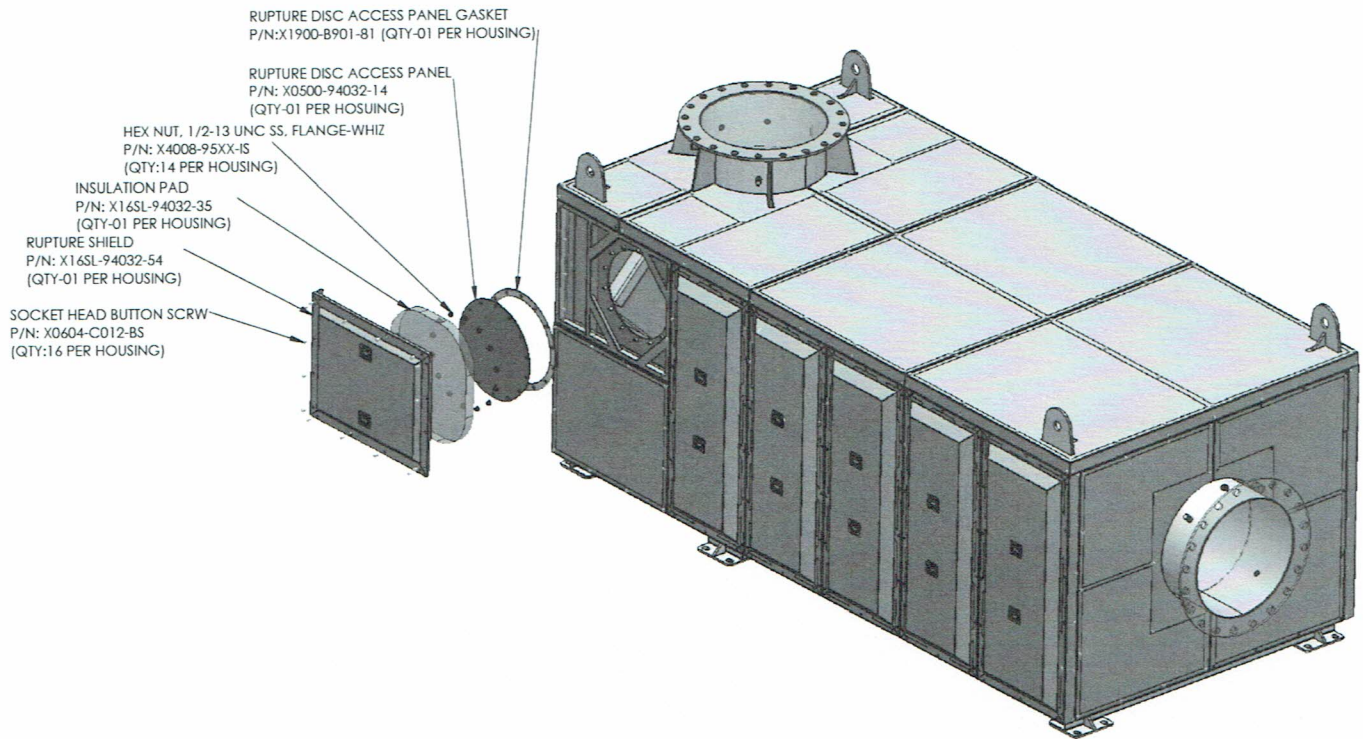


Figure 2.2 – Example of SCRonF Housing with Rupture Disc Exploded View

### 2.2.1 Installation Instructions for Filter Units

- 1) Install the filter unit gasket on the high pressure chamber wall.
- 2) While holding the handle, install the filter unit assembly on the high pressure chamber wall by pushing it into the filter holder.
- 3) Install and fasten 14 flanged nuts on the high pressure chamber wall to 50~75 ft-lb torque.
- 4) Install the cat access panel gasket on the low pressure chamber wall.
- 5) Install the catalyst access panel on the low pressure chamber wall.
- 6) Install and fasten the flanged nuts on the low pressure wall to 50~75 ft-lb torque.
- 7) Insert insulation pad in front of the filter unit
- 8) Repeat steps 1-7 for the other filter units.
- 9) Install the touchguard panels on to SCRonF housing
- 10) Install and fasten the screw on to the SCRonF housing

### 2.2.2 Installation Instructions for Spare Filter Unit Cover

- 1) Install the filter unit gasket on the spare filter slot on the high pressure chamber wall.
- 2) Install the spare filter cover on the high pressure chamber wall.
- 3) Install and fasten 14 flanged nuts on the high pressure chamber wall to 50~75 ft-lb torque.
- 4) Install the filter access panel gasket on the low pressure chamber wall.

- 5) Install the filter access panel on the low pressure chamber wall.
- 6) Install and fasten the flanged nuts on the low pressure wall to 50~75 ft-lb torque.
- 7) Insert insulation pad in front of the filter unit
- 7) Repeat steps 1-7 on the opposite side of the housing.

### **2.2.3 Installation Instructions for Rupture Disc**

- 1) Install the rupture disc gasket on to the chamber wall.
- 2) Install the rupture disc access panel on to the chamber wall.
- 3) Install and fasten 14 flanged nuts on to the chamber wall to 50~75 ft-lb torque.
- 4) Insert the insulation pad in front of the rupture disc.
- 5) Install the rupture shield on to the chamber wall.
- 6) Install and fasten the socket head screw on to the chamber wall.

### **2.2.4 Removal Instructions for Filter Unit**

- 1) Remove the touchguard panel from SCRonF housing
- 2) Remove the insulation pad from the housing
- 3) Remove flanged nuts from the catalyst access panel.
- 4) Remove the catalyst access panel and discard used access panel gasket if damaged.
- 5) Removed flanged nuts from the filter unit flange.
- 6) Remove the filter unit and discard used filter gasket if damaged.
- 7) Repeat steps 1-6 for the other filter units.



### 3 OPERATION

Table 3.1: General Operating Requirements

| Variable  | Operating Requirement  |
|---|--|
| Engine Load                                       | <ul style="list-style-type: none"> <li>○ Unless indicated otherwise in the quote or Sales Drawing, normal operation of the engine is recommended at 80-100% load.</li> </ul>   |
| Operating Exhaust Temperature                     | <ul style="list-style-type: none"> <li>○ Refer to tables 3.2 and 3.3 for suitable operating temperature.</li> <li>○ To avoid permanent catalyst damage, at inlet and outlet of the converter the temperature must never exceed a maximum 550OC.</li> <li>○ To avoid permanent clogging of the DPF, do not operate at a temperature below 300°C except for start-up and shutdown sequence.</li> </ul>       |
| NOx/PM ratio                                      | <ul style="list-style-type: none"> <li>○ Refer to table 3.2 for suitable NOx/PM ratio.</li> <li>○ The engine emission certification datasheet usually provides the NOx/PM ratio for the engine. Alternatively the NOx/PM ratio can be determined by emission testing.</li> </ul>   |
| Engine Maintenance                                | <ul style="list-style-type: none"> <li>○ The engine must be well maintained in good working order. In particular any component affecting emissions should be in good condition (injectors, turbo, etc.).</li> <li>○ The engine-out emissions must be configured to factory-level specifications for emissions, including NOx, HC, PM, CO and opacity.</li> </ul>   |
| Lube Oil Specification                            | <ul style="list-style-type: none"> <li>○ Sulfated ash &lt;1.0 wt%.</li> <li>○ Zinc &lt; 900 ppm.</li> <li>○ Phosphorus &lt; 400 ppm.</li> </ul>  |
| Lube Oil Consumption Rate                         | <ul style="list-style-type: none"> <li>○ Manufacturer's normal lube oil consumption rate or 0.5 g/bhp-hr (0.67 g/kW-h), whichever is lower.</li> </ul>   |
| Crank case ventilation                            | <ul style="list-style-type: none"> <li>○ Crank case ventilation should be routed either back to the air intake or downstream of the converter.</li> </ul>  |
| Fuel Quality for Diesel, LFO, or Biodiesel Blends | <ul style="list-style-type: none"> <li>○ Fuel must conform to ASTM D975, ASTM D6751, EN590 or EN14214 standards, plus the following additional standards:</li> <li>○ Chlorinated compounds – must be zero.</li> <li>○ Siloxane compounds – must be zero.</li> <li>○ Phosphorus – must be zero.</li> <li>○ Sulfur &lt; 15 ppm.</li> </ul>   |
| Oxygen  | <ul style="list-style-type: none"> <li>○ &gt; 2% at inlet to catalyst housing.</li> </ul>  |
| Exhaust System                                    | <ul style="list-style-type: none"> <li>○ Ensure the exhaust system is free of leaks, particularly before the converter.</li> </ul>   |
| Fuel System (Compression Ignited Engines)         | <ul style="list-style-type: none"> <li>○ Repair and replace at fuel injectors at intervals required by the engine manufacturer's maintenance schedule.</li> <li>○ Fix worn hydraulic injectors to stop lube oil leaks into the fuel.</li> </ul>  |
| High Backpressure                                 | <ul style="list-style-type: none"> <li>○ In cases where the DPF is not regenerating regularly, backpressures may rise to a higher than acceptable level. Limits on acceptable back-pressure are project specific and decided after discussion with the customer. In most cases high back-pressure can be corrected by running at a higher engine load, which increases the exhaust temperature.</li> </ul> |
| Ash Deposits                                      | <ul style="list-style-type: none"> <li>○ Ash deposits on the catalyst should not be allowed to accumulate to the point where they result in plugging, higher pressure restrictions or reduce the conversion efficiency.</li> <li>○ It is recommended that an authorized cleaning facility is contacted if cleaning of the</li> </ul>   |

|                  |  |
|------------------|--|
|                  | catalyst element is necessary.   |
| Catalyst Poisons | <ul style="list-style-type: none"> <li>○ In like manner to ash deposits, catalyst poisons build up on the catalyst element over time, due to their presence in the fuel or lube oil. The presence of certain contaminants may also indicate excessive engine wear or a coolant breach.</li> <li>○ If there is a suspected problem, the catalyst element may be returned to DCL, where a small amount of washcoat is removed and analyzed for contaminants and activity.</li> </ul> |

Table 3.2: Conditions for NOx/PM ratio with temperature (must stay within the YES)

| NOx/PM Ratio  | Exhaust Temperature (°C) |           |           |
|---------------|--------------------------|-----------|-----------|
|               | 300 - 350                | 350 - 450 | 450 - 550 |
| < 25          | NO                       | NO        | NO        |
| > 25 and < 30 | NO                       | NO        | YES       |
| > 30 and < 50 | NO                       | YES       | YES       |
| > 50          | YES                      | YES       | YES       |

Table 3.3: Conditions for NOx/PM ratio with temperature (must stay within the YES)

| % NOx Conversion | Exhaust Temperature (°C) |           |           |           |           |
|------------------|--------------------------|-----------|-----------|-----------|-----------|
|                  | 300 - 350                | 350 - 400 | 400 - 450 | 450 - 475 | 475 - 550 |
| < 70             | YES                      | YES       | YES       | YES       | YES       |
| > 70 and < 80    | NO                       | YES       | YES       | YES       | NO        |
| > 80 and < 90    | NO                       | NO        | YES       | YES       | NO        |
| > 90 and < 92    | NO                       | NO        | NO        | YES       | NO        |
| > 92             | NO                       | NO        | NO        | NO        | NO        |



## 4 MAINTENANCE

### 4.1 Maintenance Requirements

The following are maintenance requirements to follow for servicing the SCRonF. Due to large variations in operating conditions, the maintenance schedule may change slightly depending on the specifics of the application. Requirements for servicing SCRonF s are found in Table 4.1 below.

Table 4.1 – Maintenance Schedule

| Frequency  | Action                     | Description  |
|--|----------------------------|--|
| Every 200 hours of operation   | Check for Leaks            | Visually inspect the piping, fittings, clamps and gaskets in the exhaust system for exhaust leaks. Look specifically for evidence such as soot present near connection. Repair if necessary. |
| Every 200 hours of operation   | Check Pressure Transducers | Remove pressure transducer and manually apply pressure to the line. Check line for leaks. Indicator lights must illuminate at a specified backpressure.                                      |
| Every 1000 hours of operation (or sooner if high ash levels accumulate in DPF) | Filter Cleaning            | Conduct <i>Level 2 Cleaning</i> (see section 4.3 below for details).   |

### 4.2 Level 1 Cleaning (Stop Gap)

1. Remove the DPF centrebody following the instructions in step 2.2.4
2. Attach to the filter inlet (sooted end of DPF), a vacuum which feeds into a high-efficiency particle arrestance (HEPA) filter making sure that all connections are airtight to prevent soot/ash from escaping before being forced through the HEPA filter.
3. Using oil-free compressed air (~80 psi), blow the particulates/ash from the outlet end of the DPF towards the inlet of the DPF, through the vacuum and through the HEPA filter. The air gun should be held a minimum of 2 inches from the surface of the DPF to prevent damage to the filter itself.
4. Move the air gun around to ensure that all of the DPF channels on the outlet have been exposed to the compressed air. Compressed air cleaning should be performed for an approximate duration of at least 10 minutes.
5. Remove the HEPA filter and store away for reuse or dispose of if saturated with soot/ash.
6. Reinstall DPF centrebody following instructions in step 2.2.1

### 4.3 Level 2 Cleaning

1. Remove the DPF centrebody following the instructions in step 2.2.4
2. Place the DPF centrebody, inside an oven or kiln ensuring that the inlet and outlet of the DPF are exposed. I.e. do not sit the DPF vertically in the oven so that the DPF inlet or outlet filter faces are against the surface on which the DPF is resting.
3. Increase the temperature of the oven to 550°C over a period of 1.5 – 2 hours, with the ramp rate less than 10°C/min.
4. Retain an oven temperature of 550°C for a continuous period of 24 hours to allow complete combustion of accumulated soot in the DPF.
5. Decrease the temperature to a level that will allow for safe removal of the DPF by hand.
6. Remove the DPF from the oven and perform a *Level 1 Cleaning* to remove the noncombustible ash content.
7. Reinstall DPF centrebody following instructions in step 2.2.1



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# **HYDROVANE-SERIES**

## **SIMPLEX / DUPLEX**

### **TANK-MOUNTED COMPRESSOR**

#### **MODELS**

#### **HSHVB & HDHVB**

**V01 (2 HP) – V04 (5 HP)**

**V05 (7.5 HP) – V07 (10 HP)**

**60 HZ**

## **OPERATING AND SERVICE MANUAL**



## **MAINTAIN COMPRESSOR RELIABILITY AND PERFORMANCE WITH GENUINE HYDROVANE® COMPRESSOR PARTS AND SUPPORT SERVICES**

Hydrovane Compressor genuine parts, manufactured to design tolerances, are developed for optimum dependability – specifically for Hydrovane compressor systems. Design and material innovations are the result of years of experience with hundreds of different compressor applications. Reliability in materials and quality assurance are incorporated in our genuine replacement parts.

Your authorized Hydrovane Compressor distributor offers all the backup you'll need. A worldwide network of authorized distributors provides the finest product support in the air compressor industry. Your authorized distributor can support your Hydrovane air compressor with these services:

1. Trained parts specialists to assist you in selecting the correct replacement parts.
2. A full line of factory tested compressor lubricants specifically formulated for use in HYDROVANE compressors.
3. Repair and maintenance kits designed with the necessary parts to simplify servicing your compressor.

Authorized distributor service technicians are factory trained and skilled in compressor maintenance and repair. They are ready to respond and assist you by providing fast, expert maintenance and repair services.

**For the location of your local authorized Hydrovane Air Compressor distributor,**

**Visit:**

**[www.hydrovaneproducts.com/contact.asp](http://www.hydrovaneproducts.com/contact.asp)**

**Factory:  
HYDROVANE  
1800 Gardner Expwy  
Quincy, IL 62305**

**Phone: (217) 222-5400**

### **INSTRUCTIONS FOR ORDERING REPAIR PARTS**

When ordering parts, specify Compressor MODEL, HORSEPOWER and SERIAL NUMBER (see nameplate on unit). All orders for Parts should be placed with the nearest authorized distributor.

Order by part number and description. Reference numbers are for your convenience only.

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## **INTRODUCTION**

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### **IMPORTANT!**

**BEFORE INITIAL START-UP ENSURE THAT THE COMPRESSOR OIL CHAMBER IS FILLED TO THE CORRECT LEVEL WITH A HYDROVANE APPROVED OIL.**

### **Support**

Your hydrovane distributor is able to offer a wide range of compressors, dryers, filters, and ancillary air-line system products. They are fully trained and competent in all aspects of compressor and air-system maintenance. If you need any specialist help or service please contact your distributor providing the MODEL, TYPE and SERIAL NUMBER.

### **Customer Standard Warranty Terms**

All hydrovane compressors, which are serviced by an authorized hydrovane distributor, are guaranteed for twelve months from the date of commissioning or eighteen months ex works, whichever is the sooner.

The warranties excludes normal service parts, oil and wear items, dirt ingress, cleaning of filters and fluid drain devices and the tightening of electrical or other connections. Also excluded is the adjustment of pressure switches or the adjustment of any other control device shown in this handbook.

Consequential damage of any nature is not covered by the warranty.

### **Product Development**

Hydrovane adapt a policy of continual product development. The information in this handbook, while fully up to date when issued, may be subject to change without notice.

### **Product Terminology**

|                    |  |
|--------------------|--|
| V                  | Vane   |
| 01, 02, 04, 05, 07 | kW Motor                                       |
| PURHS              | Packaged Unit, Receiver, Horizontal, Starter   |
| PURVS              | Packaged Unit, Receiver, Vertical, Starter     |
| PDRHS              | Packaged Duplex, Receiver, Horizontal, Starter |

## SAFETY AND OPERATION PRECAUTIONS



**THIS MANUAL CONTAINS IMPORTANT SAFETY INFORMATION AND SHOULD ALWAYS BE AVAILABLE TO THOSE PERSONNEL OPERATING THIS UNIT.  
READ, UNDERSTAND AND RETAIN ALL INSTRUCTIONS BEFORE OPERATING THIS EQUIPMENT TO PREVENT INJURY OR EQUIPMENT DAMAGE.**

Because an air compressor is a piece of machinery with moving and rotating parts, the same precautions should be observed as with any piece of machinery of this type where carelessness in operation or maintenance is hazardous to personnel. In addition to the many obvious safety rules that should be followed with this type of machinery, the additional safety precautions as listed below must be observed:

1. Read all instructions completely before operating air compressor or unit.
2. For installation, follow all local electrical and safety codes, as well as the National Electrical Code (NEC) and the Occupational Safety and Health Act (OSHA).
3. Electric motors must be securely and adequately grounded. This can be accomplished by wiring with a grounded, metal-clad raceway system to the starter; by using a separate ground wire connected to the bare metal of the motor frame; or other suitable means.
4. Protect the power cable from coming in contact with sharp objects. Do not kink power cable and never allow the cable to come in contact with oil, grease, hot surfaces, or chemicals.
5. Make certain that the power source conforms to the requirements of your equipment.
6. Pull main electrical disconnect switch and disconnect any separate control lines, if used, before attempting to work or perform maintenance on the air compressor or unit. "Tag Out" or "Lock Out" all power sources.
7. Do not attempt to remove any compressor parts without first relieving the entire system of pressure.
8. Do not attempt to service any part while machine is in an operational mode.
9. Do not operate the compressor at pressures in excess of its rating.
10. Do not operate compressor at speeds in excess of its rating.
11. Periodically check all safety devices for proper operation. Do not change pressure setting or restrict operation in any way.
12. Be sure no tools, or rags or loose parts are left on the compressor or drive parts.
13. Do not use flammable solvents for cleaning the air inlet filter or element and other parts.
14. Exercise cleanliness during maintenance and when making repairs. Keep dirt away from parts by covering parts and exposed openings with clean cloth or Kraft paper.
15. Do not operate the compressor without guards, shields and screens in place.
16. Do not install a shut-off valve in the discharge line, unless a pressure relief valve, of proper design and size, is installed in the line between the compressor unit and shut-off valve.
17. Do not operate compressor in areas where there is a possibility of ingesting flammable or toxic fumes.
18. Be careful when touching the exterior of a recently run motor - it may be hot enough to be painful or cause injury. With modern motors this condition is normal if operated at rated load - modern motors are built to operate at higher temperatures.
19. Inspect unit daily to observe and correct any unsafe operating conditions found.
20. Do not "play around" with compressed air, nor direct air stream at body, because this can cause injuries.
21. Compressed air from this machine absolutely must not be used for food processing or breathing air without adequate downstream filters, purifiers and controls.
22. Always use an air pressure regulating device at the point of use, and do not use air pressure greater than marked maximum pressure of attachment.
23. Check hoses for weak or worn condition before each use and make certain that all connections are secure.
24. Always wear safety glasses when using a compressed air blow gun.

The user of any air compressor package manufactured by hydrovane is hereby warned that failure to follow the preceding Safety and Operation Precautions can result in injuries or equipment damage. However, hydrovane does not state as fact or does not mean to imply that the preceding list of Safety and Operating Precautions is all inclusive, and further that the observance of this list will prevent all injuries or equipment damage.



## EXPLANATION OF SAFETY INSTRUCTION SYMBOLS AND DECALS

|   |
|---|
|  |
| Indicates immediate hazards which will result in severe injury or death.          |

|  |
|--|
|   |
| Indicates hazards or unsafe practice which could result in severe injury or death. |



Risk of electric shock.



Warning unit is remotely controlled and may start without warning.



Risk of danger.



Read the instruction manual.



Risk of hot surface.



Do not operate the machine without the guard.



Eye protection must be worn.



Warning do not start the machine without consulting handbook.



Dust protection must be worn.



Lifting point.



Warning pressurized vessel.



Direction of rotation.



Warning pressurized component or system.

|  |
|--|
|                             |
| Indicates hazards or unsafe practice which could result in damage to the hydrovane compressor or minor injury. |

|  |
|--|
| <b>NOTICE</b>  |
| Notice is used to notify people of installation, operation or maintenance information which is important but not hazard-related. |

## SAFETY AND OPERATION PRECAUTIONS

---

**OBSERVE, UNDERSTAND AND RETAIN THE INFORMATION GIVEN IN THE SAFETY PRECAUTION DECALS AS SHOWN IN THE PARTS LIST SECTION**



**This compressor must not be used for breathing air. To do so will cause serious injury whether air is supplied direct from the compressor source or to breathing tanks for later use. Any and all liabilities for damage or loss due to injury, death and/or property damage including consequential damages stemming from the use of this compressor to supply breathing air, will be disclaimed by the manufacturer.**



**The use of this compressor as a booster pump and/or to compress a medium other than atmospheric air is strictly non-approved and can result in equipment damage and/or injury.**



**This unit may be equipped with special options which may not be included in this manual. User must read, understand and retain all information sent with special options.**

### NOTICE

**Hydrovane declines all liability in the event of material damage or bodily injury resulting from negligence in the application of these precautions, from non-observation or lack of elementary supervision in respect of handling, operation, servicing or repair, even if not expressly stated in this instruction notice.**

## Product Information

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### Operating Temperatures

Your compressor is designed to give optimum performance and trouble free service life when the oil temperature is between 75 – 85°C (167 – 185°F).

Certain operating conditions sustained over a period of time may cause problems that effect the performance and reliability of this compressor.

Problems may occur when compressors run for short periods on low air demand where they don't reach normal operating temperatures.

Prolonged use under these conditions can cause condensation build up within the compressor and may eventually lead to emulsification of the oil.

Normal operating temperatures are reached in typically 10/15 minutes, to purge condensate from the compressor a longer running period with high air demand, usually 60 minutes, will be required.

Conditions or applications which prevent the compressor temperature from stabilizing between parameters should be avoided.

Consult your local distributor or the factory if you have any particular concerns about operational characteristics of your compressor.

### High Operating Temperatures

If your compressor frequently operates in high ambient temperatures the oil life will be reduced.

Some of the reasons for high compressor oil temperatures are:

Low oil level.

Blocked oil cooler or cooler flow restrictions.

Wrong type or grade oil.

High ambient temperature.

Note: Compressor will stop automatically if temperature rises above 110°C (230°F).

### Noise Level

The compressor should be positioned where noise will not be a problem. We recommend the use of ear protection when near the compressor for extended periods.

## Technical Data V01, V04, V05, V07

| PERFORMANCE DATA                           |                 | MODEL                       | V01                         |            | V04                         |           | V05                         |           | V07        |             |  |
|--|-----------------|-----------------------------|-----------------------------|------------|-----------------------------|-----------|-----------------------------|-----------|------------|-------------|--|
| <b>Performance</b>                         | <b>psig</b>     |                             | <b>100</b>                  | <b>150</b> | <b>100</b>                  | <b>15</b> | <b>100</b>                  | <b>15</b> | <b>100</b> | <b>150</b>  |  |
| F.A.D.                                     | cfm             |                             | 6.3                         | 4.5        | 19.5                        | 16        | NA                          | 22.0      | NA         | 28.9        |  |
| Total Input Power (when compressor is new) | kW              |                             | 1.7                         | 1.8        | 4.9                         | 4.8       | --                          | 7.0       | --         | 8.6         |  |
| Total Input Power (after 500 hours)        | kW              |                             | 1.6                         | 1.7        | 4.6                         | 4.5       | --                          | 6.6       | --         | 8.2         |  |
| Off-Load Power                             | kW              |                             | 1.7                         | 1.8        | 4.9                         | 4.8       | --                          | 7.0       | --         | 8.6         |  |
| <b>Compressor Details</b>                  |                 |                             | <b>V01</b>                  |            | <b>V04</b>                  |           | <b>V05</b>                  |           | <b>V07</b> |             |  |
| Noise Level                                | dB(A)           |                             | 65                          |            | 72                          |           | 73                          |           | 73         |             |  |
| Power                                      | hp (kW)         |                             | 2 (1)                       |            | 5 (4)                       |           | 7.5 (5.5)                   |           | 10 (7.5)   |             |  |
| Starter Type                               |                 |                             | Automatic Direct-On-Line    |            |                             |           |                             |           |            |             |  |
| Operating Controls                         |                 |                             | Automatic Stop/Start        |            |                             |           | Automatic Stop/Start or     |           |            |             |  |
| Air End Rotation Speed                     | rpm             |                             | 1760                        |            |                             |           |                             |           |            |             |  |
| Oil Capacity                               | Gallons         |                             | 0.30                        |            | 0.50                        |           | 1.10                        |           |            |             |  |
| Air Discharge Temperature (above ambient)  | °F              |                             | 90°F (approach temp.)       |            |                             |           |                             |           |            |             |  |
| <b>Factory Settings</b>                    |                 |                             | <b>V01</b>                  |            | <b>V04</b>                  |           | <b>V05</b>                  |           | <b>V07</b> |             |  |
| Pressure Switch Cut-In                     | psi             |                             | 80                          | 115        | 80                          | 115       | 80                          | 115       | 80         | 115         |  |
| Pressure Switch Cut-Out                    | psi             |                             | 100                         | 150        | 100                         | 150       | 100                         | 150       | 100        | 150         |  |
| <b>Installation</b>                        |                 |                             | <b>V01</b>                  |            | <b>V04</b>                  |           | <b>V05</b>                  |           | <b>V07</b> |             |  |
| Air Outlet Size                            | NPT             |                             | 1/2                         |            |                             |           |                             |           |            |             |  |
| Phase                                      | ph              |                             | Single Phase or Three phase |            |                             |           |                             |           |            | Three phase |  |
| Available Motor Voltages                   | V               |                             | 208/230/460/575             |            |                             |           |                             |           |            |             |  |
| Ambient Temperature Range                  | °F              |                             | 32 – 104°F                  |            |                             |           |                             |           |            |             |  |
| Minimum Room Volume                        | ft <sup>3</sup> |                             | 353                         |            | 425                         |           | 530                         |           | 530        |             |  |
| Room Air Inlet / Outlet Area               | ft <sup>2</sup> |                             | 11                          |            | 11                          |           | 11                          |           | 11         |             |  |
| Cooling Air Flow Rate                      | cfm             |                             | 88.3                        |            | 1060                        |           | 1177                        |           | 1177       |             |  |
| <b>Model Dimensions</b>                    |                 | <b>Overall Length (In.)</b> | <b>Overall Width (In.)</b>  |            | <b>Overall Height (In.)</b> |           | <b>Overall Weight (In.)</b> |           |            |             |  |
| V01PURHS-3                                 |                 | 41                          | 19                          |            | 34                          |           | 240                         |           |            |             |  |
| V04PURHS-8                                 |                 | 38                          | 26                          |            | 66                          |           | 570                         |           |            |             |  |
| V04PURHS-8                                 |                 | 65                          | 22                          |            | 40                          |           | 425                         |           |            |             |  |
| V05PURHS-8                                 |                 | 39                          | 26                          |            | 69                          |           | 695                         |           |            |             |  |
| V05PURHS-8                                 |                 | 66                          | 22                          |            | 43                          |           | 550                         |           |            |             |  |
| V07PURHS-8                                 |                 | 66                          | 22                          |            | 43                          |           | 670                         |           |            |             |  |
| V04DRHS-12                                 |                 | 72                          | 27                          |            | 48                          |           | 845                         |           |            |             |  |
| V05DRHS-12                                 |                 | 76                          | 27                          |            | 50                          |           | 1210                        |           |            |             |  |
| V07DRHS-12                                 |                 | 76                          | 27                          |            | 50                          |           | 1325                        |           |            |             |  |

## INSTALLATION



**Do not operate unit if damaged during shipping, handling or use. Operating unit if damaged may result in injury.**

### Introduction

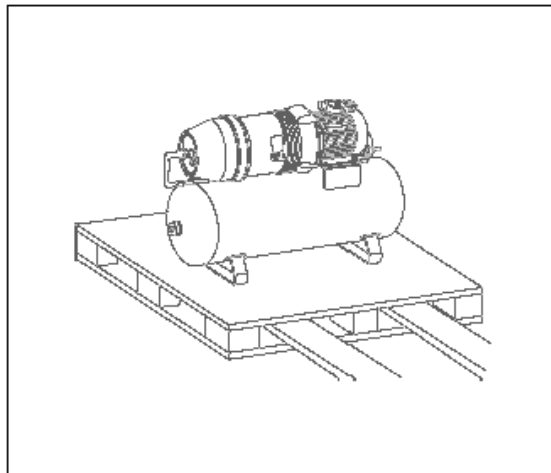
Ensure all lifting equipment and means of transportation are securely located and rated to accept the full load. Inspect all lifting equipment for signs of wear. Do not use if wear is evident.

### Lifting and Handling (Figure 1)

Before transporting, secure the compressor to a suitable pallet. Use a fork lift or pallet truck to transport the compressor.

A suitable lifting platform will be required when positioning the compressor. For normal lifting a hoist may be used.

Lift the compressor and place it in the desired location.



**Figure 1 – Lifting and Handling**

### Position Your Compressor

We recommend an approved installation from an authorized hydrovane distributor with a service agreement to maintain your compressor.

Position the compressor in a room of adequate size on a firm surface, level in both planes within five degrees of the horizontal.

Ensure the area has sufficient load-bearing capacity; normally it is not necessary to bolt the unit down.

Sufficient access (1metre/3.3 ft) for all routine service procedures should be provided all around and above the unit.

Site the compressor away from sources of dirt, coarse solids, abrasive particles, steam, liquids and gaseous impurities. It is recommended that a compressor used for painting be located in a separate room from that area where body sanding and painting are done.

This is an industrial compressor and is intended for installation in an indoor environment.

## Ventilation (FIGURE 2)

Position the compressor in a well ventilated location. Do not restrict the air-flow around the compressor or allow the hot air discharge to re-circulate into the compressor intake.

Any cooling-air inlet (A) should be positioned low allowing unrestricted air-flow to the compressor intake. The warm-air outlet (B) should be positioned high and well away from the inlet, to ensure a positive cooling air-flow through the compressor.

For maximum efficiency and reliability, the compressor should be operated in a moderate ambient temperature. If temperatures frequently fall below 0°C (32°F), consult your hydrovane distributor. A different grade of oil may be required.

Air ducting, if fitted, must not cover or restrict the cooling air flow of the compressor. Total resistance of the system must not exceed 5mm w.g. (0.2in. water gauge). If resistance is expected to be greater than 5mm w.g. then fan assistance will be required.

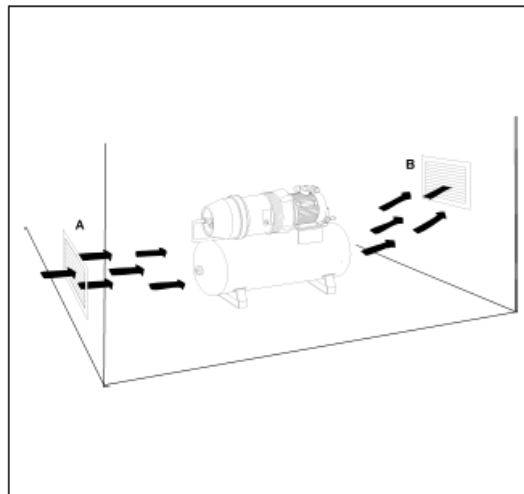


FIGURE 2 - VENTILATION

 **DANGER**

**Do not install isolating valves between compressor outlet and air receiver. This will cause excessive pressure if valve is closed, and cause injury and equipment damage.**

 **WARNING**

**Always use an air pressure regulating device at the point of use. Failure to do so can result in injury or equipment damage.**

## Electrical Connections



**Connection to, or installation of, an electrical power supply must only be carried out by authorized and qualified electricians. They must fully understand and adopt correct and safe working practices. All aspects of the installation must meet the wiring regulations presently in place.**

It is essential that the power supply and the supply wiring are adequately sized and that the voltage correspond to the unit specifications.

### NOTICE

**Upstream protection fusible disconnect or circuit breaker must be provided by installer.**

Before connecting to the main electrical supply ensure that the system can sustain the additional electrical load. To ensure reliable low resistance joints, make sure that your incoming supply cables are firmly secured to the starter terminals and that they are of the correct cross sectional area.

Refer to starter and circuit diagrams before starting work.

### TABLE GIVE RECOMMENDED WIRE SIZE BASED ON NEC CODE

| WIRE SIZE (AWG) – 75°C COPPER – 40°C AMBIENT |          |      |          |         |      |      |
|--|----------|------|----------|---------|------|------|
| MOTOR HP                                     | 3 PHASE  |      |          | 1 PHASE |      |      |
|  | 200/208V | 230V | 460/575V | 115V    | 208V | 230V |
| 2  | 14       | 14   | 14       | 10      | 12   | 12   |
| 5  | 12       | 12   | 14       | ---     | 8    | 8    |
| 7-1/2  | 8        | 8    | 12       | ---     | 8    | 8    |
| 10   | 8        | 8    | 12       | ---     | ---  | ---  |

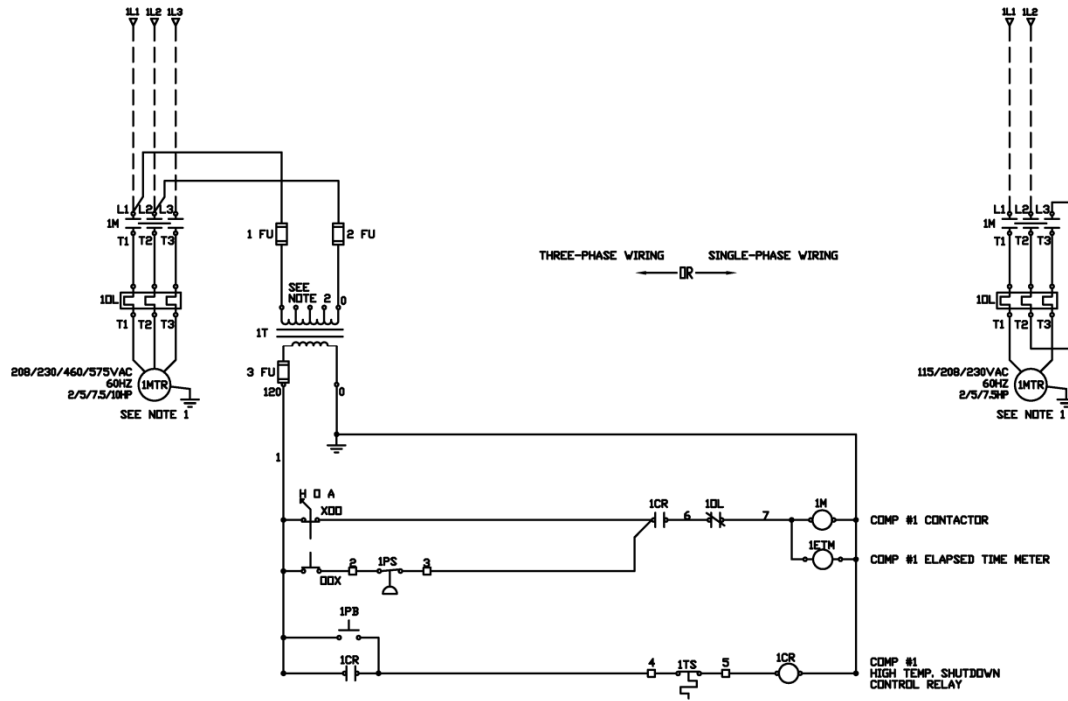
**NOTE:** Wire sizes specified are the minimum size to suit typical installation. If the compressor is located a long way away from the disconnect or the ambient temperature normally exceeds 40°C (104°F). Then wire size may need to be increased. Refer to National Electrical Code.

All models require a properly size magnetic start as specified in the National Electric Code (NEC).

See simplex wiring diagrams on pages12.

See duplex wiring diagrams on pages13.

# WIRING DIAGRAM SIMPLEX, MULTI-VOLT 1 and 3 PHASE



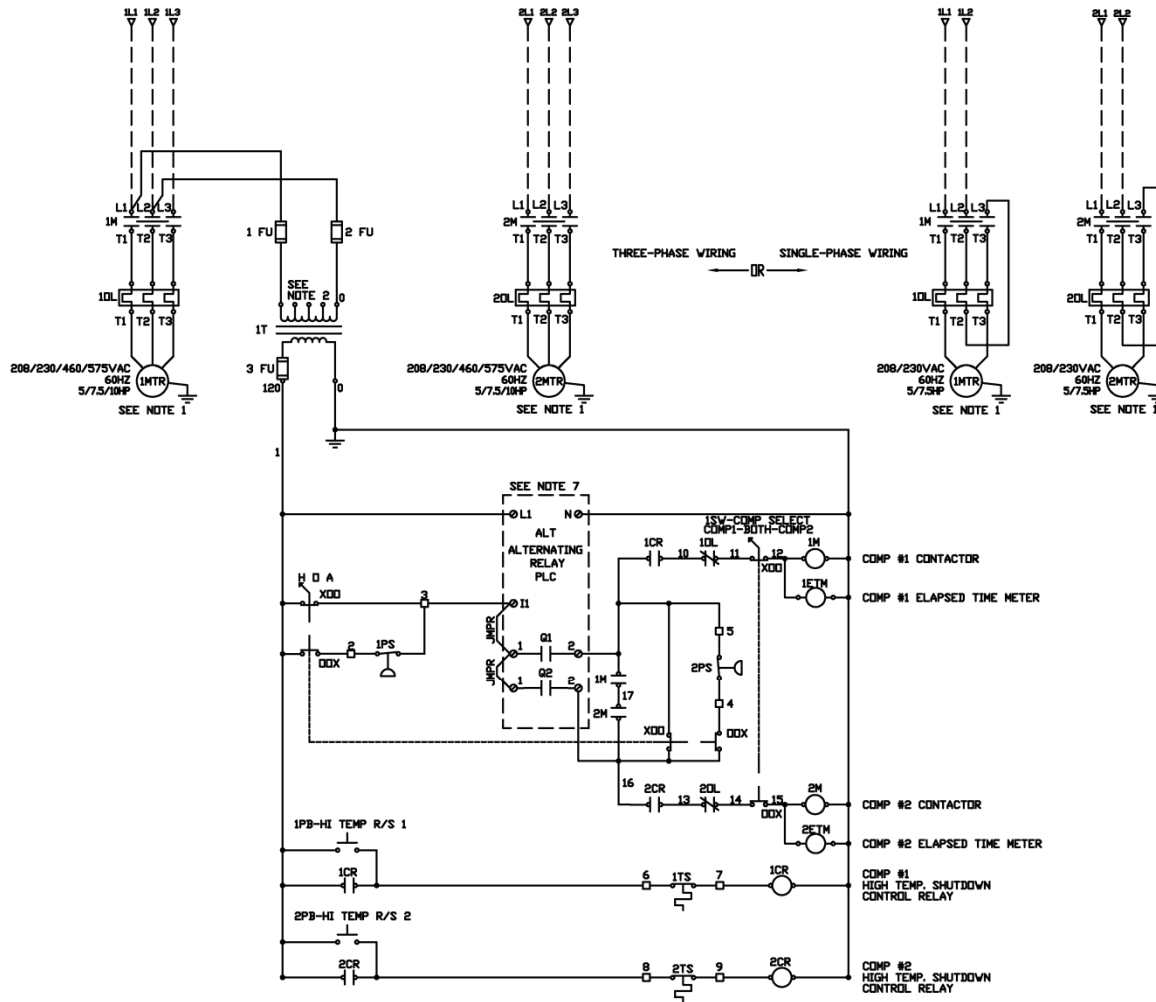
- NOTES:
- 1) SEE MOTOR NAMEPLATE FOR HORSEPOWER AND AMPS.
  - 2) TRANSFORMER TAPPED FOR APPROPRIATE SUPPLY VOLTAGE.
  - 3) □ -- DENOTES TERMINAL BLOCKS.
  - 4) BRANCH CIRCUIT PROTECTION FUSIBLE DISCONNECT OR CIRCUIT BREAKER MUST BE PROVIDED BY INSTALLER.

CONTROL TERMINALS

|    |
|----|
| 2  |
| 3  |
| 4  |
| 5  |
| PE |



# WIRING DIAGRAM DUPLEX, MULTI-VOLT 1 and 3 PHASE



**NOTES:**

- 1) SEE MOTOR NAMEPLATE FOR HORSEPOWER AND AMPS.
- 2) TRANSFORMER TAPPED FOR APPROPRIATE SUPPLY VOLTAGE.
- 3) □ -- DENOTES TERMINAL BLOCKS.
- 4) IPS SET 10 PSI HIGHER THAN 2PS.
- 5) BRANCH CIRCUIT PROTECTION FUSIBLE DISCONNECT OR CIRCUIT BREAKER MUST BE PROVIDED BY INSTALLER.
- 6) SINGLE H-O-A CONTROLS BOTH COMPRESSORS.
- 7) ALTERNATING RELAY PLC: EACH TIME THE INPUT (I1) GOES OFF, THE OUTPUTS (Q1 & Q2) CHANGE STATE. (ONLY ONE O/P IS ON AT A TIME)

**CONTROL TERMINALS**

|    |
|----|
| 2  |
| 3  |
| 4  |
| 5  |
| 6  |
| 7  |
| 8  |
| 9  |
| PE |

**)546-A  
(awing)**

## **AIR LINE PIPING**

Connection to air system should be of the same size, or larger, than discharge pipe out of unit. A union connection to the unit and water drop leg is recommended. Install a flexible connector between the discharge of the unit and the plant air piping. Plant air piping should be periodically inspected for leaks using a soap and water for detection on all pipe joints. Air leaks waste energy and are expensive.

## **OPERATION**

See Figure 3, page 15.

This compressor has been inspected, thoroughly tested and approved at the factory. For this unit to give long satisfactory service it must be installed and operated properly.

The compressor assembly comprises an air-end (A), complete with oil cooler (B), driven by an electric motor (C). This assembly is mounted on a receiver (D).

The receiver is equipped with a pressure switch (E), pressure relief valve (F), pressure gauge (G), moisture drain (H), and service valve (K) the starter (L), includes hour meter (U), hand-off-auto selector switch (Q), and hi temp reset (R).

Air enters the compressor through the air filter (M). The air is compressed with the air end pressure displayed by pressure gauge (N). It is then discharged through discharge tube (P) and check valve (J) into the receiver.

Simplex units have a pressure switch that senses changes in receiver pressure and automatically starts and stops the compressor at preset pressure limits. If the receiver pressure falls below the cut-in pressure setting of the pressure switch the compressor will run until the cut-out pressure setting of the pressure switch has been reached.

Duplex units have lead and lag pressure switches and an automatic alternating system to evenly distribute the load between the two compressors. The pressure switches sense changes in receiver pressure and automatically start and stop the compressor at preset pressure levels. If the receiver pressure falls below the cut-in pressure setting of the lead pressure switch but remains above the cut-in pressure setting of the lag pressure switch, only one compressor will run until receiver pressure reaches the cut-out pressure of the lead pressure switch. The next time the pressure in the receiver drops, the system automatically starts the compressor that was idle. If the receiver pressure falls below the cut-in pressure setting of the lag pressure switch, both compressors run until receiver pressure reaches the cut-out pressure setting of the lead pressure switch.

**Start/Stop Mode:** Compressor will automatically start and stop in response to air receiver pressure.

**Continuous Run Mode:** Compressor will continue to operate regardless of receiver pressure, supplying air from zero to full flow.

Control panel is furnished with Hand-Off-Auto selector switch for selecting continuous run (hand) mode or the Start/Stop (AUTO) Mode.

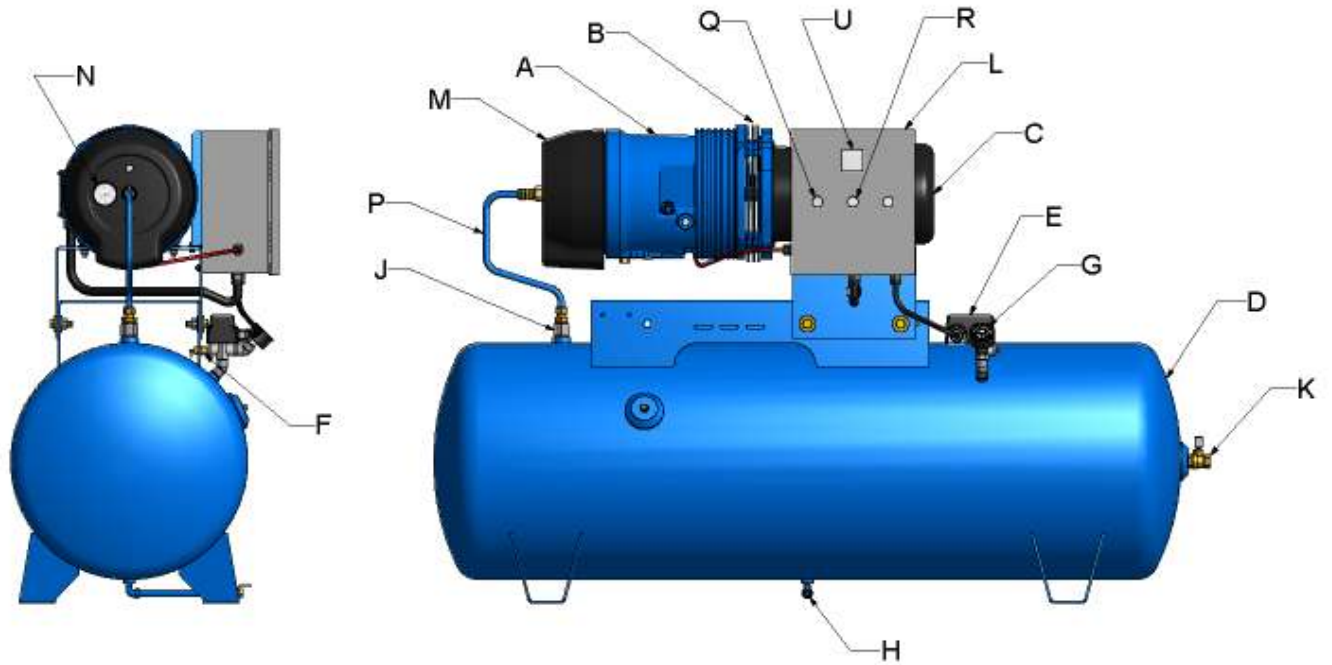


Figure 3

300HHS797 – A  
(Ref. Drawing)

## Initial Start Up

1. Inspect unit for any visible signs of damage that would have occurred in shipment or during installation.
2. Pull main disconnect switch to unit to assure that no power is coming into the unit. “Lock Out” or “Tag Out” switch. Connect power leads to start.



**Do not attempt to operate compressor on voltage other than that specified on order on compressor motor.**

3. Check compressor oil level. Add oil as required. **NOTE:** Do not mix oil type, weights or brands.
4. Activate main disconnect switch.
5. Select Automatic or Hand-Off-Auto Selector switch.
6. Push “Start/Stop” button on control panel.
7. Check for correct rotation. The correct direction of rotation is clockwise when viewed from the drive end (motor end). If rotation is wrong, reverse any two incoming power connections to the starter.
8. Close receiver outlet valve and start.
9. With receiver valve closed, let machine pump up to operating pressure. At this stage the automatic controls will take over. Check for proper cycling operation.
10. When the initial run period has shown no operating problems, shut unit down and recheck oil level.
11. Open receiver hand valve. The air compressor unit is now ready for use.



**This unit can start automatically without warning.**

## SERVICING

### Introduction



**Servicing of the compressor must only be carried-out by authorized persons fully trained and competent in the maintenance of hydrovane compressors. They must fully understand and adopt correct and safe working practices.**



**Before performing any maintenance function, switch main disconnect switch to “OFF” position to assure no power is entering unit. “Lock Out” or “Tag Out” all sources of power. Be sure all air pressure is relieved. Failure to do so may result in injury or equipment damage.**

If you are unable to carry-out the work safely in the required manner then you hydrovane distributor will be pleased to help.

Use genuine parts and approved hydrovane oil during routine servicing, the following service kits are available:

Maintenance kit, 4000 hour/12 months, use KM51 (V01) or KM52 (V04), KM (V05), KM (V07).

Full Overhaul/top-up kit, 24000 hour/10 year; use KT52 (V01), or KT53 (V04), KT (V05), KT (V07).

### Routine Service Schedule

The work listed below must be carried-out at the indicated running-hours which must be regarded as a maximum. In dusty, hot or humid conditions more frequent servicing may be necessary.

This section shows the minimum service requirements for your compressor. To ensure that the full compressor maintenance program is carried out, hydrovane recommends that your compressor is regularly serviced by an authorized hydrovane distributor.

### Checking Operation of the Compressor

Wait until air-end vent down cycle is complete.

Check that the air-end pressure gauge reads zero.

Pour a small amount of oil into the thermometer pocket of the oil filler plug. Screw a temperature gauge or thermometer into the thermometer pocket.

Assuming the compressor is serviced correctly the machine is capable of operating in ambient temperatures up to a maximum of 40°C (104°F). At this ambient the bulk oil temperature measured at the filler plug should be 70-90°C (158-194°F).

Check oil temperature. When the compressor is working the temperature should be:

|                                     |                      |
|-------------------------------------|----------------------|
| Initial start-up and warm-up period | <70°C (158°F)        |
| Optimum working temperature         | 75-85°C (167-185°F)  |
| High temperature                    | 90-100°C (194-212°F) |
| Stop! See fault finding section     | >100°C (212°F)       |

### Check Air Line Pressure

Check the air-line system pressure by using the receiver mounted pressure gauge.

### Check Air-End Pressure

To check the air-end pressure, use the pressure gauge located in the air-end.

### Check Oil Level

Check that the air-end pressure gauge reads zero.

Remove filler plug and check inside oil chamber.

Oil should be filled to overflow if not top up (see oil top-up procedure, page 19).

### Drain Air Receiver FIGURE 4

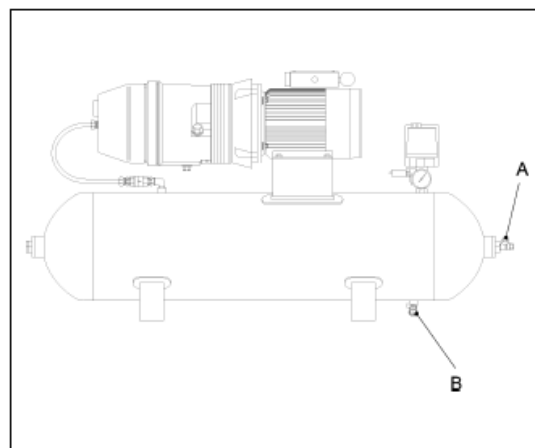
Wait for air-end vent down cycle to finish.

Position suitable container beneath condensate drain valve (B).

|  |
|--|
|   |
| <b>The air receiver is pressurized; take great care when carrying out the next operation.</b>  |

Carefully open drain valve and allow pressure to fall slowly to zero.  
Collect all condensate drained from receiver.

Note: Condensate may contain traces of oil and must be disposed of in an approved manner.



**FIGURE 4 – OUTLET DRAIN VALVE LOCATION**

Close drain valve (B) and open air outlet valve (A).



**WARNING**

**Before performing any maintenance function, switch main disconnect switch to “OFF” position to assure no power is entering unit. “Lock Out” or “Tag-Out” all sources of power. Be sure all air pressure in the unit is relieved. Failure to do this may result in injury or equipment damage.**

**CLOSE THE AIR OUTLET VALVE TO ISOLATE THE COMPRESSOR FROM THE AIR-LINE SYSTEM. FIT A SAFETY NOTICE TO THE VALVE ADVISING THAT IT IS NOT TO BE OPENED.**

**DO NOT PROCEED UNTIL GAUGE READS ZERO!**

#### **Oil Top-Up Procedure FIGURE 5**

Wait until the air-end vent down cycle is complete, check that the air-end pressure gauge reads zero.

**Note:** If pressure gauge does not fall to zero then non-return valve (D) may be faulty.

Drain air receiver following procedure above. Do not reopen air-outlet valve (A).

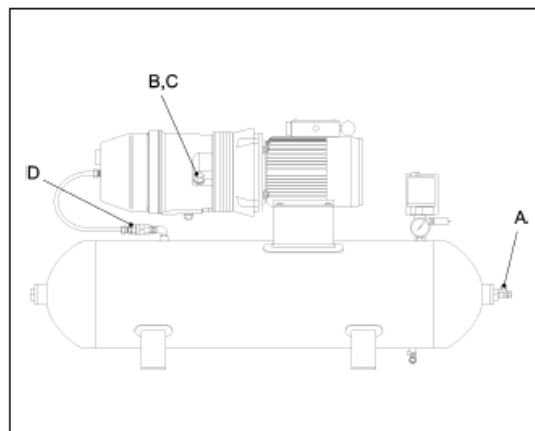
Carefully unscrew oil filler plug (B), remove filler plug (B), and retain bonded seal (C).

Fill compressor to overflow with approved hydrovane oil, do not overfill.

**Note:** Do not mix oil type, weights or brands.

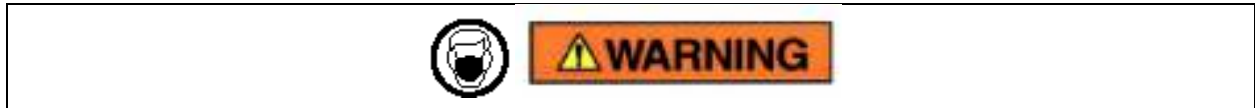
Examine bonded seal, if not damaged refit to filler plug.

Refit seal and filler plug, tighten to 18 ft-lbs.



**FIGURE 5 – OUTLET AND FILLER PLUG LOCATION**

## Check Air Intake Filter FIGURE 6



The air filter (C) is located beneath the filter cover (A). Filter cover will slide over adapter and pipe (B).

Wait until air-end vent down cycle is complete.

Open test valve to vent pressure from the receiver and associated pipework.

Check that air-end pressure gauge reads zero.

Disconnect pipe (B).

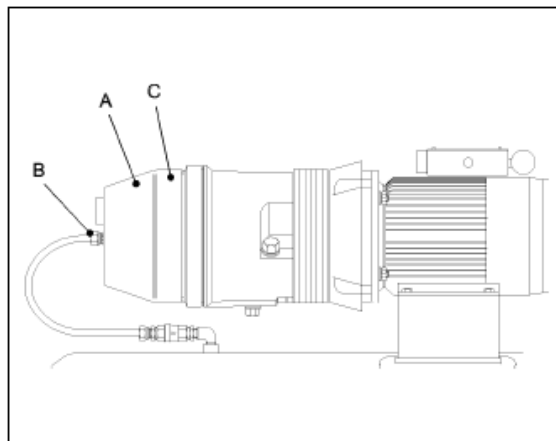
Firmly pull filter cover (A) to remove from separator casing.

Remove air filter (C).

Clean separator casing and inside of filter cover.

Vacuum clean or blow dust out of filter using low pressure, clean dry air. Renew the filter if it cannot be cleaned satisfactorily.

Install air filter (C), install filter cover (A), reconnect pipe (B).



**FIGURE 6 – OUTLET DRAIN VALVE LOCATION**

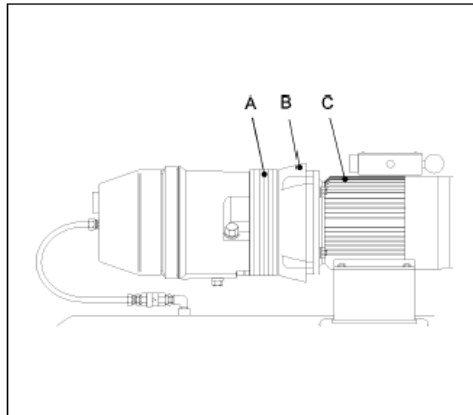


## Clean cooler and motor FIGURE 7



Carefully vacuum clean the oil cooler matrix (A), aftercooler if fitted and guard rings (B).

Vacuum clean and blow dust from motor (D) and motor grill, using low pressure, clean dry air.



**FIGURE 7 – COOLER AND MOTOR LOCATION**

## Replace Oil Separator Element FIGURE 8

Remove screws (A), gently tap the end cover (B) until it is clear of the separator casing.

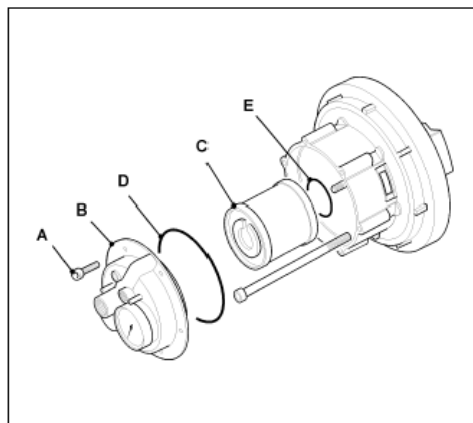
Unscrew the oil separator element (C) and discard.

**Note:** Oil separator element contains oil and must be disposed of in an approved manner.

Install a new separator element. Ensure that the “O-Ring (E) is in place. Do not over tighten.

Install end cover (B). Ensure cover is positioned correctly and bolt holes are in line. Be careful not to damage “O-Ring (D) when installing.

Install screws (A). Tighten to 8 ft-lbs.



**FIGURE 8 – SEPARATOR ELEMENT LOCATION**

## Oil Change Procedure FIGURE 9

Remove filler plug (A), discard bonded seal (B), place container, at least 1.0 Litre capacity, beneath oil drain plug (D).

Carefully remove drain plug (D) and discard bonded seal (C). Collect all the oil that drains from the compressor.

**Note:** Any waste oil collected must be disposed of in an approved manner.

Refit drain plug (D) using a new bonded seal. Tighten to 27 ft-lbs.

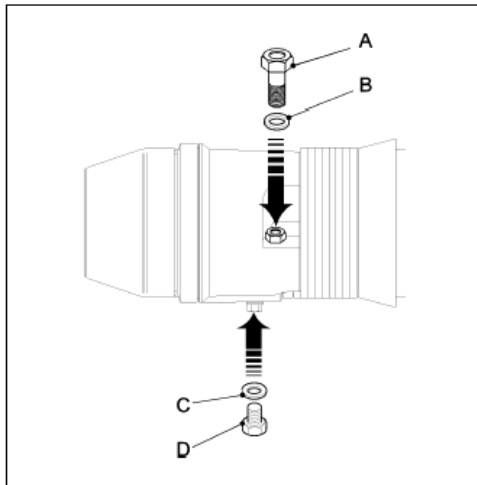


FIGURE 9 – OIL CHANGE PROCEDURE

## Electrical Checks



Remove the starter panel and pressure switch covers.

Check for any signs of overheating and ensure that all electrical connections are tightened to correct torque settings.

**Note:** Pay special attention to power connections and cables connected to contactors and incoming terminals.

## Check electric motors



Remove any dust or dirt from motor bodies and motor air intake grills.

Lubricate motor bearings as per manufacturer's instructions.

Install all covers, remove safety notices, turn electrical supply on and open air-outlet valve. Test run compressor, check pressure and inspect for oil leaks.

## Servicing Requirements

The following preventive maintenance charts cover all hydrovane compressors using hydrovane oil.

The work to be carried out must be done on or before the hours shown for this action, or every 12 months, whichever is soonest.

Table 9.1 for 4000 hour oil change are shown in entirety, shaded items are hydrovane distributor maintenance tasks only.

**NOTE:** Certain items may not be applicable to all units.

### **READ HEALTH AND SAFETY PRECAUTIONS BEFORE STARTING ANY WORK.**

#### **Service Schedule: hydrovane Oil**

For normal ambient conditions the oil temperature should not exceed 90°C (194°F)

If the oil is working above this temperature the oil life will be significantly reduced.

The service life of the air filter is indication only, actual life durability will depend on the operating conditions.

### **GENERAL MAINTENANCE NOTES**

**PRESSURE RELIEF VALVE:** The pressure relief valve is an automatic pop valve. Each valve is properly adjusted for the maximum pressure of the unit on which it is installed. If it should pop, it will be necessary to drain all the air out of the tank in order to reseal properly, or drop pressure in line. Do not readjust.

**TANK DRAIN VALVE:** Drain valve is located at bottom of tank. Open drain valve daily to drain condensation. Do not open drain valve if tank pressure exceeds 25 PSIG. The automatic tank drain equipped compressor requires draining manually once a week.

**PRESSURE SWITCH:** The pressure switch is automatic and will start compressor at the low pressure and stop when the maximum pressure is reached. It is adjusted to start and stop compressor at the proper pressure for the unit on which it is installed. Do not readjust.

**CHECK VALVE:** The check valve closes when the compressor stops operating, preventing air from flowing out of the tank through the pressure release. After the compressor stops operating, if air continues to escape through the release valve, it is an indication that the check valve is leaking. This can be corrected by removing check valve and cleaning disc and seat. If check valve is worn badly, replace same.



### **WARNING**


**Before removing check valve be sure all air is drained out of tank and power is disconnected. Failure to do so may result in injury or equipment damage.**

**MOTOR LUBRICATION:** Long time satisfactory operation of an electric motor depends in large measure on proper lubrication of the bearings. Bearing grease will lose its lubricating ability overtime, not suddenly. Refer to the motor manufacturer's instructions for the type of grease and lubrication intervals.

**Table 9.1 Service Schedule 4000 hour change period**

| Maintenance Actions                        | Install | Every Day | Every Week | Every 4000 Hours | Every 20000 Hours |
|--|---------|-----------|------------|------------------|-------------------|
| Site-sufficient access for service         | X       |           |            |                  |                   |
| Site-protected from weather                | X       |           |            |                  |                   |
| Site-adequate ventilation                  | X       | X         | X          | X                | X                 |
| Site-ambient temperature within limit      | X       | X         | X          | X                | X                 |
| Site-dust free ambient                     | X       | X         | X          | X                | X                 |
| Check/torque electrical connections        | X       |           |            | X                | X                 |
| Check oil level at filler plug/sight glass | X       | X         | X          | X                | X                 |
| Check correct drive rotation               | X       |           |            |                  | X                 |
| Check for air leaks                        | X       |           | X          | X                | X                 |
| Check for oil leaks                        | X       |           | X          | X                | X                 |
| Check air intake filter/clean if necessary | X       |           | X          |                  |                   |
| Check power on-load                        | X       |           |            | X                | X                 |
| Check power off-load                       | X       |           |            | X                | X                 |
| Check oil temperature                      | X       |           | X          | X                | X                 |
| Check RSU temperature                      | X       |           | X          | X                | X                 |
| Check servo pressure off-load              | X       |           |            | X                | X                 |
| Check motor gland/cables secure            | X       |           |            | X                | X                 |
| Check motor for damage                     | X       |           |            | X                | X                 |
| Check motor/starter for loose connections  | X       |           |            | X                | X                 |
| Check motor cables and earth               | X       |           |            | X                | X                 |
| Check motor for vibration                  | X       |           |            | X                | X                 |
| Check flexible oil pipes                   |         |           |            | X                |                   |
| Check oil seal for leakage                 |         |           |            | X                |                   |
| Check drive media/key                      |         |           |            | X                |                   |
| Check starter contactors                   |         |           |            | X                |                   |
| Check motor insulation resistance          |         |           |            |                  | X                 |
| Check combi cooler matrix                  |         |           | X          | X                | X                 |
| Clean any external dirt from compressor    | X       |           | X          | X                | X                 |
| Clean any external dirt from motor         | X       |           | X          | X                | X                 |
| Clean cabinet filter                       |         |           | X          |                  |                   |
| Clean solenoids                            |         |           |            | X                | X                 |
| Change separator element                   |         |           |            | X                | X                 |
| Change 4000 hour oil                       |         |           |            | X                | X                 |
| Change oil filter                          |         |           |            | X                | X                 |
| Change air intake filter                   |         |           |            | X                | X                 |
| Change cabinet filter                      |         |           |            | X                | X                 |
| Change unloader valve seals                |         |           |            | X                | X                 |
| Change MPV seals                           |         |           |            | X                | X                 |
| Change vacuum valve seals                  |         |           |            | X                | X                 |
| Change flexible pipes                      |         |           |            | X                | X                 |
| Change thermal motor                       |         |           |            | X                | X                 |
| Grease motor bearings (if applicable)      |         |           |            | X                |                   |
| Full air end inspection (internal)         |         |           |            |                  | X                 |
| Clean servo filter                         |         |           |            |                  | X                 |
| Change drive media/key                     |         |           |            |                  | X                 |
| Change oil seal                            |         |           |            |                  | X                 |
| Change pressure gauge                      |         |           |            |                  | X                 |
| Change motor bearings                      |         |           |            |                  | X                 |
| Full operational test/check                | X       |           |            | X                | X                 |
| Filter element fitted to Hypac units only  |         |           |            | X                |                   |

## TROUBLE SHOOTING CHART



**WARNING**

**Always disconnect unit from power supply and relieve all pressure from air tank before performing any maintenance. Failure to do so may result in equipment damage or injury. A Lock Out" or "Tag Out" all power sources.**

**Never operate unit without belt guard in place.**

**Never use gasoline or flammable solvent on or around compressor unit. Explosion may result.**

Servicing of the compressor must only be carried-out by authorized persons fully trained and competent in the maintenance of hydrovane compressors. They must fully understand and adopt correct and safe working practices.

| Symptom  | Possible Cause(s)   | Corrective Action   |
|--|---|---|
| <p><b>High Pressure</b></p> <p>Air-end pressure gauge reads high<br/>Air receiver pressure gauge reads high.<br/>Air-end pressure relief valve blowing.<br/>High temperature, high power, low air output.</p>                | <p>Safety valve setting too high.<br/>Pressure control valve stuck.<br/>MPV not operating correctly.<br/>Blocked pressure control valve or filter.<br/>Pressure switch faulty.</p>  | <p>Check that air-end pressure gauge returns to ZERO when compressor is switched off, if not renew.<br/>Replace pressure-control valve.<br/>Check that air-receiver pressure gauge returns to ZERO when receiver is fully de-pressurized, if not replace.<br/>Check pressure switch is set correctly.</p>   |
| <p><b>High Temperature</b></p> <p>Very hot to touch.<br/>High power, low air-output, high oil discharge.<br/>Compressor cuts-out.<br/>Oil life reduction.<br/>Compressor seizes.</p>   | <p>Incorrect oil level.<br/>Unapproved oil, incorrect grade of oil being used.<br/>Dirty or blocked cooler.<br/>Re-circulation of hot air or lack of ventilation.<br/>Thermostatic valve stuck in closed position.<br/>Incorrect stator/rotor end clearance.<br/>Oil relief valves leaking.<br/>Internal oil passage blocked.<br/>Oil return plug blocked.<br/>Internal high pressure to low pressure leak.</p> | <p>Check temperature in thermometer pocket.<br/>If &gt;95°C then:<br/>a) Compressor location, check:<br/>Ambient temperature too high (&gt;40°C)<br/>Air-intake temperature too high.<br/>Air-intake located near heat source.<br/>Excessively dusty conditions.<br/>b). Air-end, check:<br/>Oil level too low.<br/>Wrong type or grade of oil.<br/>Oil cooler blocked.<br/>Prolonged running off-load.</p>             |
| <p><b>Low Air Output</b></p> <p>Malfunction of air-tools/equipment.<br/>Pressure gauges reading low.<br/>Rapid pressure loss from air-end on stopping.<br/>Rapid pressure loss from air-line when compressor switch off.</p> | <p>Restriction in airline, valve closed.<br/>Minimum pressure valve stuck closed.<br/>Air intake filter blocked..<br/>Pressure control valve stuck in open position.<br/>Separator element blocked.</p>   | <p>Carry-out air delivery test.<br/>If less than specification, check air-end for:<br/>Blocked air-intake filter.<br/>Blocked separator element.<br/>M.P.V. stuck closed.<br/>Air leaks from air-end.</p>   |
| <p><b>Compressor Stops</b></p> <p>Compressor stops unexpectedly.</p>   | <p>Pressure switch set low.<br/>Over-temperature fault.<br/>Motor overload tripped.<br/>Supply voltage low.<br/>Compressor seizing.</p>   | <p>Re-adjust pressure switch.<br/>Rectify over temperature fault.<br/>Re-set motor overload.<br/>Check supply voltage status.<br/>Check compressor functionality.</p>   |
| <p><b>Excessive Oil Consumption</b></p> <p>Oil visible in tools and equipment.<br/>Excessive oil usage.<br/>Possible high oil temperature.<br/>Possible high power absorption.</p>   | <p>Wrong type or grade of oil.<br/>Compressor over filled or not sited level.<br/>Excessive air demand.<br/>Separator element fractured and/or o-ring damaged.<br/>Blocked oil return filters.<br/>Excessive condensate in oil chamber.</p>   | <p>Quantify oil discharge rate. If &gt;5ppm, check for:<br/>Wrong type or grade of oil.<br/>Ambient temperature &gt;40°C.<br/>Air-intake temperature high.<br/>Compressor not positioned on a level site.<br/>Blocked oil-return plug.<br/>Faulty separator element.</p> <p>If within specification, check for:<br/>Excessive air demand.<br/>Air leaks in air-line system.<br/>Too many stop/start cycles per hour</p> |
| <p><b>Low Operating Temperature</b></p> <p>High oil discharge, but oil level does not fall.<br/><br/>High power, Low air-output.</p>   | <p>Wrong/poor location for compressor.<br/>Low duty cycle, insufficient demand.<br/>Compressor operating temperature too low.</p>   | <p>Remove oil drain plug, if water drains out before oil you have a problem.<br/>Time the duty cycle, if compressor switches off within 15 minutes and is not called upon to restart within 2 hours, then duty cycle is too short.<br/>If duty cycle is too short then either:<br/>a) Run compressor fully on-load for at least one hour every week.</p>  |



hydrovane (the "Company") warrants to each original retail purchaser Company or its authorized distributor that such products are, at the time of delivery to the Purchaser, free of defects in material and workmanship. No warranty is made with respect to:

1. Any product which has been repaired or altered in such a way, in the Company's judgment, as to affect the product adversely.
2. Any product which has, in the Company's judgment been subject to negligence, accident, improper storage, or improper installation or application.
3. Any product which has not been operated or maintained in accordance with the recommendations of the Company.
4. Any reconditioned or prior owned product.

### **WARRANTY PERIOD**

The Company's obligation under this warranty is limited to repairing or, at its option, replacing, during normal business hours at an authorized service facility of the Company, any part which in its judgment proved not to be as warranted within the applicable warranty period as follows. Regular maintenance and use of genuine Hydrovane OEM parts are strongly recommended.

Airend and Motor – are warranted for 24 months from date of initial use or 30 months from date of shipment to the purchaser, whichever occurs first. Normal wearing items, such as shaft seals and inlet valve components, along with the servicing of these items is not covered under the warranty. A material or workmanship defect in these items is warrantable. Any disassembly or partial disassembly of the airend, or failure to return the "unopened" airend per Company instructions, will be cause for denial of warranty.

Package Components – All components within the package, excluding normal wear items, are warranted for 12 months from date of initial use or 18 months from date of shipment to first purchaser, whichever occurs first.

### **LABOR, TRANSPORTATION AND INSPECTION**

The Company will provide labor for 12 months from date of initial use or 18 months from date of shipment to first purchaser, whichever occurs first. Service will be provided by Company representative or authorized service personnel, for repair or replacement of any product or part which in the Company's judgment is proved not to be as warranted. Labor shall be limited to the amount specified in the Company's labor rate schedule.

Transportation costs for an airend claimed not to be as warranted will be covered by the Company for 12 months from date of initial use or 18 months from date of shipment to the purchaser, whichever occur first.

All costs of transportation of product, labor, parts, and repaired or replacement parts claimed not to be as warranted to and from such service facilities shall be borne by the Purchaser. The Company may require the return of any part claimed not to be as warranted to one of its facilities as designated by Company, transportation prepaid by Purchaser, to establish a claim under this warranty.

### **DISCLAIMER**

THE FOREGOING WARRANTY IS EXCLUSIVE AND IT IS EXPRESSLY AGREED THAT, EXCEPT AS TO TITLE, THE COMPANY MAKES NO OTHER WARRANTIES AND HEREBY EXPRESSLY DISCLAIMS ALL OTHER WARRANTIES, INCLUDING WITHOUT LIMITATION, EXPRESSED, IMPLIED OR STATUTORY WARRANTIES, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR USE.

THE REMEDY PROVIDED UNDER THIS WARRANTY SHALL BE THE SOLE, EXCLUSIVE AND ONLY REMEDY AVAILABLE TO PURCHASER AND IN NO CASE SHALL THE COMPANY BE SUBJECT TO ANY OTHER OBLIGATIONS OR LIABILITIES UN NO CIRCUMSTANCES SHALL THE COMPANY BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, LOSSES OR DELAYS HOWSOEVER CAUSED.

NO STATEMENT, REPRESENTATION, AGREEMENT, OR UNDERSTANDING, ORAL OR WRITTEN, MADE BY ANY AGENT, DISTRIBUTOR, REPRESENTATIVE, OR EMPLOYEE OF THE COMPANY WHICH IS NOT PRESENTED WITHIN 30 DAYS AFTER THE DATE UPON WHICH THE PRODUCT IS CLAIMED NOT TO HAVE BEEN AS WARRANTED. ANY ACTION FOR BREACH OF THIS WARRANTY MUST BE COMMENCED WITHIN ONE YEAR AFTER THE DATE UPON WHICH THE CAUSE OF ACTION OCCURRED.

ANY ADJUSTMENT MADE PURSUANT TO THIS WARRANTY SHALL NOT BE CONSTRUED AS AN ADMISSION BY THE COMPANY THAT ANY PRODUCT WAS NOT AS WARRANTED.

WARRANTY IS NOT TRANSFERRABLE.



**PLATINUM EXTENDED WARRANTY**

The extended warranty is available on all new hydrovane HV and V Series oil-lubricated rotary vane air compressor packages. To receive the extended aircend and package component warranty, the requirements listed must be performed and documented during the full warranty period.

**PLATINUM EXTENDED WARRANTY PERIOD**

Hydrovane (the"Company") shall warrant the components identified below to be free of defects in material and workmanship for the warranty period. Inlet valves and aircends contain wearing items that must be serviced according to the operator's manual. A material or workmanship defect in these items is warrantable. Normal wear and servicing of these items is not covered under the warranty.

The Company's obligation under this warranty is limited to repairing or, at it option, replacing, during normal business hours at an authorized service facility of the Company, any part which in its judgment proved not to be as warranted within the applicable warranty period as follows. Regular maintenance and use of genuine hydrovane OEM parts is required.

Aircend – Aircends are warranted for 10 years from date of initial use. Normal wearing items, such as shaft seals and inlet valve components, along with the servicing of these items is not covered under the warranty. A material of workmanship defect in per Company instructions will be caused for denial of warranty.

Major Package Components – All major package components as listed below, excluding normal wear items, are warranted for 5 years from date of initial use.

- |                    |                                 |
|--------------------|---------------------------------|
| Air cooled coolers | Controller                      |
| Air/Oil Reservoir  | Variable Speed Drive Components |
| Motor              | Chock / EMC Filter              |

This Platinum Extended Warranty is supplemental to the standard warranty outlined in Form BR-44. Company makes no other warranty or representation of any kind, either express or implied. The foregoing warranty is exclusive and it is expressly agreed that except as to the title, Company makes no other warranties expressed, implied, or statutory, including any implied warranty of merchantability.

**EXTENDED WARRANTY REQUIREMENTS**

First requirement – The Start Up, Maintenance Procedure & Warranty Registration Form (BR-42) must be complete and returned to hydrovane within 30 days of the compressor package start-up date. When submitting registration via electronic format, end customer signature must be present on the registration form. Contact you authorized local hydrovane distributor for all the details of the program and to register your compressor package.

Second requirement – Maintenance kits must be purchased from an authorized local hydrovane distributor, which has the appropriate air filters, oil filters, and parts included in the kit. The first kit must be purchased within 30 days of the compressor package start-up date. A minimum of one kit must be purchased on an annual basis (every 12 months) when operating from 0 to 4000 hours. If operating above 4000 hours per year, a second maintenance kit must be purchased. The annual maintenance kit (s) must be purchased within 60 days of the anniversary date of the compressor package startup date. At the time of purchase, the serial number of the compressor package must be provided. Additional maintenance parts may be required to meet the operating-hour requirements of the compressor package. These additional items must be purchased from your authorized local hydrovane distributor, and records maintained along with kit purchases. Consult the service manual for proper maintenance schedules.

Third requirement – Participation in hydrovane's oil analysis sampling program is required. An oil sample must be sent to our lubricant analysis laboratory every 2000 hours or every 6 months, whichever occurs first. Any recommendations detailed in the oil analysis report must be followed as outlined in the report. Oil sample bottles are to be obtained from your local authorized hydrovane distributor.

Fourth requirement – hydrovane custom blend CS300 or CSS30 must be used throughout the warranty period.

Fifth requirement – Compressor must be maintained in accordance to the User Handbook (maintenance and operations manual).

**ALL OF THE ABOVE REQUIREMENTS MUST BE PERFORMED AND DOCUMENTED TO ENSURE THAT THE EXTENDED WARRANTY IS IN EFFECT FOR THE FULL WARRANTY PERIOD.**

hydrovane reserves the right to change the extended warranty program and/or requirements as deemed appropriate by the company. hydrovane reserves the right to refuse participation in the extended warranty program to any distributor and/or end customer of the compressor package.



For additional information, contact your local representative or visit:  
[www.hydrovaneproducts.com/contact.asp](http://www.hydrovaneproducts.com/contact.asp)

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13-26-500  
Version: 04  
March 14, 2016

**HYDROVANE-SERIES  
SIMPLEX  
TANK-MOUNTED  
COMPRESSOR**

**MODELS  
HHSHVB**

**V01 (2 HP) – V04 (5 HP)**

**V05 (7.5 HP) – V07 (10 HP)**

**60 HZ**

**PARTS LIST**

## **MAINTAIN COMPRESSOR RELIABILITY AND PERFORMANCE WITH GENUINE HYDROVANE COMPRESSOR PARTS AND SUPPORT SERVICES**

Hydrovane® Compressor genuine parts, manufactured to design tolerances, are developed for optimum dependability – specifically for Hydrovane compressor systems. Design and material innovations are the result of years of experience with hundreds of different compressor applications. Reliability in materials and quality assurance are incorporated in our genuine replacement parts.

Your authorized Hydrovane Compressor distributor offers all the backup you'll need. A worldwide network of authorized distributors provides the finest product support in the air compressor industry. Your authorized distributor can support your Hydrovane air compressor with these services:

1. Trained parts specialists to assist you in selecting the correct replacement parts.
2. A full line of factory tested compressor lubricants specifically formulated for use in HYDROVANE compressors.
3. Repair and maintenance kits designed with the necessary parts to simplify servicing your compressor.

Authorized distributor service technicians are factory trained and skilled in compressor maintenance and repair. They are ready to respond and assist you by providing fast, expert maintenance and repair services.

**For the location of your local authorized Hydrovane Air Compressor distributor,  
visit:**

**[www.hydrovaneproducts.com/contact.asp](http://www.hydrovaneproducts.com/contact.asp)**

**Factory:  
HYDROVANE  
1800 Gardner Expwy  
Quincy, IL 62305**

**Phone: (217) 222-5400**

### **INSTRUCTIONS FOR ORDERING REPAIR PARTS**

When ordering parts, specify Compressor MODEL, HORSEPOWER and SERIAL NUMBER (see nameplate on unit). All orders for Parts should be placed with the nearest authorized distributor.

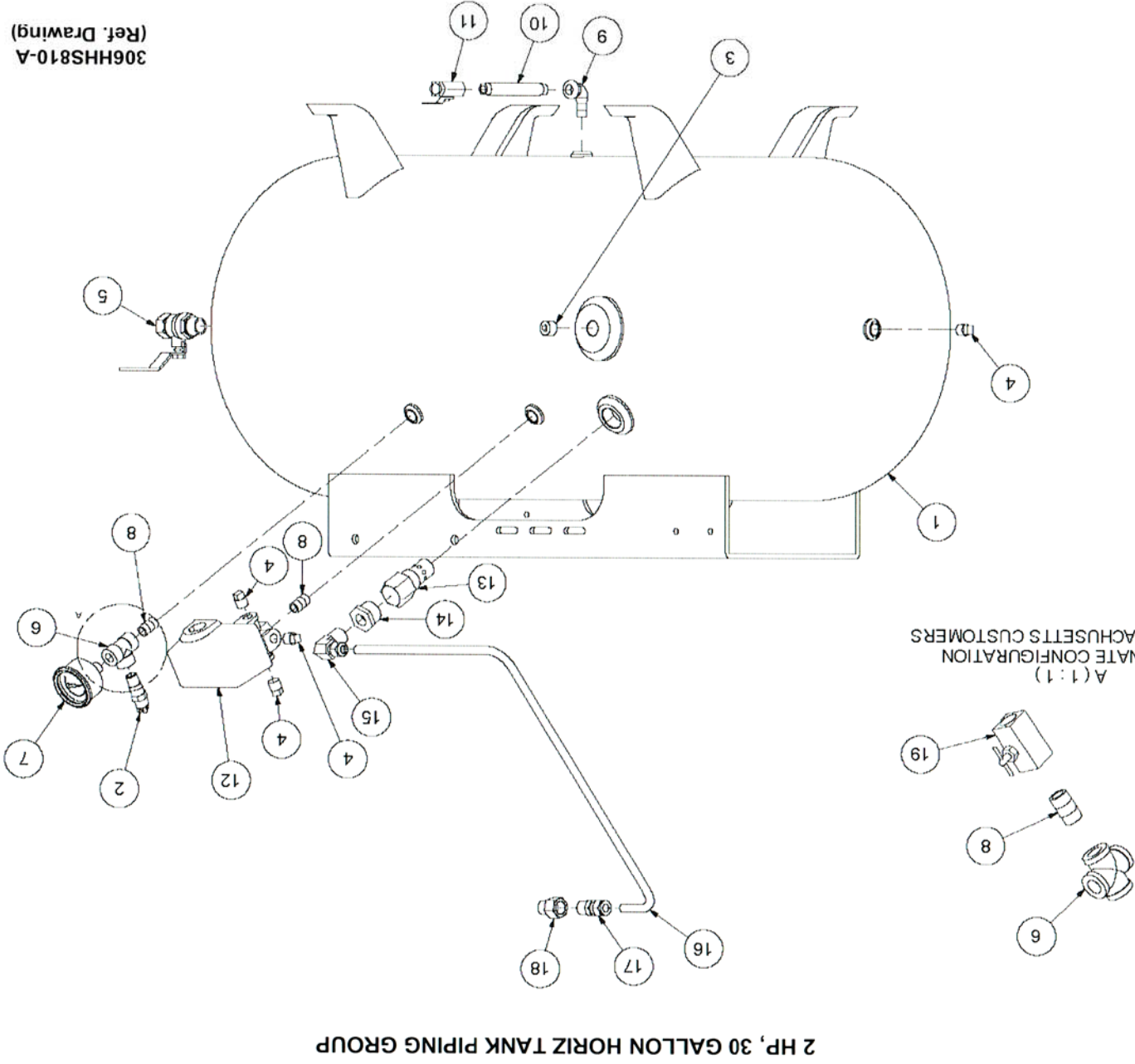
Order by part number and description. Reference numbers are for your convenience only.

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**For Operating and Service Instructions, see:**

**SERVICE MANUAL:      13-26-600**



2 HP, 30 GALLON HORIZ TANK PIPING GROUP

306HHS810-A  
(Ref. Drawing)

A (1:1)  
ALTERNATE CONFIGURATION  
FOR MASSACHUSETTS CUSTOMERS

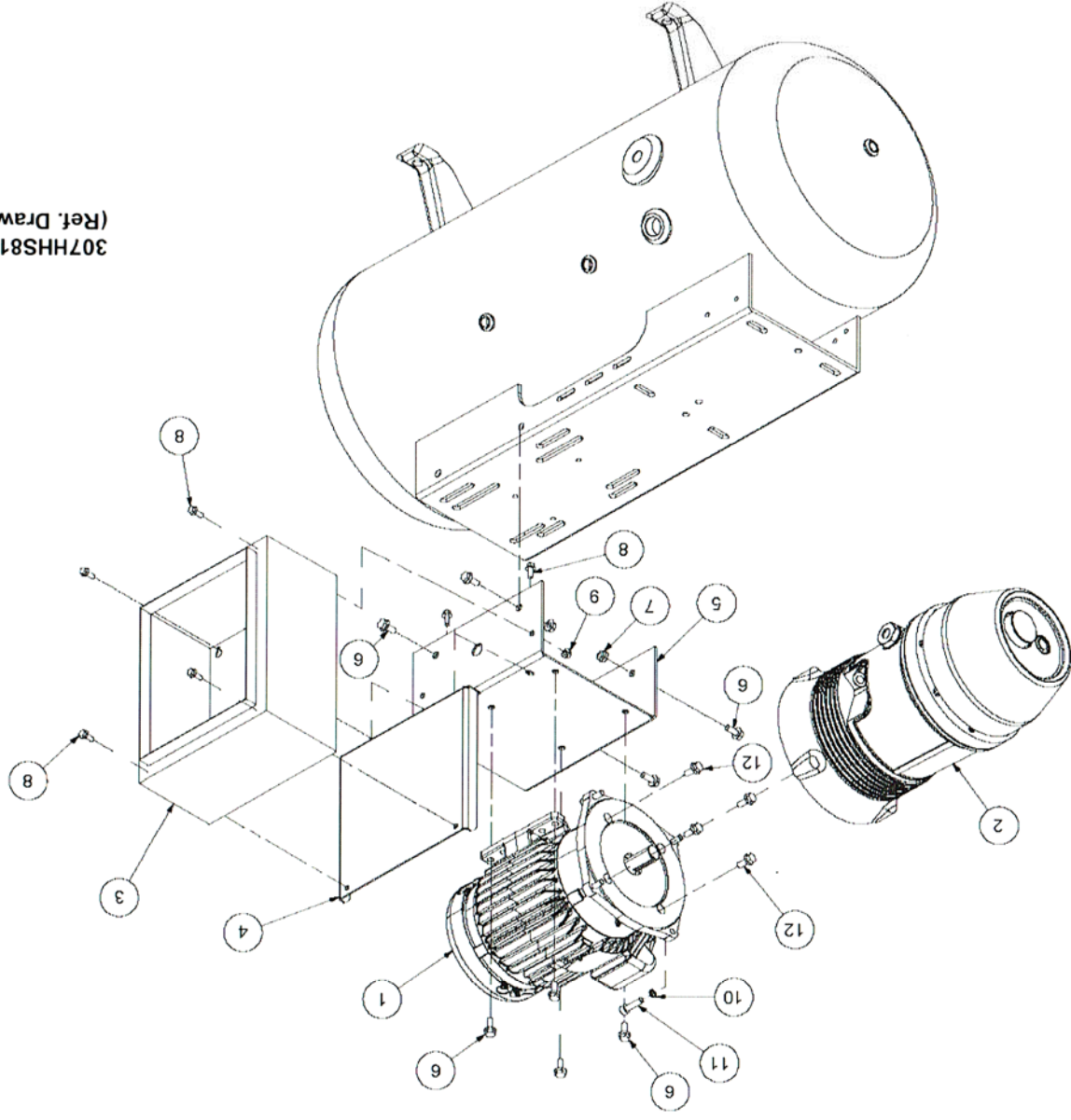
Order by Part Number and Description. Reference Numbers are for your convenience only.

2 HP, 30 GALLON HORIZ TANK PIPING GROUP

B/M: 300HHS4019

| Ref. No. | Name of Part                     | Qty. | Part No.  |
|----------|----------------------------------|------|-----------|
| 1        | AIR RECEIVER.....                | 1    | P14130D   |
| 2        | PRESSURE RELIEF VALVE.....       | 1    | M2843     |
| 2        | VALVE.....                       | 1    | M2847     |
| 3        | PLUG.....                        | 1    | 64B1      |
| 4        | PLUG.....                        | 4    | 64AA5     |
| 5        | BALL VALVE.....                  | 1    | M3590     |
| 6        | TEE (Standard Code).....         | 1    | M3012     |
| 6        | CROSS (Massachusetts Code).....  | 1    | M3094     |
| 7        | GAUGE.....                       | 1    | M519C     |
| 8        | NIPPLE (Standard Code).....      | 2    | M3011     |
| 8        | NIPPLE (Massachusetts Code)..... | 3    | M3011     |
| 9        | ELBOW.....                       | 1    | M980B     |
| 10       | NIPPLE.....                      | 1    | M9033B    |
| 11       | BALL VALVE.....                  | 1    | VP1022988 |
| 12       | PRESSURE SWITCH.....             | 1    | VP1051215 |
|          | 100 PSI.....                     |      |           |
|          | 150 PSI.....                     |      | VP1051216 |
| 13       | CHECK VALVE.....                 | 1    | P05822A   |
| 14       | BUSHING.....                     | 1    | M3136     |
| 15       | FITTING.....                     | 1    | M2877     |
| 16       | TUBE.....                        | 1    | 300HHS857 |
| 17       | FITTING.....                     | 1    | M2872     |
| 18       | ADAPTOR.....                     | 1    | K5700501  |
| 19       | VALVE (Massachusetts Code).....  | 1    | P05811A   |

2 HP, 30 GALLON HORIZ TANK - MOUNTING GROUP



307HHS810-A  
(Ref. Drawing)



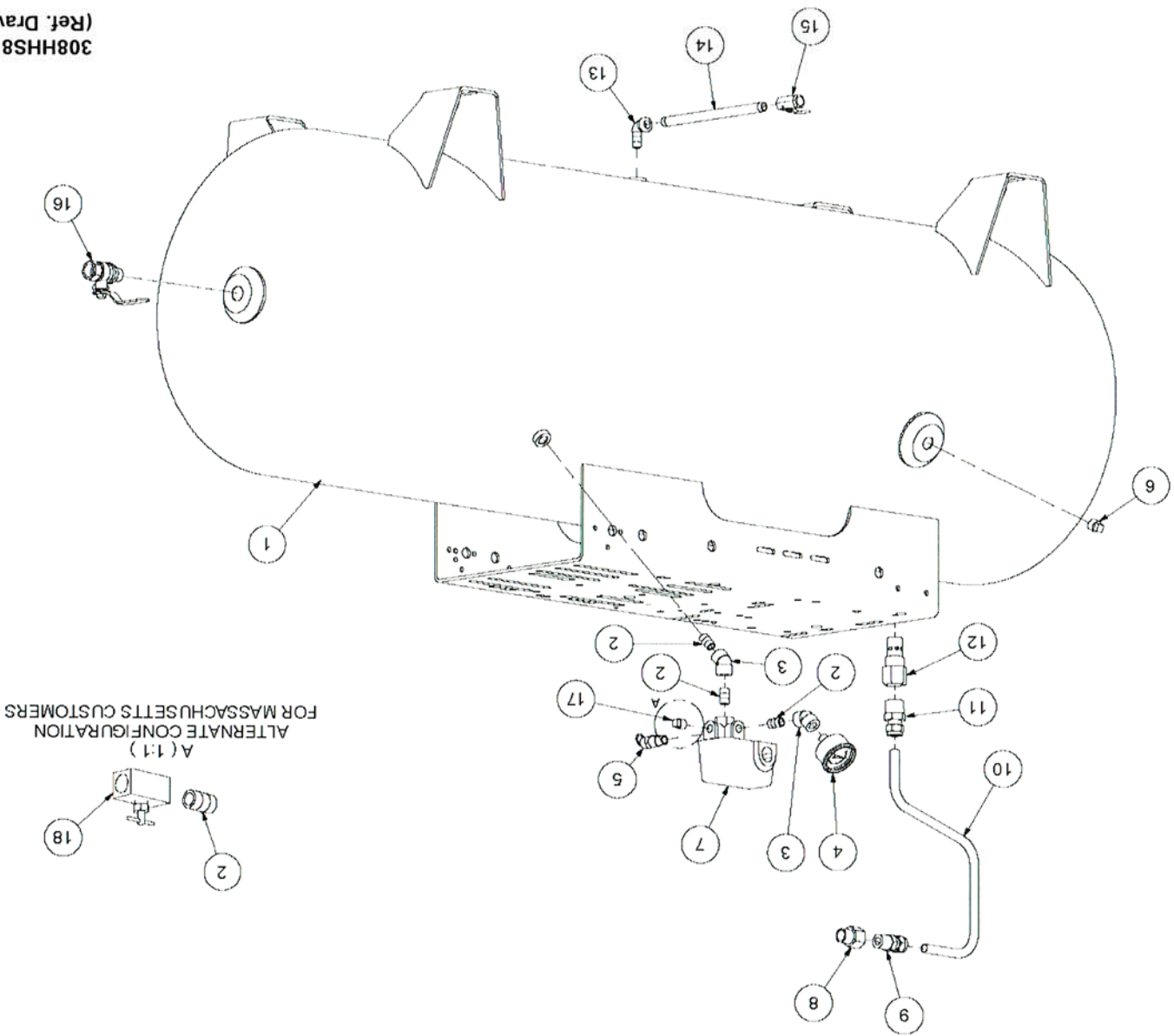
Order by Part Number and Description. Reference Numbers are for your convenience only.

2 HP, 30 GALLON HORIZ TANK - MOUNTING GROUP

B/M: 300HHS4017

| Ref. No. | Name of Part                       | Qty. | Part No.    |
|----------|------------------------------------|------|-------------|
| 1        | MOTOR<br>2 HP 208-230/460/3PH/60HZ | 1    | 24CA6708    |
|          | 2 HP 575/3PH/60HZ                  | 1    | 24CA7323    |
|          | 2 HP 115-208/230/1PH/60HZ          | 1    | K5701630    |
| 2        | AIREND                             |      |             |
|          | 2 HP 7 BAR 60HZ NEMA COMPRESSOR    | 1    | 010CK07-268 |
|          | 2 HP 10 BAR 60HZ NEMA COMPRESSOR   | 1    | 010CK10-268 |
| 3        | STARTER-CONT BOX SCP               |      |             |
|          | 2 HP 575V/3PH/60HZ                 | 1    | 301HHS466   |
|          | 2 HP 208V/3PH/60HZ                 | 1    | 302HHS466   |
|          | 2 HP 230V/3PH/60HZ                 | 1    | 303HHS466   |
|          | 2 HP 460V/3PH/60HZ                 | 1    | 304HHS466   |
|          | 2 HP 115V/1PH/60HZ                 | 1    | 306HHS466   |
|          | 2 HP 208V/1PH/60HZ                 | 1    | 307HHS466   |
|          | 2 HP 230V/1PH/60HZ                 | 1    | 308HHS466   |
| 4        | STARTER SUPPORT BRACKET            |      |             |
|          | MOTOR SUPPORT BRACKET              | 1    | CC1047483   |
| 5        | SCREW                              | 8    | 75LM50      |
| 6        | NUT                                | 8    | 50AW4       |
| 7        | NUT                                | 8    | 50AW4       |
| 8        | SCREW                              | 6    | 75LM54      |
| 9        | NUT                                | 2    | 50AW3       |
| 10       | WASHER                             | 4    | MWG8        |
| 11       | SCREW                              | 4    | MS708-30    |
| 12       | SCREW                              | 4    | 75LM50      |

5 HP, 80 GALLON HORIZ TANK PIPING GROUP



308HHS810-A  
(Ref. Drawing)



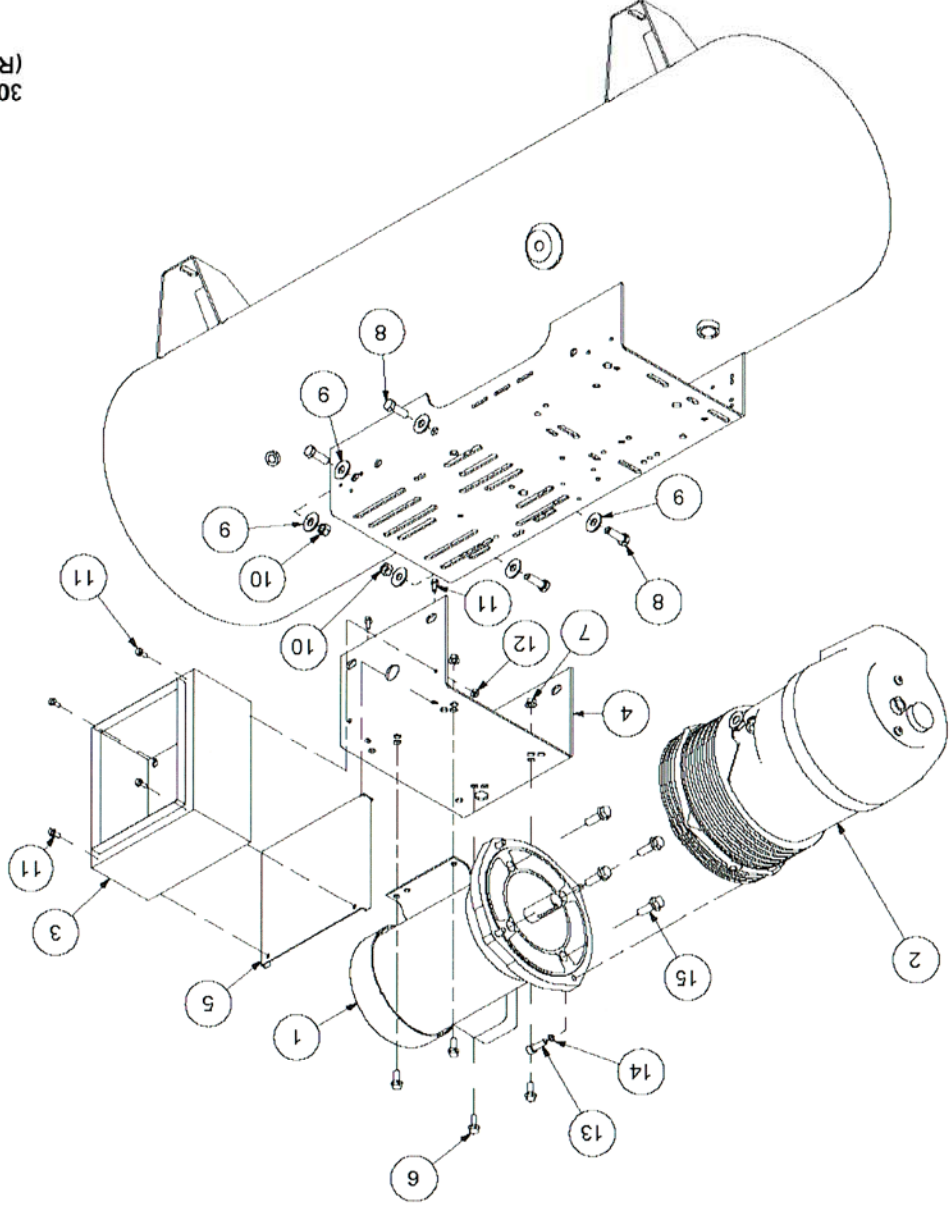
Order by Part Number and Description. Reference Numbers are for your convenience only.

5 HP, 80 GALLON HORIZ TANK PIPING GROUP

B/M: 301HHS4019

| Ref. No. | Name of Part                | Qty. | Part No.  |
|----------|-----------------------------|------|-----------|
| 1        | AIR RECEIVER                | 1    | P01164D   |
| 2        | NIPPLE (Standard Code)      | 3    | M3011     |
| 2        | NIPPLE (Massachusetts Code) | 4    | M3011     |
| 3        | ELBOW                       | 2    | M3087     |
| 4        | GAUGE                       | 1    | M519C     |
| 5        | PRESSURE RELIEF VALVE       | 1    | M2843     |
| 5        | VALVE                       | 1    | M2847     |
| 6        | PLUG                        | 1    | 64B1      |
| 7        | PRESSURE SWITCH             |      |           |
| 8        | ADAPTOR                     | 1    | VP1053138 |
| 9        | FITTING                     | 1    | M2885     |
| 10       | TUBE                        | 1    | 301HHS857 |
| 11       | FITTING                     | 1    | M2337     |
| 12       | CHECK VALVE                 | 1    | P05822A   |
| 13       | ELBOW                       | 1    | M980B     |
| 14       | NIPPLE                      | 1    | M1020B    |
| 15       | BALL VALVE                  | 1    | VP1022988 |
| 16       | BALL VALVE                  | 1    | M3590     |
| 17       | PLUG                        | 1    | 64AA5     |
| 18       | VALVE (Massachusetts Code)  | 1    | P05811A   |

5 HP, 80 GALLON HORIZ TANK - MOUNTING GROUP



309HHS810-A  
(Ref. Drawing)

Order by Part Number and Description. Reference Numbers are for your convenience only.

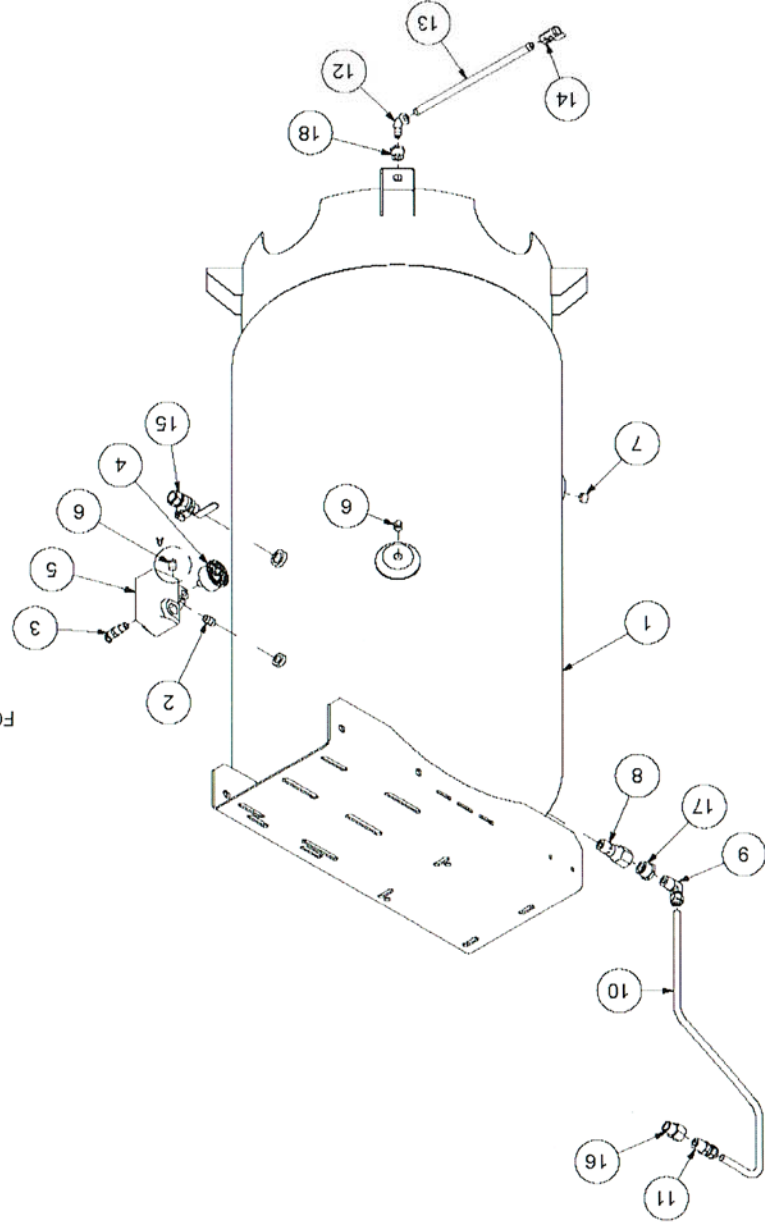
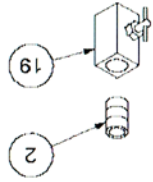
5 HP, 80 GALLON HORIZ TANK - MOUNTING GROUP

B/M: 301HHS4017

| Ref. No. | Name of Part                                | Qty. | Part No.    |
|----------|---|------|-------------|
| 1        | MOTOR<br>5 HP 208-230-460/3PH/60HZ          | 1    | 24CA6710    |
|          | 5 HP 575/3PH/60HZ                           | 1    | 24CA7324    |
|          | 5 HP 115-208-230-460/1PH/60HZ               | 1    | VP1050809   |
| 2        | AIREND<br>5 HP 7 BAR 60HZ NEMA COMPRESSOR   | 1    | 025CK07-268 |
|          | 5 HP 10 BAR 60HZ NEMA COMPRESSOR            | 1    | 025CK10-268 |
| 3        | STARTER-CONT BOX<br>5, 7.5 HP 575V/3PH/60HZ | 1    | 305HHS466   |
|          | 5, 7.5 HP 208V/3PH/60HZ                     | 1    | 309HHS466   |
|          | 5, 7.5 HP 230V/3PH/60HZ                     | 1    | 310HHS466   |
|          | 5, 7.5 HP 460V/3PH/60HZ                     | 1    | 311HHS466   |
|          | 5, 7.5 HP 208V/1PH/60HZ                     | 1    | 312HHS466   |
|          | 5, 7.5 HP 230V/1PH/60HZ                     | 1    | 313HHS466   |
| 4        | MOTOR SUPPORT BRACKET                       | 1    | CC1047697   |
| 5        | STARTER SUPPORT BRACKET                     | 1    | CC1047485   |
| 6        | SCREW                                       | 4    | 75K48       |
| 7        | NUT   | 4    | M3483       |
| 8        | SCREW                                       | 4    | 75LM200     |
| 9        | WASHER                                      | 8    | M3463       |
| 10       | NUT   | 4    | M3486       |
| 11       | SCREW                                       | 6    | 75LM54      |
| 12       | NUT   | 2    | 50AW3       |
| 13       | SCREW                                       | 4    | MS710-30    |
| 14       | SPRING WASHER                               | 4    | MWG10       |
| 15       | SCREW                                       | 4    | 75LM200     |

5 HP, 80 GALLON VERT TANK - PIPING GROUP

A (1:1)  
ALTERNATE CONFIGURATION  
FOR MASSACHUSETTS CUSTOMERS



310HHS810-A  
(Ref. Drawing)

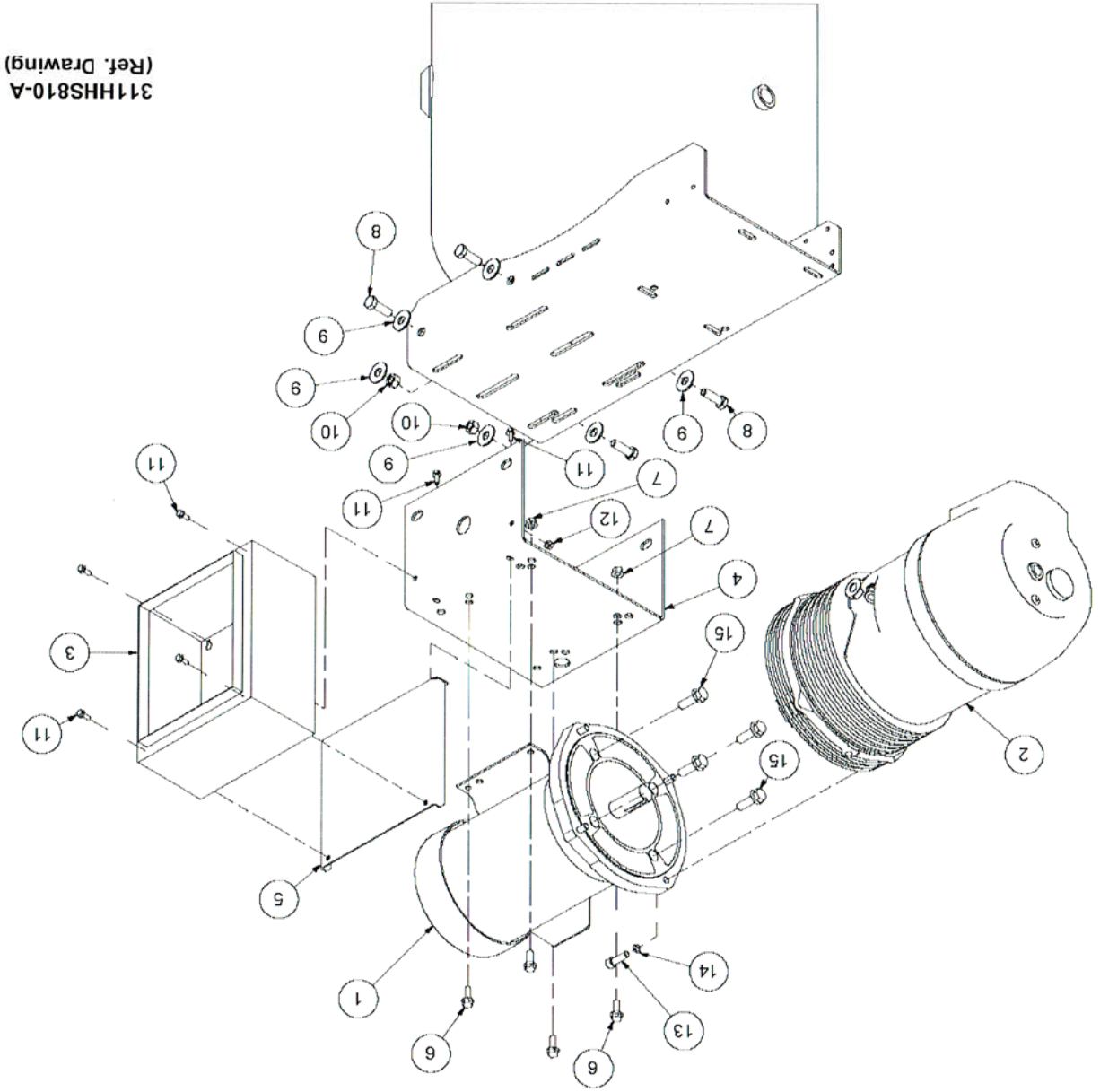
Order by Part Number and Description. Reference Numbers are for your convenience only.

5 HP, 80 GALLON VERT TANK - PIPING GROUP

B/M: 302HHS4019

| Ref. No. | Name of Part                     | Qty. | Part No.  |
|----------|----------------------------------|------|-----------|
| 1        | AIR RECEIVER.....                | 1    | CC1048923 |
| 2        | NIPPLE (Standard Code).....      | 1    | M3011     |
| 2        | NIPPLE (Massachusetts Code)..... | 2    | M3011     |
| 3        | PRESSURE RELIEF VALVE.....       | 1    | M2843     |
| 3        | VALVE.....                       | 1    | M2847     |
| 4        | GAUGE.....                       | 1    | M519C     |
| 5        | PRESSURE SWITCH.....             |      |           |
|          | 100 PSI.....                     | 1    | VP1051215 |
|          | 150 PSI.....                     | 1    | VP1051216 |
| 6        | PLUG (Standard Code).....        | 2    | 64AA5     |
| 6        | PLUG (Massachusetts Code).....   | 1    | 64AA5     |
| 7        | PLUG.....                        | 1    | 64B1      |
| 8        | CHECK VALVE.....                 | 1    | P05822A   |
| 9        | FITTING.....                     | 1    | M2873     |
| 10       | TUBE (5 HP, 80 GAL).....         | 1    | 302HHS857 |
| 11       | FITTING.....                     | 1    | M2885     |
| 12       | ELBOW.....                       | 1    | M980B     |
| 13       | NIPPLE.....                      | 1    | M3715     |
| 14       | BALL VALVE.....                  | 1    | VP1022988 |
| 15       | BALL VALVE.....                  | 1    | M3590     |
| 16       | ADAPTOR.....                     | 1    | VP1053138 |
| 17       | BUSHING.....                     | 1    | M3136     |
| 18       | BUSHING.....                     | 1    | M3080     |
| 19       | VALVE (Massachusetts Code).....  | 1    | P05811A   |

5 HP, 80 GALLON VERT TANK - MOUNTING GROUP



311HHS810-A  
(Ref. Drawing)

Order by Part Number and Description. Reference Numbers are for your convenience only.

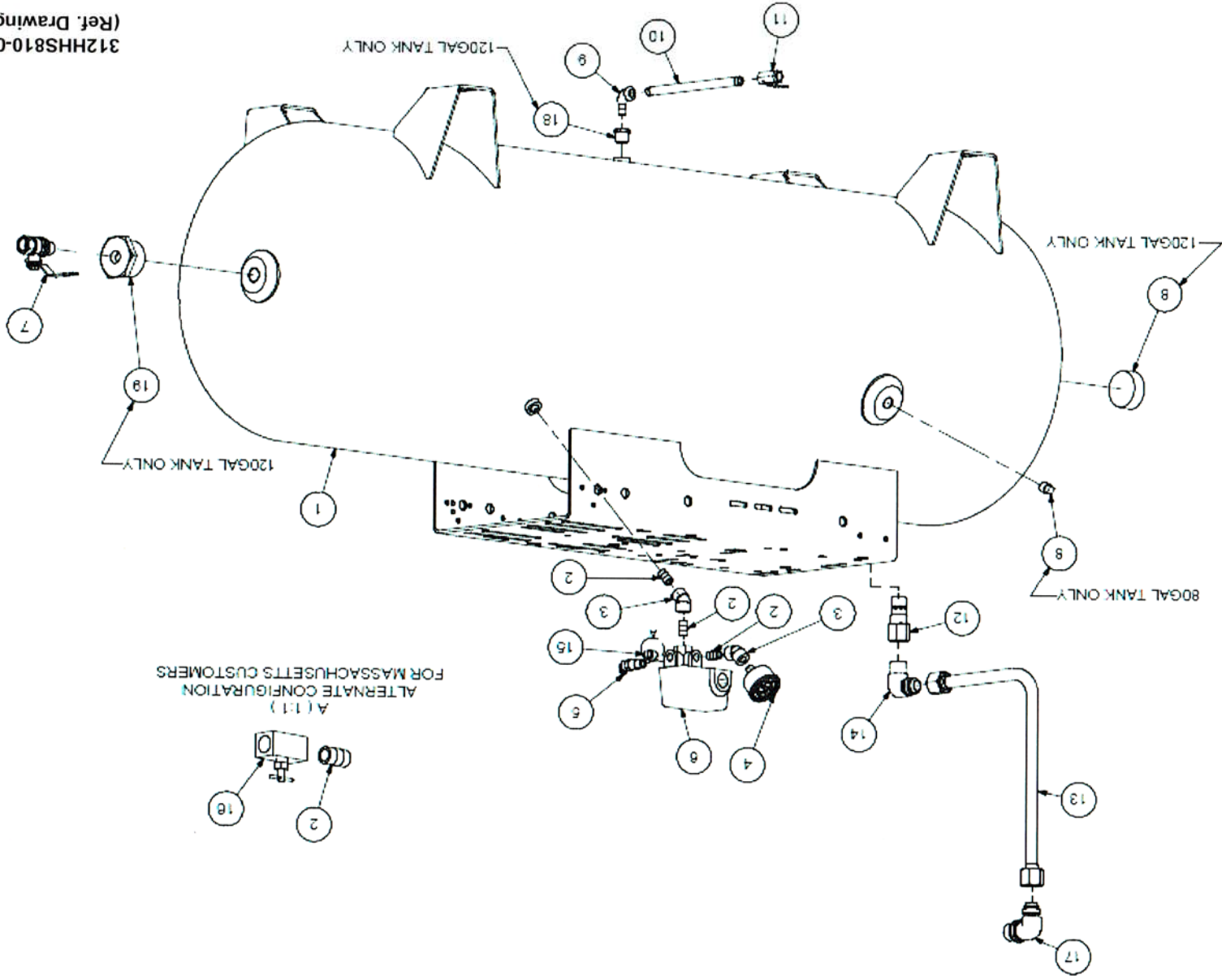
5 HP, 80 GALLON VERT TANK - MOUNTING GROUP

B/M: 302HHS4017

| Ref. No. | Name of Part                       | Qty. | Part No.    |
|----------|------------------------------------|------|-------------|
| 1        | MOTOR<br>5 HP 208-230-460/3PH/60HZ | 1    | 24CA6710    |
|          | 5 HP 575/3PH/60HZ                  | 1    | 24CA7324    |
|          | 5 HP 115-208-460/1PH/60HZ          | 1    | VP1050809   |
| 2        | AIREND                             |      |             |
|          | 5 HP 7 BAR 60HZ NEMA COMPRESSOR    | 1    | 025CK07-268 |
|          | 5 HP 10 BAR 60HZ NEMA COMPRESSOR   | 1    | 025CK10-268 |
| 3        | STARTER-CONT BOX                   |      |             |
|          | 5, 7.5 HP 575V/3PH/60HZ            | 1    | 305HHS466   |
|          | 5, 7.5 HP 208V/3PH/60HZ            | 1    | 309HHS466   |
|          | 5, 7.5 HP 230V/3PH/60HZ            | 1    | 310HHS466   |
|          | 5, 7.5 HP 460V/3PH/60HZ            | 1    | 311HHS466   |
|          | 5, 7.5 HP 208V/1PH/60HZ            | 1    | 312HHS466   |
|          | 5, 7.5 HP 230V/1PH/60HZ            | 1    | 313HHS466   |
| 4        | MOTOR SUPPORT BRACKET              | 1    | CC1047697   |
| 5        | STARTER SUPPORT BRACKET            | 1    | CC1047485   |
| 6        | SCREW                              | 4    | 75K48       |
| 7        | NUT                                | 4    | M3483       |
| 8        | SCREW                              | 4    | 75LM200     |
| 9        | WASHER                             | 8    | M3463       |
| 10       | NUT                                | 4    | M3486       |
| 11       | SCREW                              | 6    | 75LM54      |
| 12       | NUT                                | 2    | 50AW3       |
| 13       | SPRING WASHER                      | 4    | MWG10       |
| 14       | SCREW                              | 4    | MS710-30    |
| 15       | SCREW                              | 4    | 75LM200     |



7.5 HP, 80 GALLON HORIZ TANK - PIPING GROUP



312HHS810-02  
(Ref. Drawing)



Order by Part Number and Description. Reference Numbers are for your convenience only.

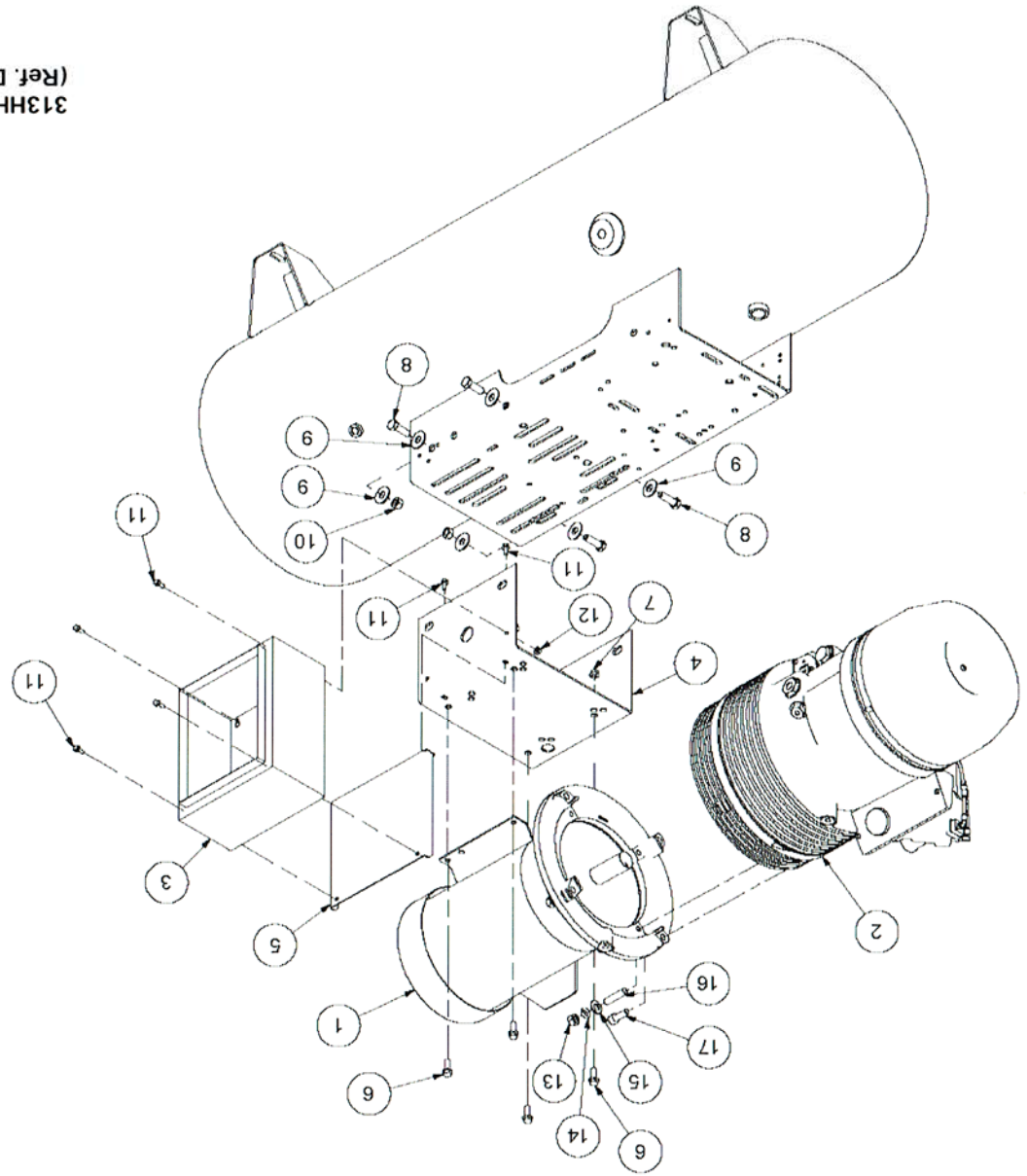
7.5 HP & 10hp, 80-120 GALLON HORIZ TANK - PIPING GROUP

B/M: 303HHS4019

| Ref. No. | Name of Part                     | Qty. | Part No.  |
|----------|----------------------------------|------|-----------|
| 1        | AIR RECEIVER.....                | 1    | P01164D   |
| 2        | 80 GALLON TANK.....              | 1    | CC1028739 |
| 2        | 120 GALLON TANK.....             | 1    | M3011     |
| 2        | NIPPLE (Standard Code).....      | 3    | M3011     |
| 2        | NIPPLE (Massachusetts Code)..... | 4    | M3011     |
| 3        | ELBOW.....                       | 2    | M3087     |
| 4        | GAUGE.....                       | 1    | M519C     |
| 5        | PRESSURE RELIEF VALVE.....       | 1    | M2843     |
| 5        | VALVE.....                       | 1    | M2847     |
| 6        | PRESSURE SWITCH.....             | 1    | VP1051215 |
| 7        | 100 PSI.....                     | 1    | VP1051216 |
| 7        | 150 PSI.....                     | 1    | M3590     |
| 8        | BALL VALVE.....                  | 1    | 64B1      |
| 8        | PLUG.....                        | 1    | M2479     |
| 9        | ELBOW.....                       | 1    | M980B     |
| 10       | NIPPLE.....                      | 1    | M1020B    |
| 11       | BALL VALVE.....                  | 1    | VP1022988 |
| 12       | CHECK VALVE.....                 | 1    | P05822A   |
| 13       | TUBE FITTING.....                | 1    | 302HHS863 |
| 14       | 80 GALLON TANK.....              | 1    | TEN000860 |
| 14       | 120 GALLON TANK.....             | 1    | 29Z241    |
| 14       | ADAPTOR.....                     | 1    | 29Z241    |
| 15       | PLUG.....                        | 1    | 29Z241    |
| 16       | VALVE (Massachusetts Code).....  | 1    | P05811A   |
| 17       | ADAPTOR.....                     | 1    | 86H194    |
| 18       | BUSHING (120 GALLON TANK).....   | 1    | 64E2G     |
| 18       | BUSHING (120 GALLON TANK).....   | 1    | M3184     |

7.5 - 10 HP, 80 GALLON HORIZ TANK - MOUNTING GROUP

313HHS810-A  
(Ref. Drawing)



Order by Part Number and Description. Reference Numbers are for your convenience only.

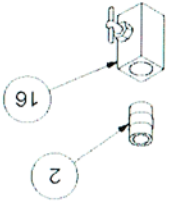
7.5 - 10 HP, 80 GALLON HORIZ TANK - MOUNTING GROUP

B/M: 303HHS4017  
& 305HHS4017

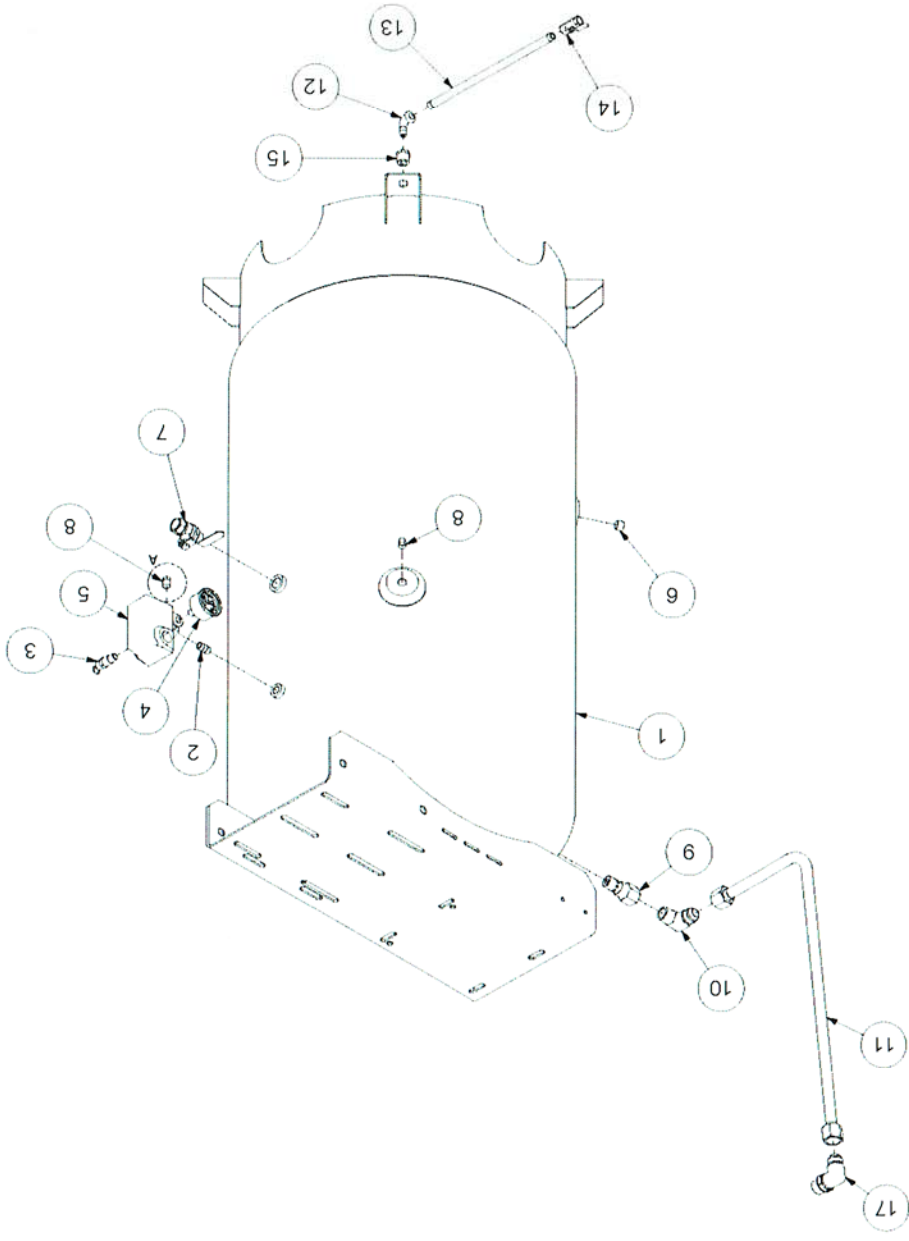
| Ref. No. | Name of Part                       | Qty. | Part No.     |
|----------|------------------------------------|------|--------------|
| 1        | MOTOR                              | 1    | 24CA6711     |
|          | 7.5 HP 208-230-460/3PH/60HZ        | 1    | 24CA6712     |
|          | 7.5 HP 575/3PH/60HZ                | 1    | 24CA7325     |
|          | 10 HP 208-230-460/3PH/60HZ         | 1    | 24CA6712     |
|          | 10 HP 575/3PH/60HZ                 | 1    | 24CA7326     |
|          | 7.5 HP 208-230/1PH/60HZ            | 1    | 24CA6978     |
| 2        | AIREND                             | 1    | HR05C07H-008 |
|          | 7.5 HP 7 BAR 60HZ NEMA COMPRESSOR  | 1    | HR05C07H-008 |
|          | 7.5 HP 10 BAR 60HZ NEMA COMPRESSOR | 1    | HR05C10H-008 |
|          | 10 HP 7 BAR 60HZ NEMA COMPRESSOR   | 1    | HR07C07H-008 |
|          | 10 HP 10 BAR 60HZ NEMA COMPRESSOR  | 1    | HR07C10H-008 |
| 3        | STARTER-CONT BOX                   | 1    | 305HHS466    |
|          | 7.5, 10 HP 575V/3PH/60HZ           | 1    | 305HHS466    |
|          | 7.5 HP 208V/3PH/60HZ               | 1    | 309HHS466    |
|          | 7.5 HP 230V/3PH/60HZ               | 1    | 310HHS466    |
|          | 7.5 HP 460V/3PH/60HZ               | 1    | 311HHS466    |
|          | 7.5 HP 208V/1PH/60HZ               | 1    | 312HHS466    |
|          | 7.5 HP 230V/1PH/60HZ               | 1    | 313HHS466    |
|          | 7.5 HP 208V/3PH/60HZ               | 1    | 314HHS466    |
|          | 10 HP 208V/3PH/60HZ                | 1    | 315HHS466    |
|          | 10 HP 230V/3PH/60HZ                | 1    | 316HHS466    |
| 4        | MOTOR SUPPORT BRACKET              | 1    | CC1047697    |
| 5        | STARTER SUPPORT BRACKET            | 1    | CC1047485    |
| 6        | SCREW                              | 4    | 75K48        |
| 7        | NUT                                | 4    | M3483        |
| 8        | SCREW                              | 4    | M3461        |
| 9        | WASHER                             | 8    | M3463        |
| 10       | NUT                                | 4    | M3486        |
| 11       | SCREW                              | 6    | 75LM54       |
| 12       | NUT                                | 2    | 50AW3        |
| 13       | NUT                                | 4    | M3462        |
| 14       | LOCKWASHER                         | 4    | M3464        |
| 15       | WASHER                             | 4    | M3463        |
| 16       | STUD                               | 4    | UFST8-16B    |
| 17       | SCREW                              | 4    | MS712-30     |

7.5 HP, 80 GALLON VERT TANK - PIPING GROUP

A (1:1)  
ALTERNATE CONFIGURATION  
FOR MASSACHUSETTS CUSTOMERS



314HHS810-B  
(Ref. Drawing)



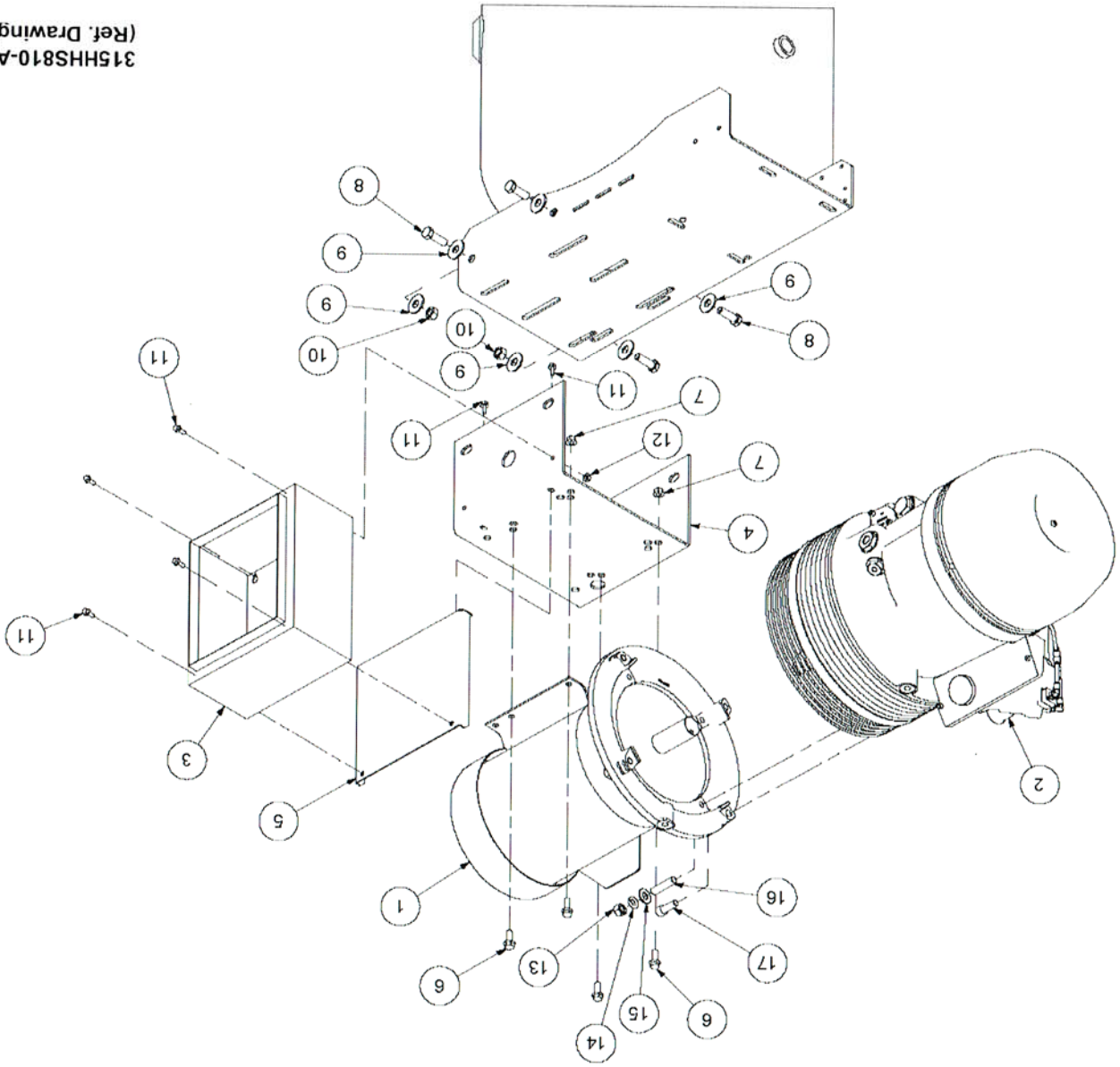
Order by Part Number and Description. Reference Numbers are for your convenience only.

7.5 HP, 80 GALLON VERT TANK - PIPING GROUP

B/M: 304HHS4019

| Ref. No. | Name of Part                     | Qty. | Part No.  |
|----------|----------------------------------|------|-----------|
| 1        | AIR RECEIVER.....                | 1    | CC1048923 |
| 2        | NIPPLE (Standard Code).....      | 3    | M3011     |
| 2        | NIPPLE (Massachusetts Code)..... | 4    | M3011     |
| 3        | PRESSURE RELIEF VALVE.....       | 1    | M2843     |
| 3        | VALVE.....                       | 1    | M2847     |
| 4        | GAUGE.....                       | 1    | M519C     |
| 5        | PRESSURE SWITCH.....             | 1    | VP1051215 |
|          | 100 PSI.....                     | 1    | VP1051216 |
|          | 150 PSI.....                     | 1    | 64B1      |
| 6        | PLUG.....                        | 1    | M3590     |
| 7        | BALL VALVE.....                  | 1    | 64AA5     |
| 8        | PLUG.....                        | 1    | P05822A   |
| 9        | VALVE.....                       | 1    | 29Z241    |
| 10       | ADAPTOR.....                     | 1    | 303HHS863 |
| 11       | TUBE FITTING.....                | 1    | M980B     |
| 12       | ELBOW.....                       | 1    | M3715     |
| 13       | NIPPLE.....                      | 1    | VP1022988 |
| 14       | BALL VALVE.....                  | 1    | M3080     |
| 15       | BUSHING.....                     | 1    | P05811A   |
| 16       | VALVE (Massachusetts Code).....  | 1    | 86H194    |
| 17       | ADAPTOR.....                     | 1    |           |

7.5 HP, 80 GALLON VERT TANK - MOUNTING GROUP



315HHS810-A  
(Ref. Drawing)



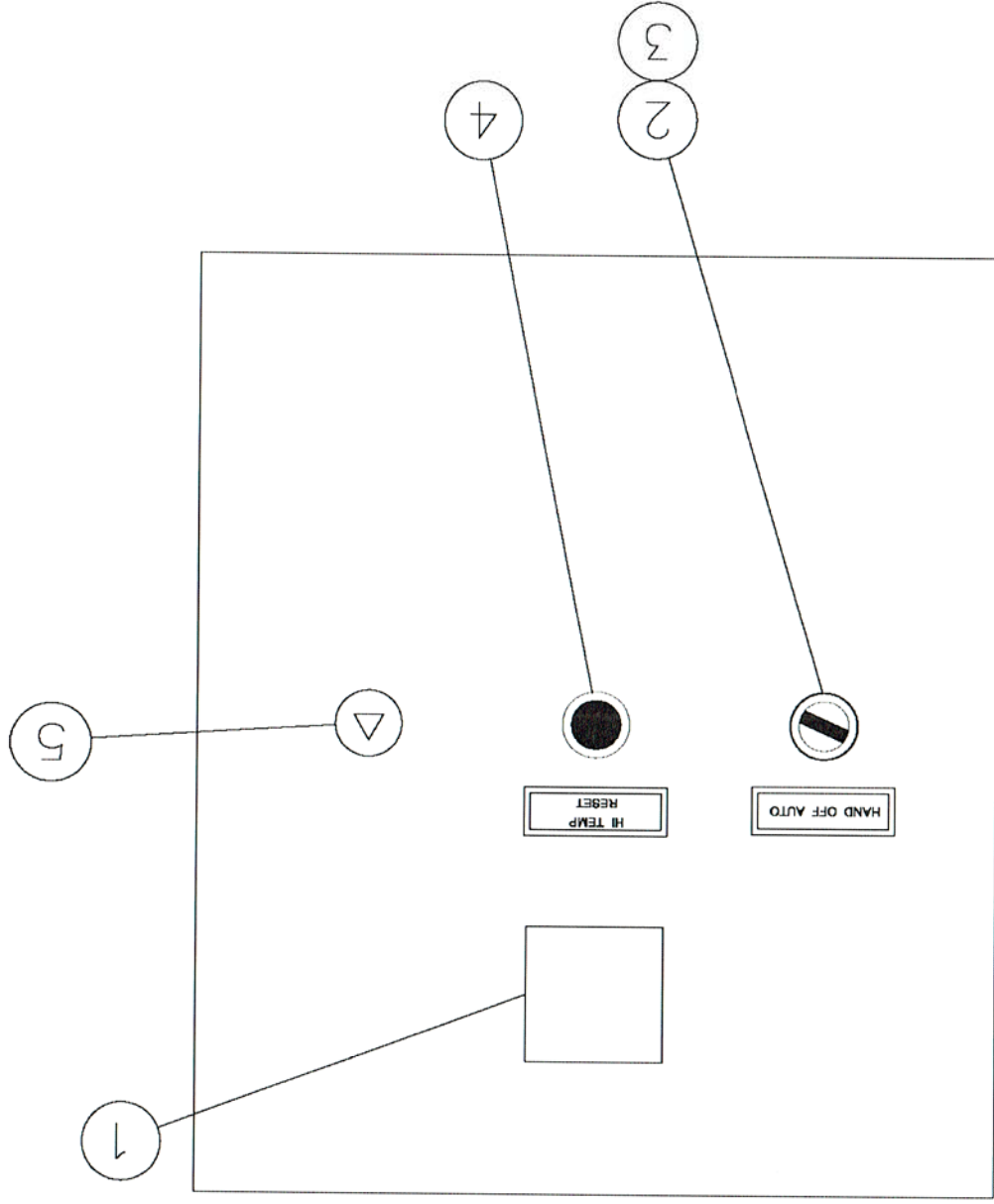
Order by Part Number and Description. Reference Numbers are for your convenience only.

7.5 HP, 80 GALLON VERT TANK - MOUNTING GROUP

B/M: 304HHS4017

| Ref. No. | Name of Part                         | Qty. | Part No.     |
|----------|--------------------------------------|------|--------------|
| 1        | MOTOR<br>7.5 HP 208-230-460/3PH/60HZ | 1    | 24CA6710     |
|          | 7.5 HP 575/3PH/60HZ                  | 1    | 24CA7325     |
|          | 7.5 HP 208-230/1PH/60HZ              | 1    | 24CA6978     |
| 2        | AIREND                               |      |              |
|          | 7.5 HP 7 BAR 60HZ NEMA COMPRESSOR    | 1    | HR05C07H-008 |
|          | 7.5 HP 10 BAR 60HZ NEMA COMPRESSOR   | 1    | HR05C10H-008 |
| 3        | STARTER-CONT BOX                     |      |              |
|          | 7.5 HP 575V/3PH/60HZ                 | 1    | 305HHS466    |
|          | 7.5 HP 208V/3PH/60HZ                 | 1    | 309HHS466    |
|          | 7.5 HP 230V/3PH/60HZ                 | 1    | 310HHS466    |
|          | 7.5 HP 460V/3PH/60HZ                 | 1    | 311HHS466    |
|          | 7.5 HP 208V/1PH/60HZ                 | 1    | 312HHS466    |
|          | 7.5 HP 230V/1PH/60HZ                 | 1    | 313HHS466    |
| 4        | MOTOR SUPPORT BRACKET                | 1    | CC1047697    |
| 5        | STARTER SUPPORT BRACKET              | 1    | CC1047485    |
| 6        | SCREW                                | 4    | 75K48        |
| 7        | NUT                                  | 4    | M3483        |
| 8        | SCREW                                | 4    | M3461        |
| 9        | WASHER                               | 8    | M3463        |
| 10       | NUT                                  | 4    | M3486        |
| 11       | SCREW                                | 6    | 75LM54       |
| 12       | NUT                                  | 2    | 50AW3        |
| 13       | NUT                                  | 4    | M3462        |
| 14       | LOCKWASHER                           | 4    | M3464        |
| 15       | WASHER                               | 4    | M3463        |
| 16       | STUD                                 | 4    | UFST8-16B    |
| 17       | SCREW                                | 4    | MS712-30     |

CONTROL PANEL



303HHS810-A  
(Ref. Drawing)  
Page 1 of 2



Order by Part Number and Description. Reference Numbers are for your convenience only.

CONTROL PANEL

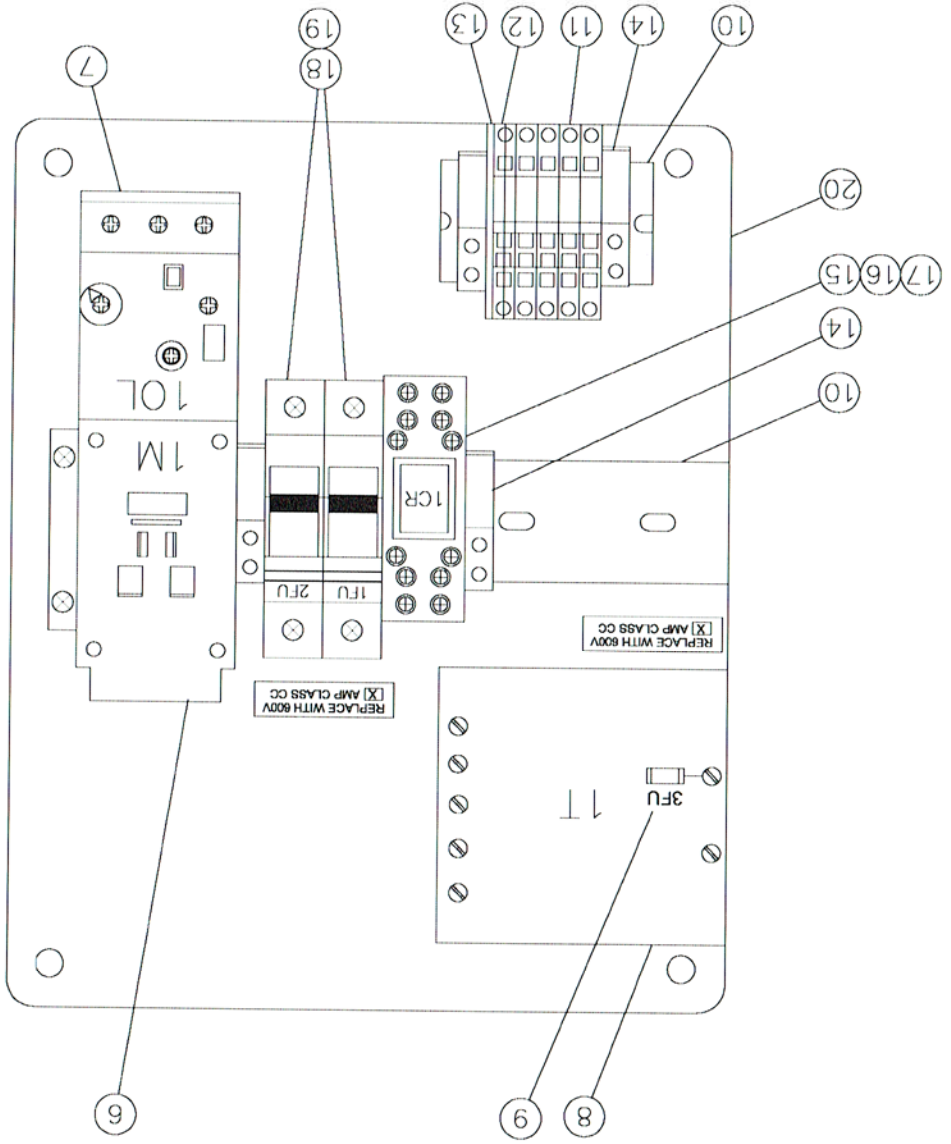
B/M: \*

| Ref. No. | Name of Part                   | Qty. | Part No. |
|----------|--------------------------------|------|----------|
| 1        | HOUR METER.....                | 1    | 24CA7186 |
| 2        | SELECTOR-SWITCH.....           | 1    | 24CA7196 |
| 3        | ANTI-ROTATION RING-SWITCH..... | 1    | 24CA7197 |
| 4        | PUSHBOTON-SWITCH.....          | 1    | 24CA7194 |
| 5        | DOOR LATCH (SLOTTED).....      | 1    | 24CA7207 |

\* Drawing 303HHS810 and B/M reference the following part numbers.

|           |           |           |           |           |           |
|-----------|-----------|-----------|-----------|-----------|-----------|
| 301HHS466 | 304HHS466 | 307HHS466 | 310HHS466 | 313HHS466 | 316HHS466 |
| 302HHS466 | 305HHS466 | 308HHS466 | 311HHS466 | 314HHS466 | 315HHS466 |
| 303HHS466 | 306HHS466 | 309HHS466 | 312HHS466 |           |           |

CONTROLLER ASSEMBLY, 2 HP (208, 230, 460 & 575 MULTI-VOLT) 3 PHASE

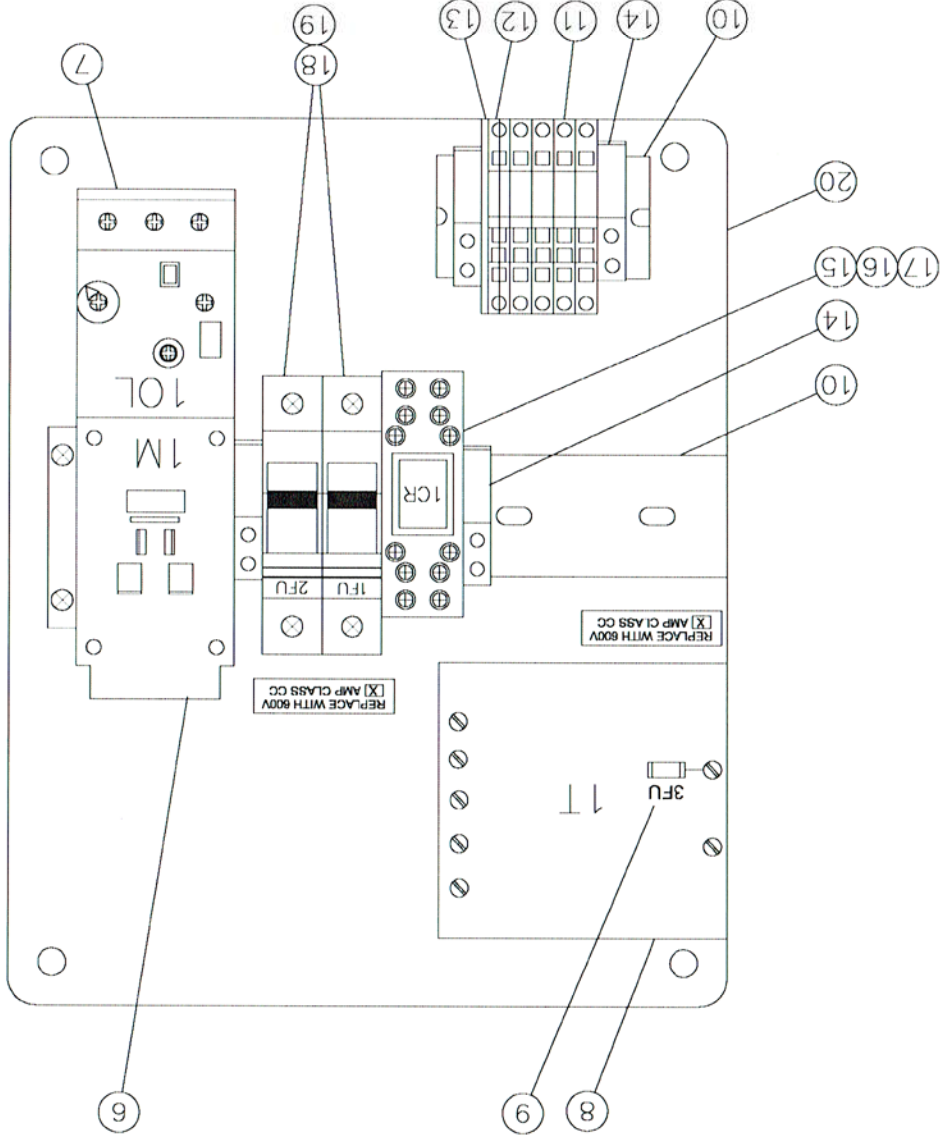


303HHS810-A  
(Ref. Drawing)  
Page 2 of 2

Order by Part Number and Description. Reference Numbers are for your convenience only.  
**CONTROLLER ASSEMBLY, 2 HP (208, 230, 460 & 575 MULTI-VOLT) 3 PHASE**

| Ref. No. | Name of Part                  | QTY. | 2 HP      | 2 HP      | 2 HP      | 2 HP      | 460V | 575V |
|----------|-------------------------------|------|-----------|-----------|-----------|-----------|------|------|
| 6        | UL TYPE 4 CONTROL BOX.....    | 1    | 302HHS466 | 303HHS466 | 304HHS466 | 301HHS466 |      |      |
| 7        | CONTACTOR.....                | 1    | 24CA7204  | 24CA7204  | 24CA7204  | 24CA7205  |      |      |
| 8        | OVERLOAD RELAY.....           | 1    | 24CA7192  | 24CA7192  | 24CA7192  | 24CA7193  |      |      |
| 9        | TRANSFORMER.....              | 1    | 24CA7191  | 24CA7191  | 24CA7191  | 24CA7191  |      |      |
| 10       | FUSE.....                     | 1    | 24CA5991  | 24CA5991  | 24CA5991  | 24CA5991  |      |      |
| 11       | DIN RAIL.....                 | 1    | 24CA7199  | 24CA7199  | 24CA7199  | 24CA7199  |      |      |
| 12       | TERMINAL BLOCK.....           | 4    | 24CA7200  | 24CA7200  | 24CA7200  | 24CA7200  |      |      |
| 13       | GROUND BLOCK.....             | 1    | 24CA7202  | 24CA7202  | 24CA7202  | 24CA7202  |      |      |
| 14       | TERMINAL BLOCK-END COVER..... | 1    | 24CA7201  | 24CA7201  | 24CA7201  | 24CA7201  |      |      |
| 15       | TERMINAL BLOCK-END CLAMP..... | 4    | 24CA7188  | 24CA7188  | 24CA7188  | 24CA7188  |      |      |
| 16       | CONTROL RELAY.....            | 1    | 24CA7287  | 24CA7287  | 24CA7287  | 24CA7287  |      |      |
| 17       | CONTROL RELAY SOCKET.....     | 1    | 24CA7189  | 24CA7189  | 24CA7189  | 24CA7189  |      |      |
| 18       | CONTROL RELAY CLIPS.....      | 2    | 24CA7198  | 24CA7198  | 24CA7198  | 24CA7198  |      |      |
| 19       | FUSE HOLDER.....              | 2    | 24CA3718  | 24CA3718  | 24CA3718  | 24CA3718  |      |      |
| 20       | FUSE.....                     | 1    | 300HHS179 | 300HHS179 | 300HHS179 | 300HHS179 |      |      |

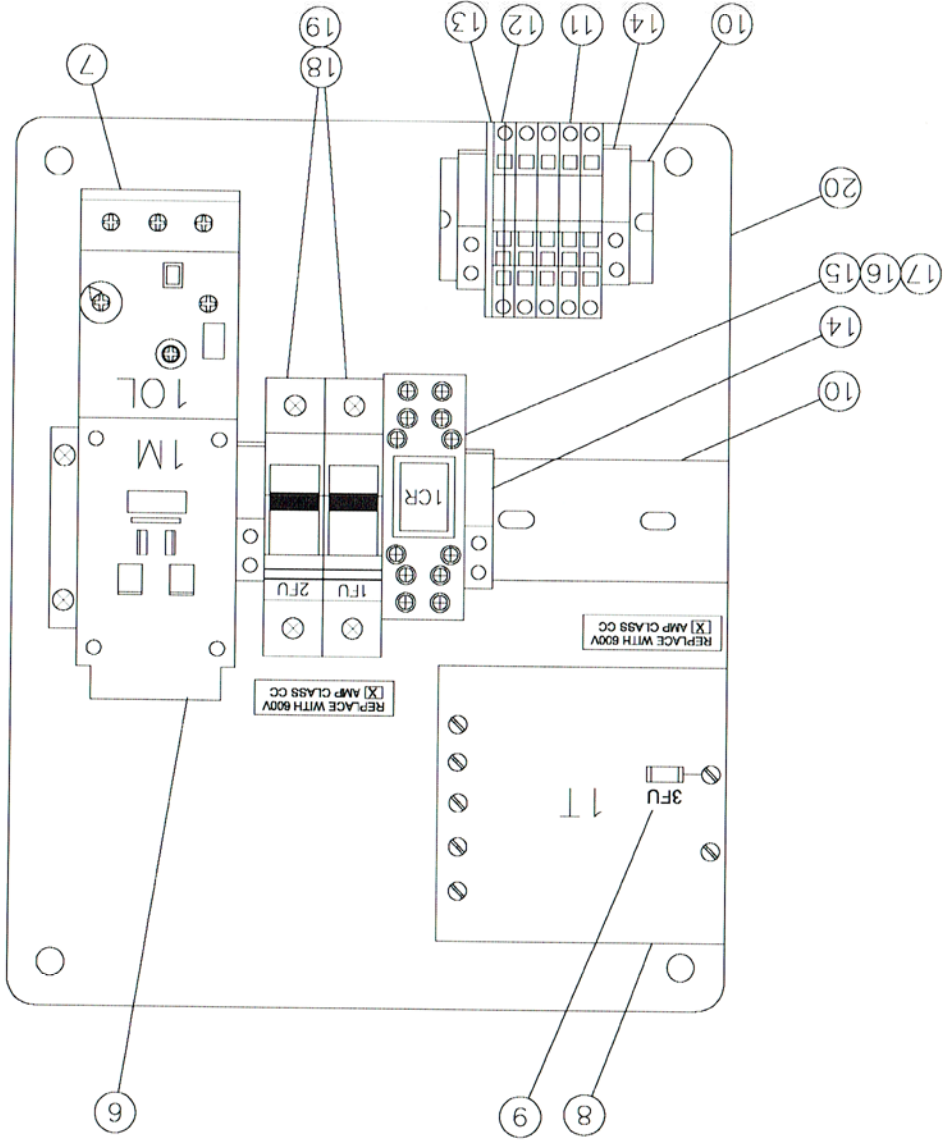
CONTROLLER ASSEMBLY, 5 7.5 HP (208, 230, 460 & 575 MULTI-VOLT) 3 PHASE



Order by Part Number and Description. Reference Numbers are for your convenience only.  
**CONTROLLER ASSEMBLY, 5 & 7.5 HP (208, 230, 460 & 575 MULTI-VOLT) 3 PHASE**

| Ref. No. | Name of Part                  | QTY. | 5 & 7.5 HP | 5 & 7.5 HP | 230V      | 5 & 7.5 HP | 460V | 575V |
|----------|-------------------------------|------|------------|------------|-----------|------------|------|------|
| 6        | UL TYPE 4 CONTROL BOX.....    | 1    | 309HHS466  | 310HHS466  | 311HHS466 | 305HHS466  |      |      |
| 7        | OVERLOAD RELAY.....           | 1    | 24CA6890   | 24CA6890   | 24CA6890  | 24CA6965   |      |      |
| 8        | TRANSFORMER.....              | 1    | 24CA7193   | 24CA7193   | 24CA7193  | 24CA7192   |      |      |
| 9        | FUSE.....                     | 1    | 24CA7191   | 24CA7191   | 24CA7191  | 24CA7191   |      |      |
| 10       | DIN RAIL.....                 | 1    | 24CA5991   | 24CA5991   | 24CA5991  | 24CA5991   |      |      |
| 11       | TERMINAL BLOCK.....           | 4    | 24CA7199   | 24CA7199   | 24CA7199  | 24CA7199   |      |      |
| 12       | GROUND BLOCK.....             | 1    | 24CA7200   | 24CA7200   | 24CA7200  | 24CA7200   |      |      |
| 13       | TERMINAL BLOCK-END COVER..... | 1    | 24CA7202   | 24CA7202   | 24CA7202  | 24CA7202   |      |      |
| 14       | TERMINAL BLOCK-END CLAMP..... | 4    | 24CA7201   | 24CA7201   | 24CA7201  | 24CA7201   |      |      |
| 15       | CONTROL RELAY.....            | 1    | 24CA7188   | 24CA7188   | 24CA7188  | 24CA7188   |      |      |
| 16       | CONTROL RELAY SOCKET.....     | 1    | 24CA7287   | 24CA7287   | 24CA7287  | 24CA7287   |      |      |
| 17       | CONTROL RELAY CLIPS.....      |      | 24CA7189   | 24CA7189   | 24CA7189  | 24CA7189   |      |      |
| 18       | FUSE HOLDER.....              | 2    | 24CA7198   | 24CA7198   | 24CA7198  | 24CA7198   |      |      |
| 19       | FUSE.....                     | 2    | 24CA3718   | 24CA3718   | 24CA3718  | 24CA2896   |      |      |
| 20       | CONTROL BOX ENCLOSURE.....    | 1    | 300HHS179  | 300HHS179  | 300HHS179 | 300HHS179  |      |      |

CONTROLLER ASSEMBLY, 10 HP (208, 230, 460 & 575 MULTI-VOLT) 3 PHASE



303HHS810-A  
 (Ref. Drawing)  
 Page 2 of 2

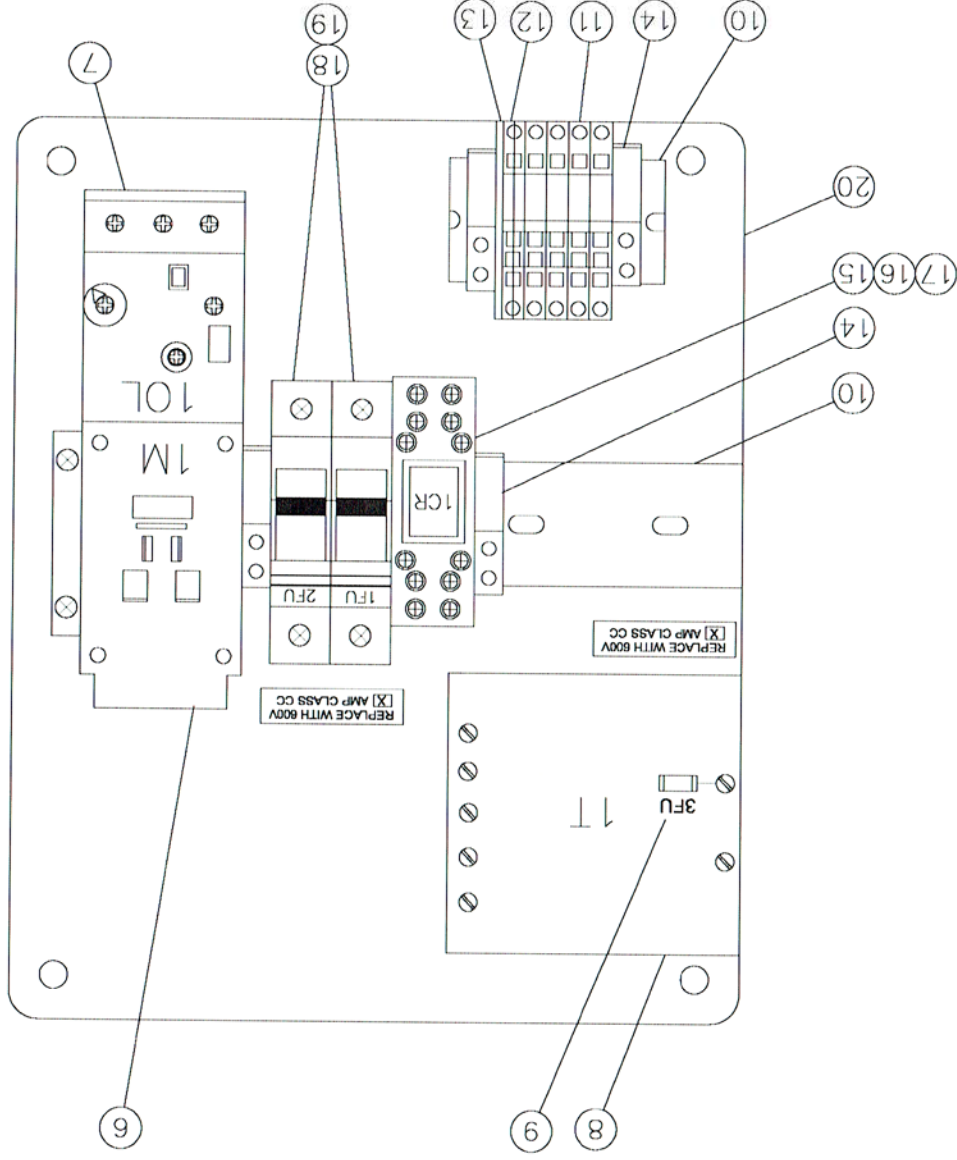
Order by Part Number and Description. Reference Numbers are for your convenience only.

CONTROLLER ASSEMBLY, 10 HP (208, 230, 460 & 575 MULTI-VOLT) 3 PHASE

| Ref. No. | Name of Part                   | QTY. | 208V      | 230V      | 460V      | 575V      |
|----------|--------------------------------|------|-----------|-----------|-----------|-----------|
| 6        | UL TYPE 4 CONTROL BOX.....     | 1    | 314HHS466 | 315HHS466 | 316HHS466 | 305HHS466 |
| 7        | OVERLOAD RELAY .....           | 1    | 24CA6272  | 24CA6272  | 24CA6272  | 24CA6272  |
| 8        | TRANSFORMER .....              | 1    | 24CA7192  | 24CA7192  | 24CA7192  | 24CA7192  |
| 9        | FUSE .....                     | 1    | 24CA7191  | 24CA7191  | 24CA7191  | 24CA7191  |
| 10       | DIN RAIL .....                 | 1    | 24CA5991  | 24CA5991  | 24CA5991  | 24CA5991  |
| 11       | TERMINAL BLOCK.....            | 4    | 24CA7199  | 24CA7199  | 24CA7199  | 24CA7199  |
| 12       | GROUND BLOCK.....              | 1    | 24CA7200  | 24CA7200  | 24CA7200  | 24CA7200  |
| 13       | TERMINAL BLOCK-END COVER ..... | 1    | 24CA7202  | 24CA7202  | 24CA7202  | 24CA7202  |
| 14       | TERMINAL BLOCK-END CLAMP.....  | 4    | 24CA7201  | 24CA7201  | 24CA7201  | 24CA7201  |
| 15       | CONTROL RELAY.....             | 1    | 24CA7188  | 24CA7188  | 24CA7188  | 24CA7188  |
| 16       | CONTROL RELAY SOCKET.....      | 1    | 24CA7187  | 24CA7187  | 24CA7187  | 24CA7187  |
| 17       | CONTROL RELAY CLIPS.....       | 1    | 24CA7189  | 24CA7189  | 24CA7189  | 24CA7189  |
| 18       | FUSE HOLDER .....              | 2    | 24CA7198  | 24CA7198  | 24CA2896  | 24CA2896  |
| 19       | FUSE .....                     | 2    | 24CA3718  | 24CA3718  | 24CA2896  | 24CA2896  |
| 20       | CONTROL BOX ENCLOSURE.....     | 1    | 300HHS179 | 300HHS179 | 300HHS179 | 300HHS179 |



CONTROLLER ASSEMBLY, 2, 5 & 7.5 HP (115, 208 & 230 MULTI-VOLT) 1 PHASE



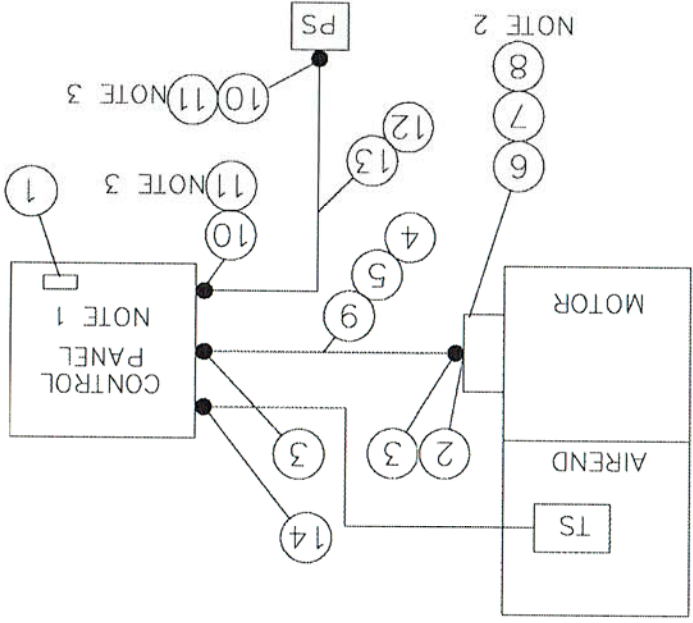
302HHS810-A  
 (Ref. Drawing)  
 Page 2 of 2



Order by Part Number and Description. Reference Numbers are for your convenience only.  
 CONTROLLER ASSEMBLY, 2, 5 & 7.5 HP (115, 208 & 230 MULTI-VOLT) 1 PHASE

| Ref. No. | Name of Part                  | QTY. | 2 HP      | 2 HP      | 2 HP      | 5 & 7.5 HP | 5 & 7.5 HP |
|----------|-------------------------------|------|-----------|-----------|-----------|------------|------------|
| 6        | UL TYPE 4 CONTROL BOX.....    | 1    | 306HHS466 | 307HHS466 | 308HHS466 | 312HHS466  | 313HHS466  |
| 7        | CONTACTOR.....                | 1    | 24CA7205  | 24CA7205  | 24CA7205  | 24CA7206   | 24CA7206   |
| 8        | OVERLOAD RELAY.....           | 1    | 24CA6890  | 24CA6890  | 24CA6890  | 24CA6272   | 24CA6272   |
| 9        | TRANSFORMER.....              | 1    | 24CA7193  | 24CA7193  | 24CA7193  | 24CA7192   | 24CA7192   |
| 10       | FUSE.....                     | 1    | 24CA7191  | 24CA7191  | 24CA7191  | 24CA7191   | 24CA7191   |
| 11       | DIN RAIL.....                 | 1    | 24CA5991  | 24CA5991  | 24CA5991  | 24CA5991   | 24CA5991   |
| 12       | TERMINAL BLOCK.....           | 4    | 24CA7199  | 24CA7199  | 24CA7199  | 24CA7199   | 24CA7199   |
| 13       | GROUND BLOCK.....             | 1    | 24CA7200  | 24CA7200  | 24CA7200  | 24CA7200   | 24CA7200   |
| 14       | TERMINAL BLOCK-END COVER..... | 1    | 24CA7202  | 24CA7202  | 24CA7202  | 24CA7202   | 24CA7202   |
| 15       | TERMINAL BLOCK-END CLAMP..... | 4    | 24CA7201  | 24CA7201  | 24CA7201  | 24CA7201   | 24CA7201   |
| 16       | CONTROL RELAY.....            | 1    | 24CA7188  | 24CA7188  | 24CA7188  | 24CA7188   | 24CA7188   |
| 17       | CONTROL RELAY.....            | 1    | 24CA7187  | 24CA7187  | 24CA7187  | 24CA7287   | 24CA7287   |
| 18       | CONTROL RELAY CLIPS.....      | 1    | 24CA7189  | 24CA7189  | 24CA7189  | 24CA7189   | 24CA7189   |
| 19       | FUSE HOLDER.....              | 2    | 24CA7198  | 24CA7198  | 24CA7198  | 24CA7198   | 24CA7198   |
| 20       | FUSE.....                     | 2    | 24CA3719  | 24CA3718  | 24CA3718  | 24CA3718   | 24CA3718   |
|          | CONTROL BOX ENCLOSURE.....    | 1    | 300HHS179 | 300HHS179 | 300HHS179 | 300HHS179  | 300HHS179  |

**SINGLE PHASE WIRING HARNESS  
2, 5 & 7.5 HP - 115, 208 & 230 VOLT**



NOTES:

1) CONTROL PANEL ENTRY LOCATIONS VARY  
BY UNIT CONFIGURATION.

2) ITEM 6 OR ITEMS 7 & 8.

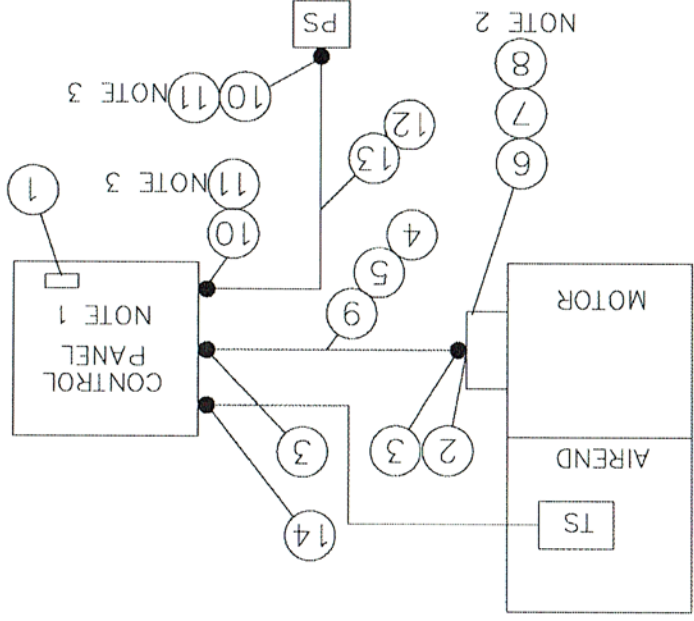
3) ITEM 10 OR ITEM 11.

TS = TEMPERATURE SWITCH INTEGRAL TO AIREND.  
PS = PRESSURE SWITCH ON RECEIVER.

**304HHS810-A  
(Ref. Drawing)**



**THREE PHASE WIRING HARNESS**  
**5, 7.5 & 10 HP - 208, 230 & 460 VOLT**



NOTES:

1) CONTROL PANEL ENTRY LOCATIONS VARY  
 BY UNIT CONFIGURATION.

2) ITEM 6 OR ITEMS 7 & 8.

3) ITEM 10 OR ITEM 11.

TS = TEMPERATURE SWITCH INTEGRAL TO AIREND.  
 PS = PRESSURE SWITCH ON RECEIVER.

303HHS810-A  
 (Ref. Drawing)

Order by Part Number and Description. Reference Numbers are for your convenience only.

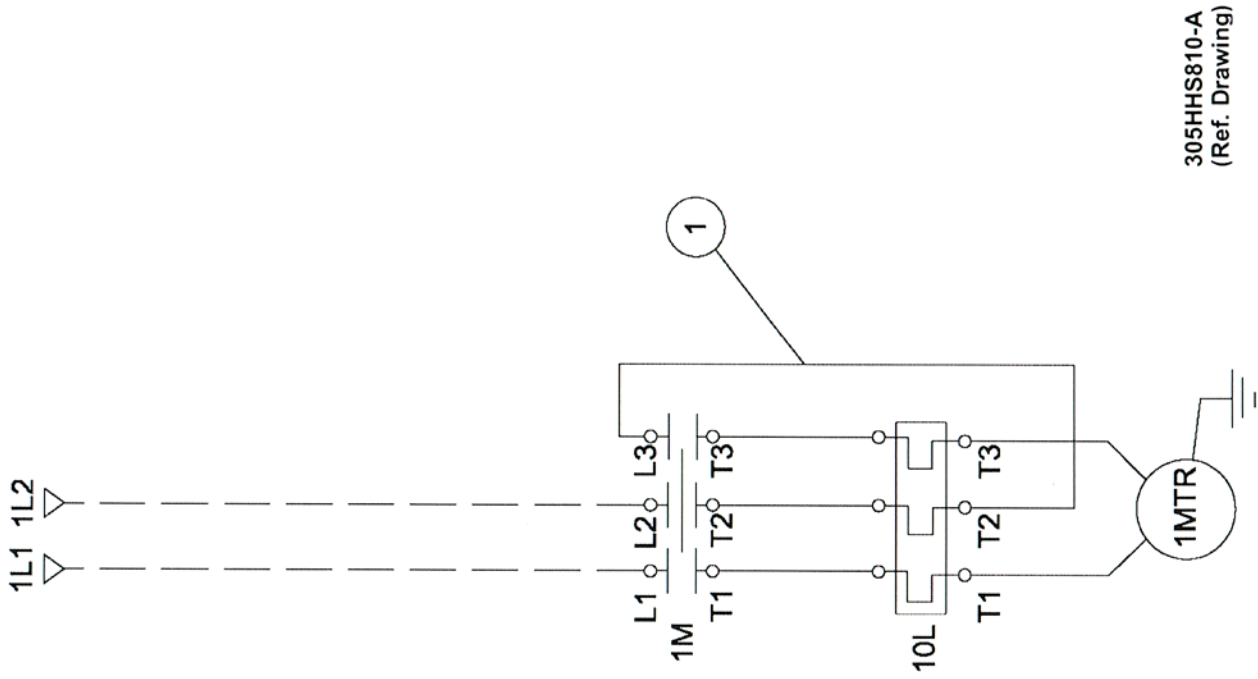
THREE PHASE WIRING HARNESS  
5, 7.5 & 10 HP - 208, 230, 460 & 575 VOLT

| Ref. No. | NAME   | QTY. | PART NO.           | QTY. | PART NO.           | QTY. | PART NO.           | QTY. | PART NO.           |
|----------|--------|------|--------------------|------|--------------------|------|--------------------|------|--------------------|
|          | 2 HP   |      | B/M:<br>305HHS4007 |      | B/M:<br>308HHS4007 |      | B/M:<br>301HHS4007 |      | B/M:<br>315HHS4007 |
|          | 2 HP   |      | 302HHS4007         |      | 302HHS4007         |      | 302HHS4007         |      | 302HHS4007         |
|          | 2 HP   |      | 303HHS4007         |      | 303HHS4007         |      | 303HHS4007         |      | 303HHS4007         |
|          | 7.5 HP |      | B/M:<br>310HHS4007 |      | B/M:<br>310HHS4007 |      | B/M:<br>301HHS4007 |      | B/M:<br>315HHS4007 |
|          | 7.5 HP |      | 302HHS4007         |      | 302HHS4007         |      | 302HHS4007         |      | 302HHS4007         |
|          | 7.5 HP |      | 303HHS4007         |      | 303HHS4007         |      | 303HHS4007         |      | 303HHS4007         |
|          | 10 HP  |      | B/M:<br>315HHS4007 |      | B/M:<br>310HHS4007 |      | B/M:<br>301HHS4007 |      | B/M:<br>315HHS4007 |
|          | 10 HP  |      | 302HHS4007         |      | 302HHS4007         |      | 302HHS4007         |      | 302HHS4007         |
|          | 10 HP  |      | 303HHS4007         |      | 303HHS4007         |      | 303HHS4007         |      | 303HHS4007         |

|    |                   |      |           |      |           |      |           |      |           |
|----|-------------------|------|-----------|------|-----------|------|-----------|------|-----------|
| 1  | VOLTAGE MARKER    | 1    | 69F50     | 1    | 69F50     | 1    | 69F50     | 1    | 69F50     |
|    | 208 VOLT          | 1    | 69F51     | 1    | 69F51     | 1    | 69F51     | 1    | 69F51     |
|    | 230 VOLT          | 1    | 69F52     | 1    | 69F52     | 1    | 69F52     | 1    | 69F52     |
| 2  | CONDUIT FITTING   | 2    | M2588     | 2    | M2694     | 2    | M2586     | 2    | M2586     |
| 3  | CONDUIT           | 2    | M1883     | 2    | M1883     | 2    | M2367     | 2    | M2367     |
| 4  | WIRE (In Feet)    | 6.75 | M2446     | 8.25 | M2446     | 8.25 | M2452     | 8.25 | M2452     |
| 5  | WIRE (In Feet)    | 2.5  | M3753     | 2.75 | M3753     | 2.75 | M3753     | 2.75 | M3753     |
| 6  | WIRE              | 3    | M3734     | 3    | M3734     | 3    | M3734     | 3    | M3734     |
| 9  | CONDUIT (In Feet) | 1.75 | M2461     | 2    | M2461     | 2    | M2461     | 2    | M2461     |
| 10 | CONDUIT           | 1    | M1757     | 1    | M1757     | 1    | M1757     | 1    | M1757     |
| 11 | CONDUIT           | 1    | M1606     | 1    | M1606     | 1    | M1606     | 1    | M1606     |
| 12 | WIRE (In Feet)    | 2    | M2438     | 4.2  | M2438     | 4.2  | M2438     | 4    | M2438     |
| 13 | CONDUIT (In Feet) | 1    | CC1019312 | 1.3  | CC1019312 | 1.3  | CC1019312 | 1    | CC1019312 |
| 14 | FITTING-CORD      | 1    | P13259A   | 1    | P13259A   | 1    | P13259A   | 1    | P13259A   |

Order by Part Number and Description. Reference Numbers are for your convenience only.

**SINGLE PHASE MOTOR-WIRE**  
**2 HP - 115, 208 & 230 VOLT**



B/M: 316HHS4007

| Ref. No. | Name of Part              | Qty. | Part No. |
|----------|---------------------------|------|----------|
| 15       | BLACK WIRE (In Feet)..... | 2    | M2446    |

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 hydrovane

For additional information, contact your local representative or visit:  
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Please recycle after use.



# Gardner Denver

## FIL SERIES COMPRESSED AIR FILTERS MODELS: FIL12 through FIL30

### General Safety Information

1. Pressurized devices

**▲WARNING**

- Do not exceed maximum operating pressure indicated on serial number tag.
- Make certain filter is fully depressurized before servicing.

2. Breathing Air

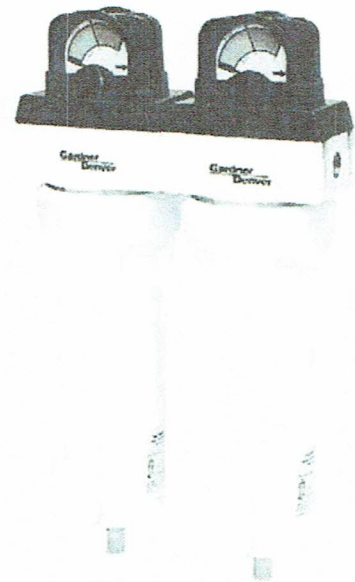
- Air treated by this equipment may not be suitable for breathing without further purification. Refer to OSHA standard 1910.134 for breathing air requirements.

3. Flammable devices

**▲WARNING**

While the materials of construction are compatible with many flammable gases, the following application limitations must be considered:

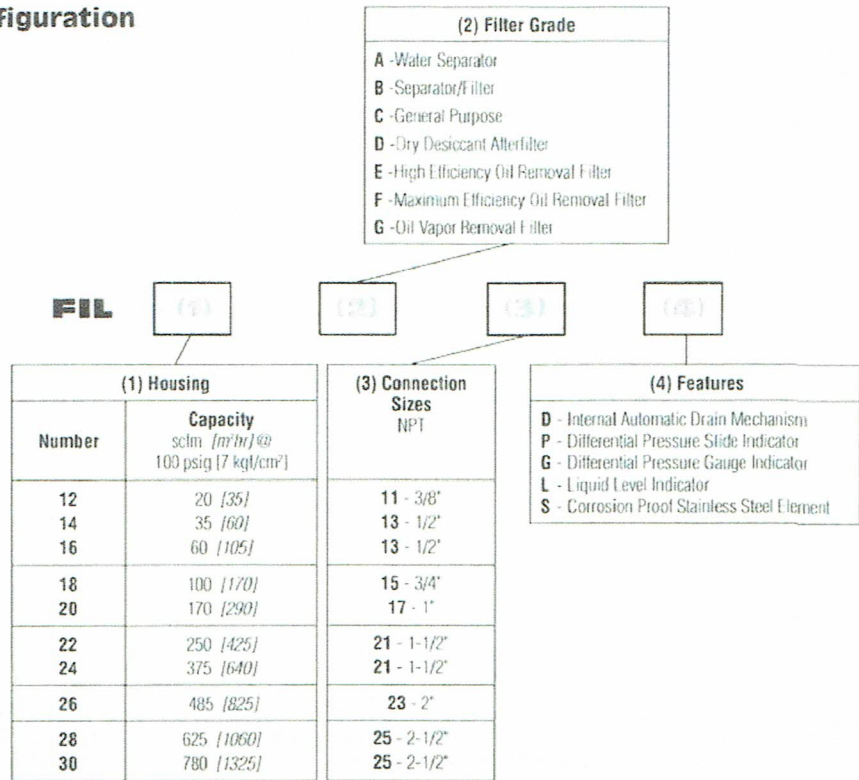
- Housing materials are slightly porous. The product must be used in a well ventilated area in the absence of sparks or ignition sources. Do not use in Class 1, Division 1, Group D environments.
- The type of area - forced exhaust system used (i.e., high or low level) would be dependent on the gas involved.
- Each application (other than for air or inert gas) must be reviewed to minimize fire or explosion hazard.



### CONTENTS

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## Model Number Configuration



1. **Housing Number** is indicated in space (1).
2. **Filter Grade** is indicated in space (2).
3. **Connection Size** is indicated in space (3).
4. **Features** are indicated in space (4).  
 D = Internal Automatic Drain Mechanism  
 P = Differential Pressure Slide Indicator  
 G = Differential Pressure Gauge Indicator  
 L = Liquid Level Indicator  
 S = Corrosion Proof Stainless Steel Element

*Example:* A Grade E high efficiency oil removal filter with a capacity of 100 scfm and 3/4" NPT F-connections would be configured as: **FIL18E15DG**

## Grade Identification

Filter grade can be identified by the third digit of the model number. In addition, elements with a foam outer sleeve can be identified by color

| Grade | Description                           | Type  | Outer foam color |
|-------|---------------------------------------|---|------------------|
| A     | Water Separator                       | Impaction type separator                    | none             |
| B     | Separator/filter                      | Mechanical separator and 3 micron coalescer | none             |
| C     | General purpose                       | 1 micron coalescer                          | none             |
| D     | Dry Desiccant Afterfilter             | 1 micron afterfilter for desiccant dryers   | none             |
| E     | High efficiency oil removal filter    | High efficiency (99.99+%) coalescer         | Red              |
| F     | Maximum efficiency oil removal filter | Maximum efficiency (99.999-%) coalescer     | Blue             |
| G     | Oil vapor removal filter              | Activated carbon adsorber                   | Green            |

## 1.0 Installation

### A. Where Used/Air Quality After Filtration

| Grade | Where used  | Solid particle removal (maximum size in microns) | Liquid removal efficiency (at rated conditions) | Maximum inlet liquid loading ppm w/w | Remaining oil content ppm w/w |
|-------|---|--|---|--------------------------------------|-------------------------------|
| A     | Separator - downstream of an aftercooler<br>Point-of-use - where no aftercooler is installed upstream   | —  | 95% of water                                    | 30,000<br>bulk liquids               | —                             |
| B     | Separator - downstream of an aftercooler<br>Point-of-use - where no aftercooler is installed upstream or as prefilter to refrigerated dryer   | 3  | 99+ % of water                                  | 25,000<br>aerosols & bulk liquids    | 5<br>aerosols                 |
| C     | Prefilter<br>• Prefilter to Grade F & Grade E high efficiency filters<br>• Point-of-use - where aftercooler is installed upstream   | 1  | 100% of water                                   | 2,000<br>aerosols                    | 1<br>aerosols                 |
| D     | Afterfilter - downstream of a pressure-swing (heatless) desiccant dryer<br>Downstream of an Activated Carbon or Desiccant Tower   | 1  | No liquid should be present at inlet            | No liquid should be present at inlet | —                             |
| E     | Prefilter - ahead of desiccant and membrane dryers<br>Afterfilter<br>• Downstream of refrigerated dryer<br>• Downstream of pressure-swing (heatless) desiccant dryers for finer solid particle removal<br>• Oil removal at point-of-use | 0.01   | 99.99+ % of oil                                 | 1,000<br>aerosols                    | 0.008<br>aerosols             |
| F     | Prefilter - ahead of desiccant and membrane dryers (use after Grade C to reduce liquid and solids load, prolong element life and ensure filtration efficiency)<br>Afterfilter - downstream of refrigerated dryer                        | 0.01   | 99.999+ % of oil                                | 100<br>aerosols                      | 0.0008<br>aerosols            |
| G     | Afterfilter to Grade E & Grade F for true oil free applications   | 0.01   | Removes vapors only                             | No liquid should be present          | 0.003<br>vapor                |

### B. Mounting

#### 1. Wall mounting brackets - Mount bracket to filter head:

- (1) remove four (4) screws holding black plastic top cap to filter head
- (2) place bracket on head over plastic cap
- (3) install screws supplied with bracket.

#### 2. Differential Pressure Gauge Mounting to Filter head

- (1) make certain o-rings are in place on the bottom of the gauge body.
- (2) connect the low pressure transmission bolt (bolt next to the RED band on gauge) to the gauge port at the filter outlet (downstream side of filter).
- (3) connect the high pressure transmission bolt (bolt next to GREEN band on gauge) to the gauge port at the filter inlet (upstream side of the filter).
- (4) use a coin or a flat head screwdriver to tighten/loosen bolts. The tip width of the screwdriver should be at least 3/8" inch (9.5 mm). Torque bolts to 25 +/- 5 inch oz. **DO NOT OVER TIGHTEN.**

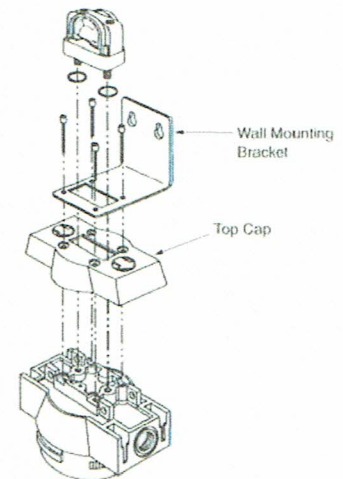


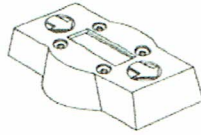
Figure 1.1



### C. Piping

1. Before installing, blow out pipe line to remove scale and other foreign matter.
2. This unit has DRYSEAL pipe threads; use pipe compound or tape sparingly to male threads only.
3. Mounting (Grades A, B, C, D, E, F) - mount so that inlet and outlet connections are horizontal (filter bowl vertical) to ensure proper liquid drainage.
4. Flow Direction - install so that the air flow is in the direction of arrows on the filter head.

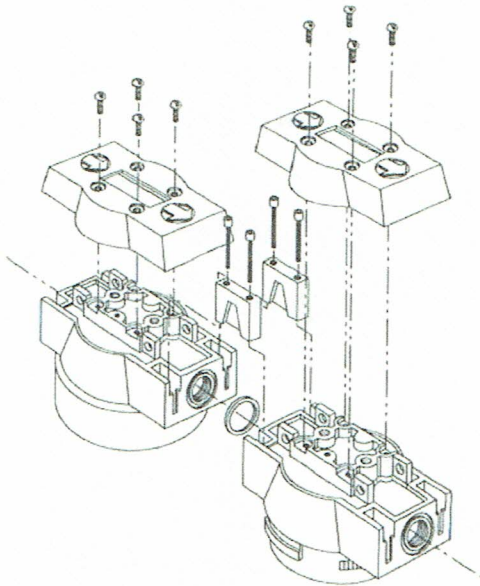
NOTE: Grade D flows from outside to inside of element. All other grades flow from inside to outside of element. Observe flow arrows on cap.



5. Direct filter-to-filter (modular) connection - Filter heads may be joined without using a pipe nipple

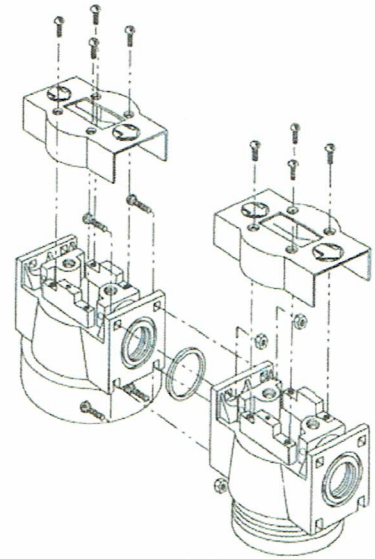
- a. Bayonet type heads - Use two (2) modular connectors, o-ring, and four (4) socket head cap screws (sold as kit).

Remove black plastic top cap, apply generous amount of lubricant to o-ring, install o-ring in groove, and insert connectors. Screw connectors to head using socket head cap screws.



### b. Threaded heads

Use four carriage bolts, nuts and o-ring (sold as kit). Remove black plastic top caps, apply generous amount of lubricant to o-ring, install o-ring in groove, and install bolts and nuts.



NOTE: Make certain flow direction through filters is correct (observe pin hole used for aligning top caps). Grades A, B, C, E, F, G - when hole is on side closest to you, inlet is to left. Grade D - when hole is on the side farther from you, inlet is to left.

NOTE: Lubricate o-ring with generous amount of lubricant before installation.

6. Isolation valves and by-pass piping - For ease of service, isolation and by-pass valves are desirable. In critical applications, two filters installed in parallel may be necessary to avoid interruption of air supply.

### D. Drain provisions

1. Internal Automatic Drains - Drain line  
The bottom of internal automatic drains are provided with 1/8" (inside threads) for connection of a drain line if desired.
2. External Auto Drains - External auto drains may be added as follows:

Models 12 through 20 - remove internal drain and install adapter (available from factory). Adapter outlet connection is 1/8" (inside threads).

**⚠ WARNING** Discharge is at system pressure; anchor drain line.

Models 22 through 30 - Remove adapter fitting from bottom of bowl; 1/2" (inside threads) port is available for external drain connection.

## 2.0 Operation

**⚠ WARNING** Do not operate filter at pressures in excess of Maximum Working Pressure indicated on Serial Number Tag.

NOTE: Maximum Operating Temperature - 150°F, 66°C. Liquid filtration above 120°F, 49°C is not recommended since there is typically oil present in a vapor state which passes through the filter and condenses downstream.

NOTE: Grade G - If operated above 100°F, 38°C may experience less than 1000 hours of life because of greater oil vapor content.

### A. Liquid Draining - Grades A, B, C, E, F

NOTE: Collected liquids must be removed to ensure proper operation.

NOTE: Depressurize slowly, to avoid filter element damage.

1. Manual Drain - Turn to your right (clockwise) to open and to your left (counterclockwise) to close.
2. Automatic Drain - Liquids will automatically discharge when sufficient accumulation occurs.
  - a. Internally Mounted Auto Drains - These drains may be manually drained by turning to your right (clockwise) to open and to your left (counterclockwise) to close.



NOTE: Manually drain internal auto drains daily to verify drain function.

### B. Operational Checkpoints

#### All Grades

Check flow, pressure, and temperature to make certain filter is being operated within design conditions.

#### Grades A, B, C, D, E, F

Check pressure drop across the filter

1. Pressure differential in excess of 6 psi (0.42 kgf/cm<sup>2</sup>) - pressure indicator in red area - indicates that the filter sleeve or element should be replaced.

NOTE: Element should be changed annually or when indicator changes to red, whichever occurs first.

NOTE: Pressure drop should never exceed 15 psi (1.0 kgf/cm<sup>2</sup>).

2. Check for sudden reduction in pressure drop. This might indicate:
  - a. Possible leak across element o-ring seal
  - b. Leak through the element due to physical damage

### Grades A, B, C, E, F

1. Check to see that filter is installed level to insure proper drainage.
2. Check that manual drains are drained periodically or that automatic drains are functioning.
3. On models with Liquid Level Sight glass - Check that liquid level is below top of Sight glass.

### Grade G

1. Check for an oily smell by opening the manual valve. If an oily smell exists, the following should be checked:
  - a. Filter element adsorption capacity exhausted.
  - b. Leak across element o-ring seal.
  - c. Leak through element due to physical damage.
  - d. Presence of liquids because of lack of or failure of prefilters.
  - e. Flow, pressure and temperatures outside design conditions.
  - f. Presence of gaseous impurities which cannot be adsorbed.

**⚠ CAUTION** Methane, carbon monoxide, carbon dioxide and various inorganic gases cannot be removed by an activated carbon filter.

### C. Flow Capacity

Maximum air flow for the various filters at 100 psig (7 kgf/cm<sup>2</sup>) is indicated in Table 1. To determine maximum air flows at inlet pressures other than 100 psig

(7 kgf/cm<sup>2</sup>), multiply flow from Table 1 by air flow correction factor from Table 2 that corresponds to the minimum operating pressure at the inlet of the filter.

NOTE: Filters should not be selected by pipe size. Select using flow rate and operating pressure only.

Table 1 - Maximum Flow @100 psig (7 kgf/cm<sup>2</sup>)

| Housing | scfm | [m <sup>3</sup> /hr] |
|---------|------|----------------------|
| 12      | 20   | [35]                 |
| 14      | 35   | [60]                 |
| 16      | 60   | [105]                |
| 18      | 100  | [170]                |
| 20      | 170  | [290]                |
| 22      | 250  | [425]                |
| 24      | 375  | [640]                |
| 26      | 485  | [825]                |
| 28      | 625  | [1060]               |
| 30      | 780  | [1325]               |

Table 2 - Air Flow Correction Factor

| Maximum Inlet Pressure | psig                | 20   | 30   | 40   | 60   | 80   | 100  | 120  | 150  | 200  | 250  | 300  |
|------------------------|---------------------|------|------|------|------|------|------|------|------|------|------|------|
|                        | kgf/cm <sup>2</sup> | 1.4  | 2.1  | 2.8  | 4.2  | 5.6  | 7.0  | 8.4  | 10.6 | 14.1 | 17.6 | 21.1 |
| Correction Factor      |                     | 0.30 | 0.39 | 0.48 | 0.65 | 0.82 | 1.00 | 1.17 | 1.43 | 1.87 | 2.31 | 2.74 |



### 3.0 Maintenance

#### A. When to Replace Filter Element

NOTE: Grades C, D, E, F, G, - complete element is replaced.

1. Grade D (dry desiccant afterfilter)  
Initial drop: 1 psi (0.07 kgf/cm<sup>2</sup>). Pressure drop increases as element loads with solid particles. Replace when pressure drop reaches 6 psi (0.42 kgf/cm<sup>2</sup>) (indicator in red area) or annually, whichever occurs first. Reference page 7, Figure 3.2 for gauge scale detail.
2. Grade A (mechanical separator)  
Element should not require replacement unless physically damaged. If sludge accumulates, element can be removed and cleaned with soap and water.
3. Grades B, C, E, F
  - a. Initial (dry) pressure drop: 1 psi (0.07 kgf/cm<sup>2</sup>) to 2 psi (0.14 kgf/cm<sup>2</sup>)
  - b. Operating pressure drop: As filter becomes liquid loaded (wetted), pressure drop will increase to 2 to 4 psi (0.14 to 0.28 kgf/cm<sup>2</sup>). Further pressure drop occurs as element loads with solid particles.
  - c. FOR MAXIMUM FILTRATION EFFICIENCY, REPLACE ELEMENT WHEN PRESSURE DROP REACHES 6 PSI (0.42 KGF/CM<sup>2</sup>) (INDICATOR IN RED AREA) OR ANNUALLY, WHICHEVER OCCURS FIRST. Reference page 7, Figure 3.2 for gauge scale detail.

NOTE: Pressure drop may temporarily increase when flow is resumed after flow stoppage. Pressure drop should return to normal within one hour.

NOTE: Grades E and F - During normal operation bottom of foam sleeve will have a band of oil. Spotting above the band indicates that liquids are accumulating faster than they can be drained and that prefiltration is required.

4. Grade G (activated carbon filters)
  - a. Adsorption capacity - 1000 hours at rated capacity. Element life is exhausted when odor can be detected downstream of the filter.

#### B. Procedure for Element Replacement

**▲WARNING** THIS FILTER IS A PRESSURE CONTAINING DEVICE. DEPRESSURIZE BEFORE SERVICING. If filter has not been depressurized before disassembly, an audible alarm will sound when the bowl begins to be removed from the head. If this occurs, stop disassembly, isolate and completely depressurize filter before proceeding.

1. Isolate filter (close inlet and outlet valves if installed) or shut off air supply.
2. Depressurize filter by slowly opening manual drain valve.
3. Remove bowl
  - a. For models 12 through 20 - bayonet mount - push bowl up, turn bowl 1/8th turn to your left, and pull bowl straight down
  - b. For models 22 through 30 - threaded bowls - unscrew bowl from head using hand, strap wrench or C spanner.

4. Clean filter bowl
5. Replace element
  - a. Replacing complete element
    - 1) Pull off old element and discard.
    - 2) Make certain o-ring inside top of replacement element is in place and push element onto filter head. For Housing sizes 40 to 48, place element in bowl and secure with centering device.

NOTE: Grades E, F, and G - Do not handle elements by outside foam cover. Handle by bottom end cap only.

6. After making certain that o-ring inside top of bowl (and on bayonet mount heads, wave spring) are in place, reassemble bowl to head.

NOTE: Make certain o-ring is generously lubricated.

NOTE: Wave spring ends should be pointed down to prevent the wave spring from interfering with reassembly.

NOTE: Threaded bowl to head connection, generously lubricate threads with a high grade/temperature lubricant good for 150°F, 66°C.

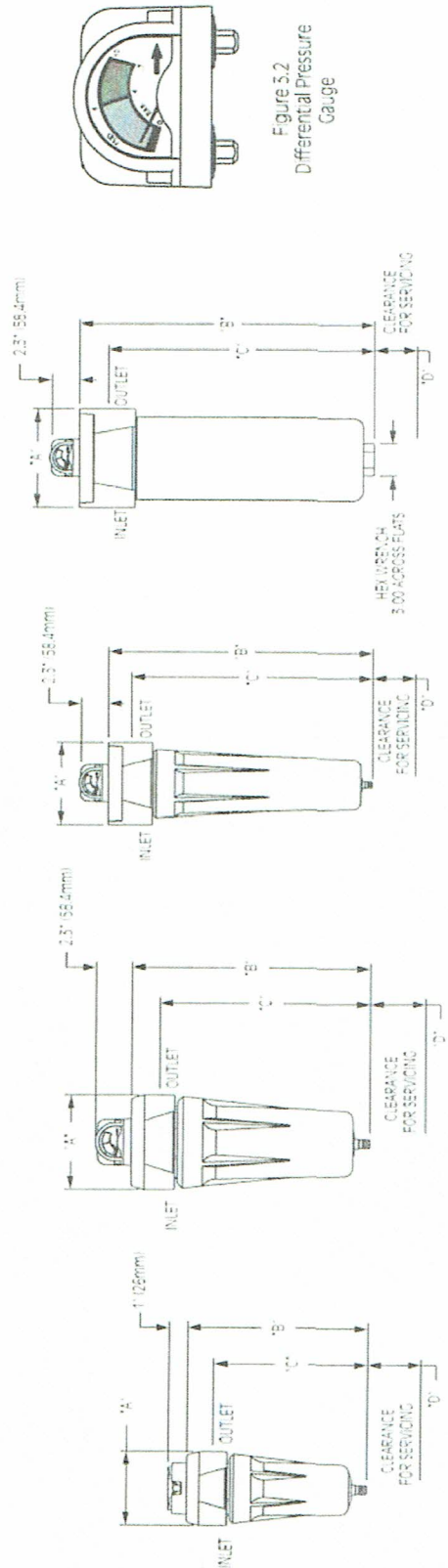
#### C. Auto Drain Mechanism

It is recommended that drain mechanism be replaced annually.

## Dimensions and Weights

| Filter Type   | 12   | 14          | 16          | 18          | 20          | 22          | 24          | 26          | 28          | 30           |
|---|--|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|
| Replacement Element   | 12 or 12S  | 14 or 14S   | 16 or 16S   | 18 or 18S   | 20 or 20S   | 22 or 22S   | 24 or 24S   | 26 or 26S   | 28 or 28S   | 30 or 30S    |
| Nominal Air Flow<br>scfm @100 psig (m <sup>3</sup> /hr @ 7.0 bar) | 20 (35)  | 35 (60)     | 50 (105)    | 100 (170)   | 170 (290)   | 250 (425)   | 375 (640)   | 485 (825)   | 625 (1060)  | 780 (1325)   |
| In/Out Connection   | NPT  | NPT         | NPT         | NPT         | NPT         | NPT         | NPT         | NPT         | NPT         | NPT          |
| "A" in. (mm)  | 3/8  | 1/2         | 1/2         | 3/4         | 1           | 1-1/2       | 1-1/2       | 2           | 2-1/2       | 2-1/2        |
| "B" in. (mm)  | 4.13 (105)   | 4.13 (105)  | 4.13 (105)  | 5.25 (133)  | 5.25 (133)  | 6.44 (164)  | 6.44 (164)  | 7.63 (194)  | 7.63 (194)  | 7.63 (194)   |
| "C" in. (mm)  | 7.86 (200)   | 10.05 (255) | 12.40 (316) | 13.32 (338) | 17.57 (446) | 20.80 (528) | 25.29 (642) | 29.08 (739) | 34.83 (885) | 40.96 (1040) |
| "D" in. (mm)  | 6.40 (163)   | 8.59 (224)  | 10.97 (285) | 11.74 (298) | 15.99 (406) | 18.98 (482) | 23.47 (596) | 26.83 (681) | 32.58 (827) | 38.71 (983)  |
| Weight: lb. (kg)  | 3.00 (76)  | 3.00 (76)   | 3.00 (76)   | 3.50 (89)   | 3.50 (89)   | 4.00 (102)  | 4.00 (102)  | 4.00 (102)  | 4.00 (102)  | 4.00 (102)   |
| Maximum Working Pressure  | Housing - 300 psig, 21.1 kg/cm <sup>2</sup><br>Models with Internal Drain or<br>Liquid level indicator - 250 psig, 17.6 kg/cm <sup>2</sup> |             |             |             |             |             |             |             |             |              |
| Maximum Operating Temperature                                     | 150°F, 66°C  |             |             |             |             |             |             |             |             |              |
| Head Material   | Zinc   |             |             |             |             | Aluminum    |             |             |             |              |
| Bowl Material   | Aluminum   |             |             |             |             | Aluminum    |             |             |             |              |
| Liquid Level Indicator Material                                   | Isoplast   |             |             |             |             | Isoplast    |             |             |             |              |

NOTE: Dimensions and Weights are for reference only. Request certified drawings for construction purposes.



FIL(Grade) 12, 14, 16

FIL(Grade) 18, 20

FIL(Grade) 22, 24

FIL(Grade) 26, 28, 30



## WARRANTY

The manufacturer warrants the product manufactured by it, when properly installed, operated, applied, and maintained in accordance with procedures and recommendations outlined in manufacturer's instruction manuals, to be free from defects in material and workmanship for a period of one (1) year from date shipment to the buyer by the manufacturer or manufacturer's authorized distributor provided such defect is discovered and brought to the manufacturer's attention within the aforesaid warranty period.

The manufacturer will repair or replace any product or part determined to be defective by the manufacturer within the warranty period, provided such defect occurred in normal service and not as a result of misuse, abuse, neglect or accident. Normal maintenance items requiring routine replacement are not warranted. The warranty covers parts and labor for the warranty period. Repair or replacement shall be made at the factory or the installation site, at the sole option of the manufacturer. Any service performed on the product by anyone other than the manufacturer must first be authorized by the manufacturer.

Unauthorized service voids the warranty and any resulting charge or subsequent claim will not be paid.

Products repaired or replaced under warranty shall be warranted for the unexpired portion of the warranty applying to the original product.

The foregoing is the exclusive remedy of any buyer of the manufacturer's product. The maximum damages liability of the manufacturer is the original purchase price of the product or part.

THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, WHETHER WRITTEN, ORAL, OR STATUTORY, AND IS EXPRESSED IN LIEU OF THE IMPLIED WARRANTY OF MERCHANTABILITY AND THE IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE. THE MANUFACTURER SHALL NOT BE LIABLE FOR LOSS OR DAMAGE BY REASON OF STRICT LIABILITY IN TORT OR ITS NEGLIGENCE IN WHATEVER MANNER INCLUDING DESIGN, MANUFACTURE OR INSPECTION OF THE EQUIPMENT OR ITS FAILURE TO DISCOVER, REPORT, REPAIR, OR MODIFY LATENT DEFECTS INHERENT THEREIN.

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The manufacturer does not warrant any product, part, material, component, or accessory manufactured by others and sold or supplied in connection with the sale of manufacturer's products.

**AUTHORIZATION FROM THE SERVICE DEPARTMENT IS NECESSARY BEFORE MATERIAL IS RETURNED TO THE FACTORY OR IN-WARRANTY REPAIRS ARE MADE.**

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# **Gardner Denver**

For additional information contact  
your local representative or

Gardner Denver Inc.  
1800 Gardner Expressway, Quincy, IL 62305  
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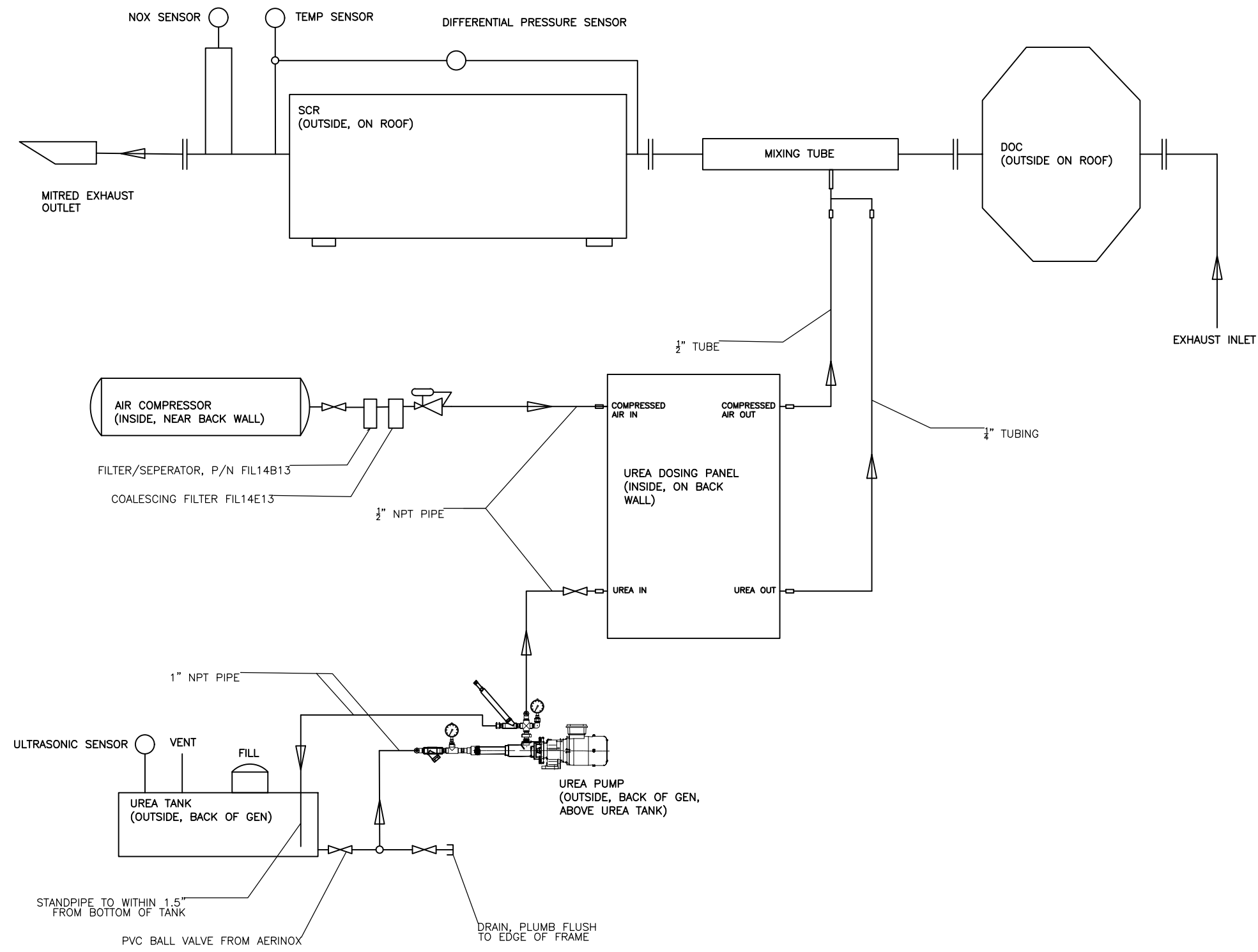
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






3150962 Rev.B 04/15  
18-5-605







**LEGEND**

-  BALL VALVE
-  PLUGGED END
-  CONNECTOR (MAY BE A GROUPING OF ADAPTERS) - SEE NOTE (2)
-  PRESSURE REDUCER
-  FLANGE
-  DIRECTION OF FLOW (DURING NORMAL OPERATION)
-  TEE

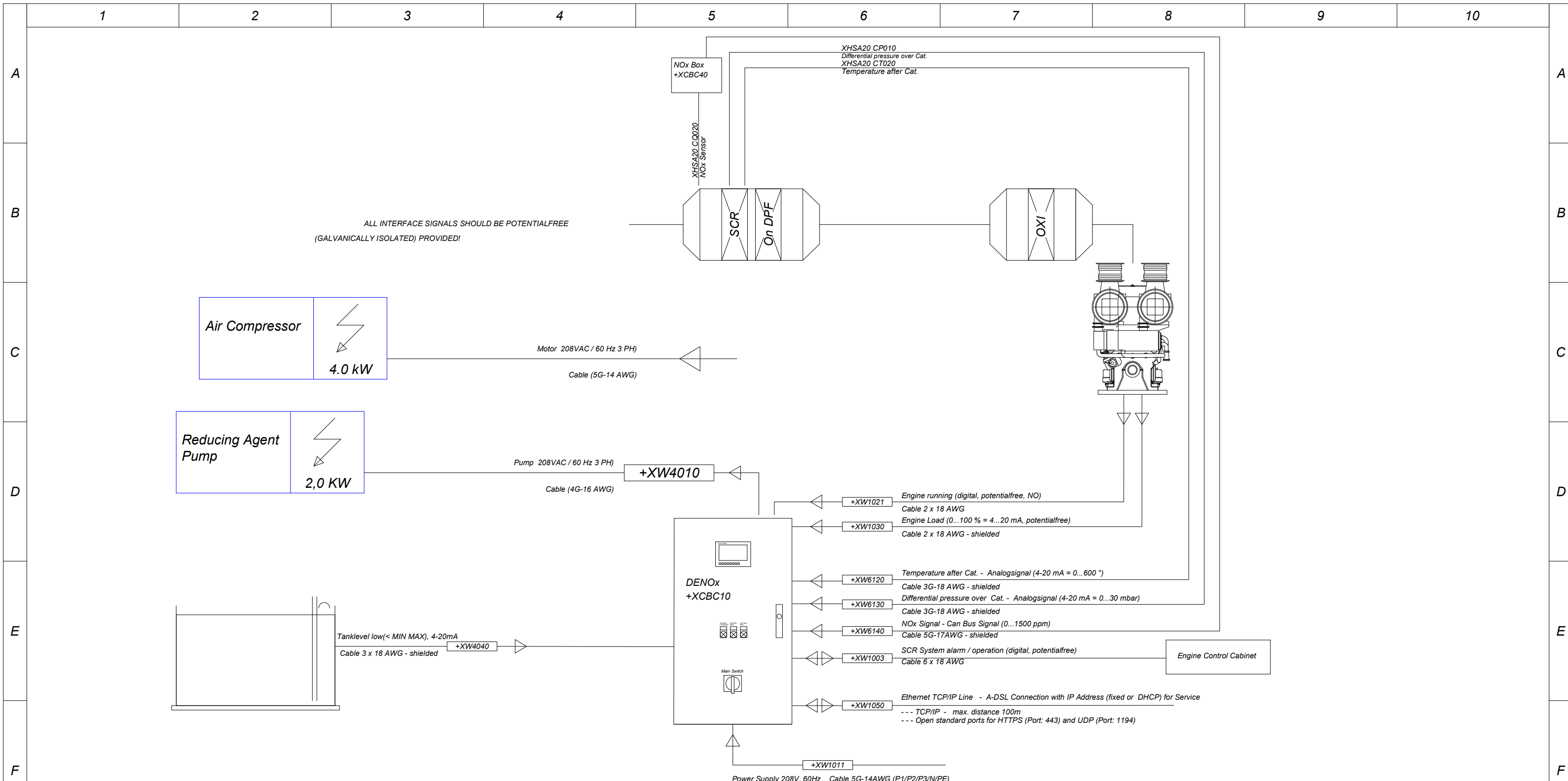
**NOTES**

- 1) GENERALLY ALL PIPING AND FITTINGS THAT CONTAIN UREA MUST BE STAINLESS STEEL, COMPRESSED AIR LINE FITTINGS MAY BE OF BRASS OR BLACK IRON IF STAINLESS NOT ON HAND.
- 2) THIS IS THE AS BUILT DRAWING - DEVIATIONS FROM SUPPLIER GENERIC DRAWING WERE MADE TO SUIT THE EMISSIONS CONTROL SYSTEM TO THIS GENERATOR PACKAGE. MAIN DEVIATIONS OCCUR IN PIPE SIZE.

REV 0 INITIAL RELEASE  
 REV 1 UPDATED PIPING AND NOTES



|   |                  |
|---|------------------|
| DWG # 10433-PID   | DATE 10 MAR 2017 |
| REV 1   | DATE 12 APR 2017 |
| CLIENT EGD  |                  |
| TITLE PROCESS AND INSTRUMENTATION DIAGRAM<br>ADAPTED FROM AERINOX'S PID |                  |
| DRN BY GW   | W/O # 67060      |



Notes:  
 1. Use shielded cables for all analog signals.  
 2. The "X" in the applicable tag numbers on this sheet will be replaced with the unit number (1 or 2) for construction. Example: XW4040 will be come 1W4040 for unit 1.

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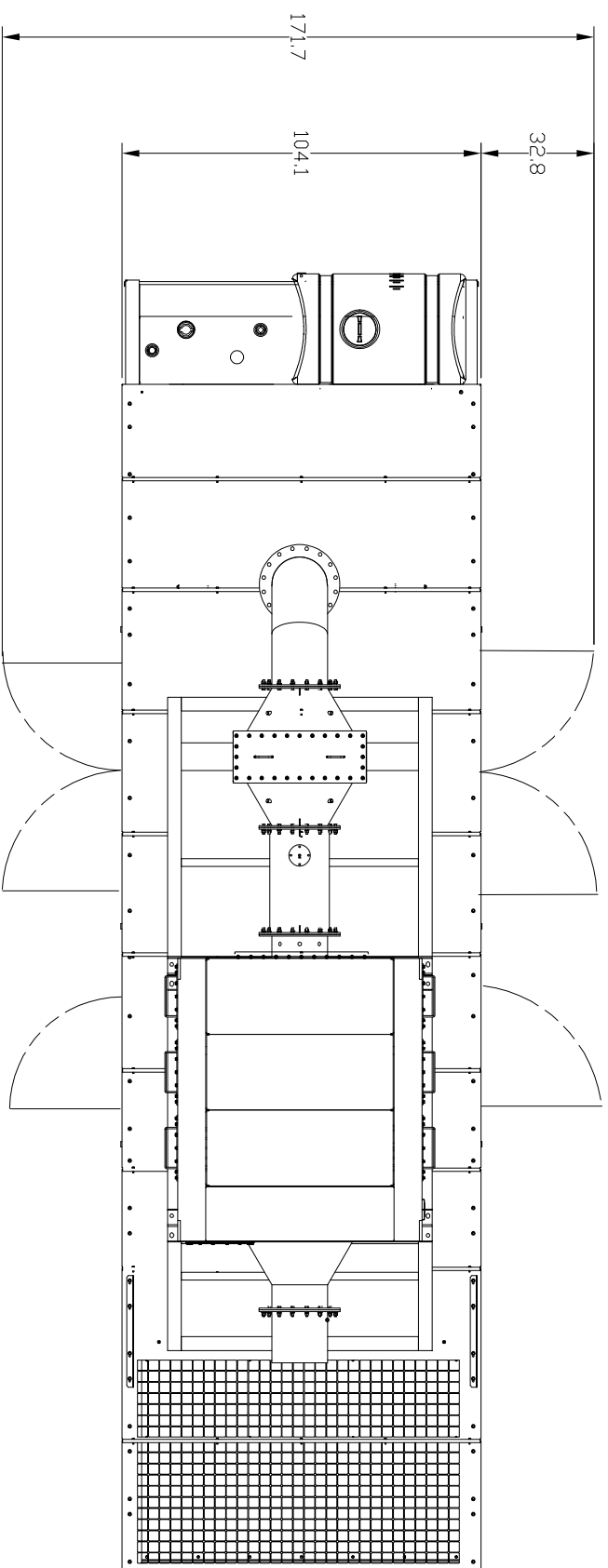
Unless Otherwise Specified:  
 -Dimensions are in inches.  
 -Dimensions shown are nominal.  
 For information on manufacturing tolerances contact AeriNOx Inc.



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 Office: (970) 454-5639  
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| ENGINEERING APPROVALS |          |             |           |               |
|-----------------------|----------|-------------|-----------|---------------|
| REV NUM.              | DRAWN BY | APPROVED BY | DATE      | IFC SIGNATURE |
| 1                     | ASC      |             | 1/13/2017 |               |
|                       |          |             |           |               |
|                       |          |             |           |               |
|                       |          |             |           |               |
|                       |          |             |           |               |

|          |   |           |                     |
|----------|---|-----------|---------------------|
| CUSTOMER | FRONTIER POWER PRODUCTS                     |           |                     |
| PROJECT  | KOHLER 750REOZMD - TIER 4 EMISSIONS PROJECT |           |                     |
| SCALE    | NTS   | DWG TITLE | CABLE BLOCK DIAGRAM |
| DATE     | 10/13/16                                    | DWG No.   | 16084-150           |
| DWN BY   | ASC   | SIZE      | D                   |
| REV      | 1   | SHT       | 1 of 1              |



TANK INFORMATION

| LITERS (GALLONS)<br>MIN HOURS | GENSETS                         | DIM A MM (INCH) | DIM B MM (INCH) | TANK WEIGHT KG (LBS)<br>(ND FUEL) |
|-------------------------------|---------------------------------|-----------------|-----------------|-----------------------------------|
| LIFT BASE ONLY                | 700-1000REDZDE / MD             | 254 [10.0]      | 8773 [345.4]    | 934 [2060]                        |
| 3682 [9731] 12 HOURS          | 700-1000REDZDE / MD             | 3048 [12.0]     | 7967 [313.6]    | 3512 [7743]                       |
| 6679 [1791] 24 HOURS          | 700-1000REDZDE / 750-800REDZMD  | 5080 [20.0]     | 7967 [313.6]    | 3938 [8681]                       |
| 8215 [2170] 24 HOURS          | 900-1000REDZMD                  | 609.6 [24.0]    | 7967 [313.6]    | 4139 [9125]                       |
| 8215 [2170] 36 HOURS          | 700-800REDZDE                   | 609.6 [24.0]    | 7967 [313.6]    | 4139 [9125]                       |
| 10824 [2859] 36 HOURS         | 900-1000REDZDE / 750-1000REDZMD | 914.4 [36.0]    | 7967 [313.6]    | 4500 [9920]                       |
| 10824 [2859] 48 HOURS         | 700-800REDZDE                   | 914.4 [36.0]    | 7967 [313.6]    | 4500 [9920]                       |
| 13970 [3690] 48 HOURS         | 900-1000REDZDE / 750-1000REDZMD | 914.4 [36.0]    | 7967 [313.6]    | 4832 [10653]                      |
| 16193 [4278] 72 HOURS         | 700-800REDZDE                   | 914.4 [36.0]    | 9567 [376.6]    | 5498 [12120]                      |
| 20914 [5525] 72 HOURS         | 900-1000REDZDE / 750-1000REDZMD | 914.6 [36.0]    | 11430 [450.0]   | 6322 [13938]                      |

NOTE: DIMENSIONS IN INCHES, DIMENSIONS AND FEATURES ARE SUBJECT TO CHANGE WITHOUT NOTICE

TANK/LIFT BASE WEIGHT  
+ENCLOSURE WEIGHT  
=TOTAL WEIGHT

700-1000 KW SOUND ENCLOSURE  
WITH SUB BASE TANK  
OR LIFTING BASE OPTION

| REV | DATE     | DESCRIPTION   | BY  |
|-----|----------|---|-----|
| E   | 03-19-14 | DN COMPASSITE DWGS, SET PART NUMBER REVISION LEVEL                | SSH |
| F   | 5-24-14  | SEE SHEET 4 TC1750981   | JMR |
| G   | 10-09-14 | SEE SHEET 6 FOR CHANGE TC185282J                                  | JMR |
| H   | 12-11-14 | SEE SHEET 6 FOR CHANGE TC192730J                                  | PRM |
| J   | 4-21-15  | SEE SHEET 3 TC1100596J  | PRM |
| K   | 7-22-15  | (C, D-5) DOOR LOCATION CORRECTED, SEE SHEETS 1 & 3 TC111126J      | SAM |
| L   | 10-27-15 | SEE SHEETS 1 AND 3 DF-5, (D-6) VIEW OF EVENTS UPDATED. TC1128608J | JFR |

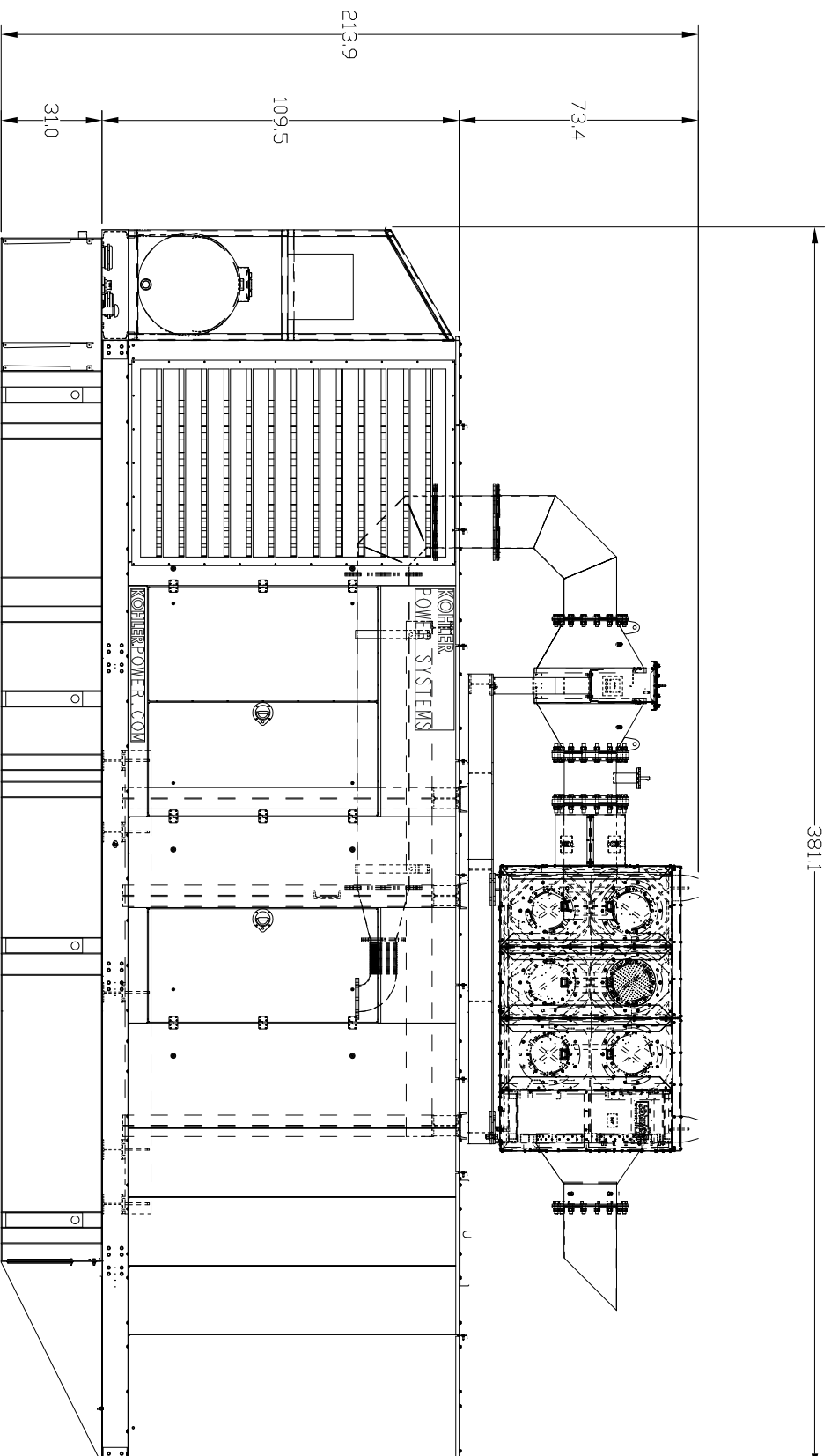
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TITLE  
DIMENSION PRINT

SCALE 0.04 (2x) 1/8" = 1"

ADV-8249 SHEET 2 OF 6



TANK INFORMATION

| LITERS [GALLONS]<br>MIN HOURS | GENSETS                         | DIM A MM [INCH] | DIM B MM [INCH] | TANK WEIGHT KG [LBS]<br>(ND FUEL) |
|-------------------------------|---------------------------------|-----------------|-----------------|-----------------------------------|
| LIFT BASE ONLY                | 700-1000REDZDE / MD             | 254 [10.0]      | 8773 [345.4]    | 934 [206.0]                       |
| 3682 [973] 12 HOURS           | 700-1000REDZDE / MD             | 3048 [12.0]     | 7967 [313.6]    | 3512 [774.3]                      |
| 6679 [1791] 24 HOURS          | 700-1000REDZDE / 750-800REDZMD  | 5080 [20.0]     | 7967 [313.6]    | 3938 [868.1]                      |
| 8215 [2170] 24 HOURS          | 900-1000REDZMD                  | 609.6 [24.0]    | 7967 [313.6]    | 4139 [912.5]                      |
| 8215 [2170] 36 HOURS          | 700-800REDZDE                   | 609.6 [24.0]    | 7967 [313.6]    | 4139 [912.5]                      |
| 10824 [2859] 36 HOURS         | 900-1000REDZDE / 750-1000REDZMD | 914.4 [36.0]    | 7967 [313.6]    | 4500 [992.0]                      |
| 10824 [2859] 48 HOURS         | 700-800REDZDE                   | 914.4 [36.0]    | 7967 [313.6]    | 4500 [992.0]                      |
| 13970 [3690] 48 HOURS         | 900-1000REDZDE / 750-1000REDZMD | 914.4 [36.0]    | 7967 [313.6]    | 4832 [1065.3]                     |
| 16193 [4278] 72 HOURS         | 700-800REDZDE                   | 914.4 [36.0]    | 9567 [376.6]    | 5498 [1212.0]                     |
| 20914 [5525] 72 HOURS         | 900-1000REDZDE / 750-1000REDZMD | 914.6 [36.0]    | 11430 [450.0]   | 6322 [1393.8]                     |

NOTE: DIMENSIONS IN INCHES, DIMENSIONS AND FEATURES ARE SUBJECT TO CHANGE WITHOUT NOTICE

TANK/LIFT BASE WEIGHT  
+ENCLOSURE WEIGHT  
=TOTAL WEIGHT

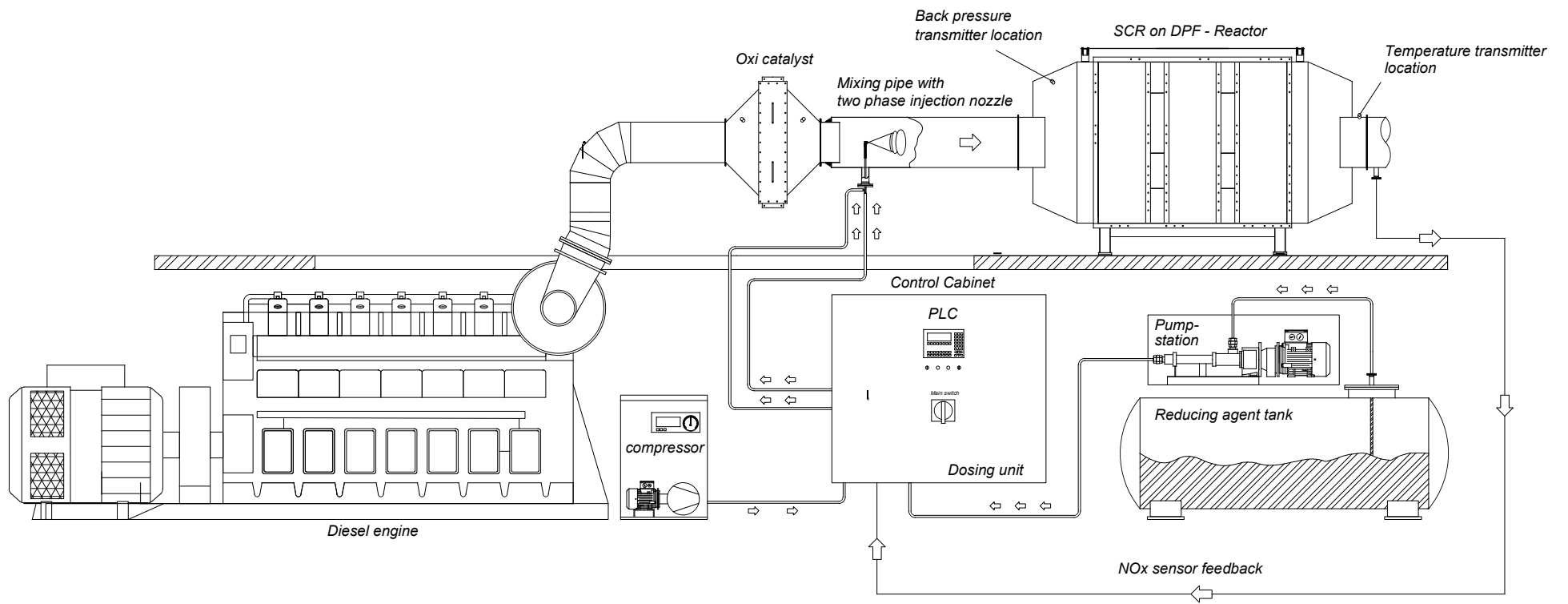
700-1000 KW SOUND ENCLOSURE  
WITH SUB BASE TANK  
OR LIFTING BASE OPTION

| REV | DATE     | DN   | COMPOSITE DWGS. SEE PART NO. FOR REVISION LEVEL | BY  | UNLESS OTHERWISE SPECIFIED<br>DIMENSIONS ARE IN MILLIMETERS |
|-----|----------|--|---|-----|---|
| E   | 03-19-14 | SEE SHEET 4  | ICT1750981                                      | SSH |   |
| F   | 6-24-14  | SEE SHEET 6 FOR CHANGE                                 | ICT1852823                                      | JMR | XXX ± 0.25  |
| G   | 10-09-14 | SEE SHEET 6 FOR CHANGE                                 | ICT1927303                                      | JMR | ANGLES ± 0° 30'   |
| H   | 12-11-14 | SEE SHEET 3  | ICT11005961                                     | PRM |   |
| J   | 4-21-15  | (C, D-S) DOOR LOCATION CORRECTED, SEE SHEETS 1 & 3     | ICT11112261                                     |     |   |
| K   | 7-22-15  | SEE SHEET 4  | ICT11190881                                     | SAM | THIRD ANGLE   |
| L   | 10-27-15 | SEE SHEETS 1 AND 3 FOR 6- (D-6) VIEW OF EVENTS UPDATED | ICT1286081                                      | GFR | APPROVALS   |

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SCALE 0:04 (0:04)  
DWG NO. ADV-8249  
SHEET 2 OF 6



Instruction Manual  
for AC Generators  
English

QAS 70-90-120 JD T4A HOP



# **QAS 70-90-120 JD T4A HOP**

## **Instruction Manual for AC Generators**

|                          |    |
|--------------------------|----|
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| Circuit diagrams .....   | 47 |

### **Original instructions**

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Use only authorized parts.

Any damage or malfunction caused by the use of unauthorized parts is not covered by Warranty or Product Liability.

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Neglecting maintenance or making changes to the setup of the machine can result in major hazards, including fire risk.

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Congratulations on the purchase of your AC generator. It is a solid, safe and reliable machine, built according to the latest technology. Follow the instructions in this booklet and we guarantee you years of troublefree operation. Please read the following instructions carefully before starting to use your machine.

While every effort has been made to ensure that the information in this manual is correct, Atlas Copco does not assume responsibility for possible errors. Atlas Copco reserves the right to make changes without prior notice.

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# ***Safety precautions for portable generators***

To be read attentively and acted accordingly before towing, lifting, operating, performing maintenance or repairing the generator.

## ***Introduction***

The policy of Atlas Copco is to provide the users of their equipment with safe, reliable and efficient products. Factors taken into account are among others:

- the intended and predictable future use of the products, and the environments in which they are expected to operate,
- applicable rules, codes and regulations,
- the expected useful product life, assuming proper service and maintenance,
- providing the manual with up-to-date information.

Before handling any product, take time to read the relevant instruction manual. Besides giving detailed operating instructions, it also gives specific information about safety, preventive maintenance, etc.

Keep the manual always at the unit location, easy accessible to the operating personnel.

See also the safety precautions of the engine and possible other equipment, which are separately sent along or are mentioned on the equipment or parts of the unit.

These safety precautions are general and some statements will therefore not always apply to a particular unit.

Only people that have the right skills should be allowed to operate, adjust, perform maintenance or repair on Atlas Copco equipment. It is the responsibility of management to appoint operators with the appropriate training and skill for each category of job.

### **Skill level 1: Operator**

An operator is trained in all aspects of operating the unit with the push-buttons, and is trained to know the safety aspects.

### **Skill level 2: Mechanical technician**

A mechanical technician is trained to operate the unit the same as the operator. In addition, the mechanical technician is also trained to perform maintenance and repair, as described in the instruction manual, and is allowed to change settings of the control and safety system. A mechanical technician does not work on live

electrical components.

### **Skill level 3: Electrical technician**

An electrical technician is trained and has the same qualifications as both the operator and the mechanical technician. In addition, the electrical technician may carry out electrical repairs within the various enclosures of the unit. This includes work on live electrical components.

### **Skill level 4: Specialist from the manufacturer**

This is a skilled specialist sent by the manufacturer or its agent to perform complex repairs or modifications to the equipment.

In general it is recommended that not more than two people operate the unit, more operators could lead to unsafe operating conditions. Take necessary steps to keep unauthorized persons away from the unit and eliminate all possible sources of danger at the unit.

When handling, operating, overhauling and/or performing maintenance or repair on Atlas Copco equipment, the mechanics are expected to use safe engineering practices and to observe all relevant local safety requirements and ordinances. The following list is a reminder of special safety directives and precautions mainly applicable to Atlas Copco equipment.

Neglecting the safety precautions may endanger people as well as environment and machinery:

- endanger people due to electrical, mechanical or chemical influences,
- endanger the environment due to leakage of oil, solvents or other substances,
- endanger the machinery due to function failures.

All responsibility for any damage or injury resulting from neglecting these precautions or by non-observance of ordinary caution and due care required in handling, operating, maintenance or repair, also if not expressly mentioned in this instruction manual, is disclaimed by Atlas Copco.

The manufacturer does not accept any liability for any

damage arising from the use of non-original parts and for modifications, additions or conversions made without the manufacturer's approval in writing.

If any statement in this manual does not comply with local legislation, the stricter of the two shall be applied.

Statements in these safety precautions should not be interpreted as suggestions, recommendations or inducements that it should be used in violation of any applicable laws or regulations.

## ***General safety precautions***

- 1 The owner is responsible for maintaining the unit in a safe operating condition. Unit parts and accessories must be replaced if missing or unsuitable for safe operation.
- 2 The supervisor, or the responsible person, shall at all times make sure that all instructions regarding machinery and equipment operation and maintenance are strictly followed and that the machines with all accessories and safety devices, as well as the consuming devices, are in good repair, free of abnormal wear or abuse, and are not tampered with.
- 3 Whenever there is an indication or any suspicion that an internal part of a machine is overheated, the machine shall be stopped but no inspection covers shall be opened before sufficient cooling time has elapsed; this to avoid the risk of spontaneous ignition of oil vapour when air is admitted.
- 4 Normal ratings (pressures, temperatures, speeds, etc.) shall be durably marked.
- 5 Operate the unit only for the intended purpose and within its rated limits (pressure, temperature, speeds, etc.).
- 6 The machinery and equipment shall be kept clean, i.e. as free as possible from oil, dust or other deposits.
- 7 To prevent an increase in working temperature, inspect and clean heat transfer surfaces (cooler fins, intercoolers, coolant jackets, etc.) regularly. See the maintenance schedule.

- 8 All regulating and safety devices shall be maintained with due care to ensure that they function properly. They may not be put out of action.
- 9 Pressure and temperature gauges shall be checked regularly with regard to their accuracy. They shall be replaced whenever outside acceptable tolerances.
- 10 Safety devices shall be tested as described in the maintenance schedule of the instruction manual to determine that they are in good operating condition.
- 11 Mind the markings and information labels on the unit.
- 12 In the event the safety labels are damaged or destroyed, they must be replaced to ensure operator safety.
- 13 Keep the work area neat. Lack of order will increase the risk of accidents.
- 14 When working on the unit, wear safety clothing. Depending on the kind of activities these are: safety glasses, ear protection, safety helmet (including visor), safety gloves, protective clothing, safety shoes. Do not wear the hair long and loose (protect long hair with a hairnet), or wear loose clothing or jewellery.
- 15 Take precautions against fire. Handle fuel, oil and anti-freeze with care because they are inflammable substances. Do not smoke or approach with naked flame when handling such substances. Keep a fire-extinguisher in the vicinity.

**16a Portable generators (with earthing pin):**

Earth the generator as well as the load properly.

**16b Portable generators IT:**

**Note:** This generator is built to supply a sheer alternating current IT network.  
Earth the load properly.

**Safety during transport and installation**

To lift a unit, all loose or pivoting parts, e.g. doors and towbar, shall first be securely fastened.

Do not attach cables, chains or ropes directly to the lifting eye; apply a crane hook or lifting shackle meeting local safety regulations. Never allow sharp bends in lifting cables, chains or ropes.

Helicopter lifting is not allowed.

It is strictly forbidden to dwell or stay in the risk zone under a lifted load. Never lift the unit over people or residential areas. Lifting acceleration and retardation shall be kept within safe limits.

**1 Before towing the unit:**

- check the towbar, the brake system and the towing eye. Also check the coupling of the towing vehicle,
- check the towing and brake capability of the towing vehicle,
- check that the towbar, jockey wheel or stand leg is safely locked in the raised position,
- ascertain that the towing eye can swivel freely on the hook,
- check that the wheels are secure and that the tyres are in good condition and inflated correctly,
- connect the signalisation cable, check all lights and connect the pneumatic brake couplers,
- attach the safety break-away cable or safety chain to the towing vehicle,
- remove wheel chocks, if applied, and disengage the parking brake.

**2 To tow a unit use a towing vehicle of ample capacity. Refer to the documentation of the towing vehicle.**

**3 If the unit is to be backed up by the towing vehicle, disengage the overrun brake mechanism (if it is not an automatic mechanism).**

**4 Never exceed the maximum towing speed of the unit (mind the local regulations).**

**5 Place the unit on level ground and apply the parking brake before disconnecting the unit from the towing vehicle. Unclip the safety break-away cable or safety chain. If the unit has no parking brake or jockey wheel, immobilize the unit by placing chocks in front of and/or behind the wheels. When the towbar can be positioned vertically, the locking device must be applied and kept in good order.**

- 6 To lift heavy parts, a hoist of ample capacity, tested and approved according to local safety regulations, shall be used.
- 7 Lifting hooks, eyes, shackles, etc., shall never be bent and shall only have stress in line with their design load axis. The capacity of a lifting device diminishes when the lifting force is applied at an angle to its load axis.
- 8 For maximum safety and efficiency of the lifting apparatus all lifting members shall be applied as near to perpendicular as possible. If required, a lifting beam shall be applied between hoist and load.
- 9 Never leave a load hanging on a hoist.
- 10 A hoist has to be installed in such a way that the object will be lifted perpendicular. If that is not possible, the necessary precautions must be taken to prevent load-swinging, e.g. by using two hoists, each at approximately the same angle not exceeding 30° from the vertical.
- 11 Locate the unit away from walls. Take all precautions to ensure that hot air exhausted from the engine and driven machine cooling systems cannot be recirculated. If such hot air is taken in by the engine or driven machine cooling fan, this may cause overheating of the unit; if taken in for combustion, the engine power will be reduced.
- 12 Generators shall be stalled on an even, solid floor, in a clean location with sufficient ventilation. If the floor is not level or can vary in inclination, consult Atlas Copco.
- 13 The electrical connections shall correspond to local codes. The machines shall be earthed and protected against short circuits by fuses or circuit breakers.
- 14 Never connect the generator outlets to an installation which is also connected to a public mains.
- 15 Before connecting a load, switch off the corresponding circuit breaker, and check whether frequency, voltage, current and power factor comply with the ratings of the generator.

## **Safety during use and operation**

- 1 When the unit has to operate in a fire-hazardous environment, each engine exhaust has to be provided with a spark arrestor to trap incendiary sparks.
- 2 The exhaust contains carbon monoxide which is a lethal gas. When the unit is used in a confined space, conduct the engine exhaust to the outside atmosphere by a pipe of sufficient diameter; do this in such a way that no extra back pressure is created for the engine. If necessary, install an extractor. Observe any existing local regulations.

Make sure that the unit has sufficient air intake for operation. If necessary, install extra air intake ducts.
- 3 When operating in a dust-laden atmosphere, place the unit so that dust is not carried towards it by the wind. Operation in clean surroundings considerably extends the intervals for cleaning the air intake filters and the cores of the coolers.
- 4 Never remove a filler cap of the coolant system of a hot engine. Wait until the engine has sufficiently cooled down.
- 5 Never refill fuel while the unit is running, unless otherwise stated in the Atlas Copco Instruction Book (AIB). Keep fuel away from hot parts such as air outlet pipes or the engine exhaust. Do not smoke when fuelling. When fuelling from an automatic pump, an earthing cable should be connected to the unit to discharge static electricity. Never spill nor leave oil, fuel, coolant or cleansing agent in or around the unit.
- 6 All doors shall be shut during operation so as not to disturb the cooling air flow inside the bodywork and/or render the silencing less effective. A door should be kept open for a short period only e.g. for inspection or adjustment.
- 7 Periodically carry out maintenance works according to the maintenance schedule.
- 8 Stationary housing guards are provided on all rotating or reciprocating parts not otherwise protected and which may be hazardous to personnel. Machinery shall never be put into operation, when such guards have been removed, before the guards are securely reinstalled.
- 9 Noise, even at reasonable levels, can cause irritation and disturbance which, over a long period of time, may cause severe injuries to the nervous system of human beings.

When the sound pressure level, at any point where personnel normally has to attend, is:

  - below 70 dB(A): no action needs to be taken,
  - above 70 dB(A): noise-protective devices should be provided for people continuously being present in the room,
  - below 85 dB(A): no action needs to be taken for occasional visitors staying a limited time only,
  - above 85 dB(A): room to be classified as a noise-hazardous area and an obvious warning shall be placed permanently at each entrance to alert people entering the room, for even relatively short times, about the need to wear ear protectors,
  - above 95 dB(A): the warning(s) at the entrance(s) shall be completed with the recommendation that also occasional visitors shall wear ear protectors,
  - above 105 dB(A): special ear protectors that are adequate for this noise level and the spectral composition of the noise shall be provided and a special warning to that effect shall be placed at each entrance.
- 10 Insulation or safety guards of parts the temperature of which can be in excess of 80°C (175°F) and which may be accidentally touched by personnel shall not be removed before the parts have cooled to room temperature.
- 11 Never operate the unit in surroundings where there is a possibility of taking in flammable or toxic fumes.
- 12 If the working process produces fumes, dust or vibration hazards, etc., take the necessary steps to eliminate the risk of personnel injury.
- 13 When using compressed air or inert gas to clean down equipment, do so with caution and use the appropriate protection, at least safety glasses, for the operator as well as for any bystander. Do not apply compressed air or inert gas to your skin or direct an air or gas stream at people. Never use it to clean dirt from your clothes.
- 14 When washing parts in or with a cleaning solvent, provide the required ventilation and use appropriate protection such as a breathing filter, safety glasses, rubber apron and gloves, etc.
- 15 Safety shoes should be compulsory in any workshop and if there is a risk, however small, of falling objects, wearing of a safety helmet should be included.
- 16 If there is a risk of inhaling hazardous gases, fumes or dust, the respiratory organs must be protected and depending on the nature of the hazard, so must the eyes and skin.
- 17 Remember that where there is visible dust, the finer, invisible particles will almost certainly be present too; but the fact that no dust can be seen is not a reliable indication that dangerous, invisible dust is not present in the air.
- 18 Never operate the generator in excess of its limits as indicated in the technical specifications and avoid long no-load sequences.
- 19 Never operate the generator in a humid atmosphere. Excessive moisture causes worsening of the generator insulation.
- 20 Do not open electrical cabinets, cubicles or other equipment while voltage is supplied. If such cannot be avoided, e.g. for measurements, tests or adjustments, have the action carried out by a qualified electrician only, with appropriate tools, and ascertain that the required bodily protection against electrical hazards is applied.
- 21 Never touch the power terminals during operation of the machine.
- 22 Whenever an abnormal condition arises, e.g. excessive vibration, noise, odour, etc., switch the circuit breakers to OFF and stop the engine. Correct the faulty condition before restarting.
- 23 Check the electric cables regularly. Damaged cables and insufficient tightening of connections may cause electric shocks. Whenever damaged wires or dangerous conditions are observed, switch the circuit breakers to OFF and stop the engine. Replace the damaged wires or correct the dangerous condition

before restarting. Make sure that all electric connections are securely tightened.

- 24 Avoid overloading the generator. The generator is provided with circuit breakers for overload protection. When a breaker has tripped, reduce the concerned load before restarting.
- 25 If the generator is used as stand-by for the mains supply, it must not be operated without control system which automatically disconnects the generator from the mains when the mains supply is restored.
- 26 Never remove the cover of the output terminals during operation. Before connecting or disconnecting wires, switch off the load and the circuit breakers, stop the machine and make sure that the machine cannot be started inadvertently or there is any residual voltage on the power circuit.
- 27 Running the generator at low load for long periods will reduce the lifetime of the engine.

### ***Safety during maintenance and repair***

Maintenance, overhaul and repair work shall only be carried out by adequately trained personnel; if required, under supervision of someone qualified for the job.

- 1 Use only the correct tools for maintenance and repair work, and only tools which are in good condition.
- 2 Parts shall only be replaced by genuine Atlas Copco replacement parts.
- 3 All maintenance work, other than routine attention, shall only be undertaken when the unit is stopped. Steps shall be taken to prevent inadvertent starting. In addition, a warning sign bearing a legend such as “work in progress; do not start” shall be attached to the starting equipment.  
On engine-driven units the battery shall be disconnected and removed or the terminals covered by insulating caps.  
On electrically driven units the main switch shall be locked in open position and the fuses shall be taken out. A warning sign bearing a legend such as “work in progress; do not supply voltage” shall be attached to the fuse box or main switch.
- 4 Prior to stripping an engine or other machine or undertaking major overhaul on it, prevent all movable parts from rolling over or moving.
- 5 Make sure that no tools, loose parts or rags are left in or on the machine. Never leave rags or loose clothing near the engine air intake.
- 6 Never use flammable solvents for cleaning (fire-risk).
- 7 Take safety precautions against toxic vapours of cleaning liquids.
- 8 Never use machine parts as a climbing aid.
- 9 Observe scrupulous cleanliness during maintenance and repair. Keep away dirt, cover the parts and exposed openings with a clean cloth, paper or tape.
- 10 Never weld on or perform any operation involving heat near the fuel or oil systems. Fuel and oil tanks must be completely purged, e.g. by steam-cleaning, before carrying out such operations. Never weld on, or in any way modify, pressure vessels. Disconnect the alternator cables during arc welding on the unit.

- 11 Support the towbar and the axle(s) securely if working underneath the unit or when removing a wheel. Do not rely on jacks.
- 12 Do not remove any of, or tamper with, the sound-damping material. Keep the material free of dirt and liquids such as fuel, oil and cleansing agents. If any sound-damping material is damaged, replace it to prevent the sound pressure level from increasing.
- 13 Use only lubricating oils and greases recommended or approved by Atlas Copco or the machine manufacturer. Ascertain that the selected lubricants comply with all applicable safety regulations, especially with regard to explosion or fire-risk and the possibility of decomposition or generation of hazardous gases. Never mix synthetic with mineral oil.
- 14 Protect the engine, alternator, air intake filter, electrical and regulating components, etc., to prevent moisture ingress, e.g. when steam-cleaning.
- 15 When performing any operation involving heat, flames or sparks on a machine, the surrounding components shall first be screened with non-flammable material.
- 16 Never use a light source with open flame for inspecting the interior of a machine.
- 17 When repair has been completed, the machine shall be barred over at least one revolution for reciprocating machines, several revolutions for rotary ones to ensure that there is no mechanical interference within the machine or driver. Check the direction of rotation of electric motors when starting up the machine initially and after any alteration to the electrical connection(s) or switch gear, to check that the oil pump and the fan function properly.
- 18 Maintenance and repair work should be recorded in an operator’s logbook for all machinery. Frequency and nature of repairs can reveal unsafe conditions.
- 19 When hot parts have to be handled, e.g. shrink fitting, special heat-resistant gloves shall be used and, if required, other body protection shall be applied.
- 20 When using cartridge type breathing filter equipment, ascertain that the correct type of cartridge is used and that its useful service life is not surpassed.

- 21 Make sure that oil, solvents and other substances likely to pollute the environment are properly disposed of.
- 22 Before clearing the generator for use after maintenance or overhaul, submit it to a testrun, check that the AC power performance is correct and that the control and shutdown devices function correctly.

### ***Tool applications safety***

Apply the proper tool for each job. With the knowledge of correct tool use and knowing the limitations of tools, along with some common sense, many accidents can be prevented.

Special service tools are available for specific jobs and should be used when recommended. The use of these tools will save time and prevent damage to parts.

### ***Battery safety precautions***

#### **Batteries**

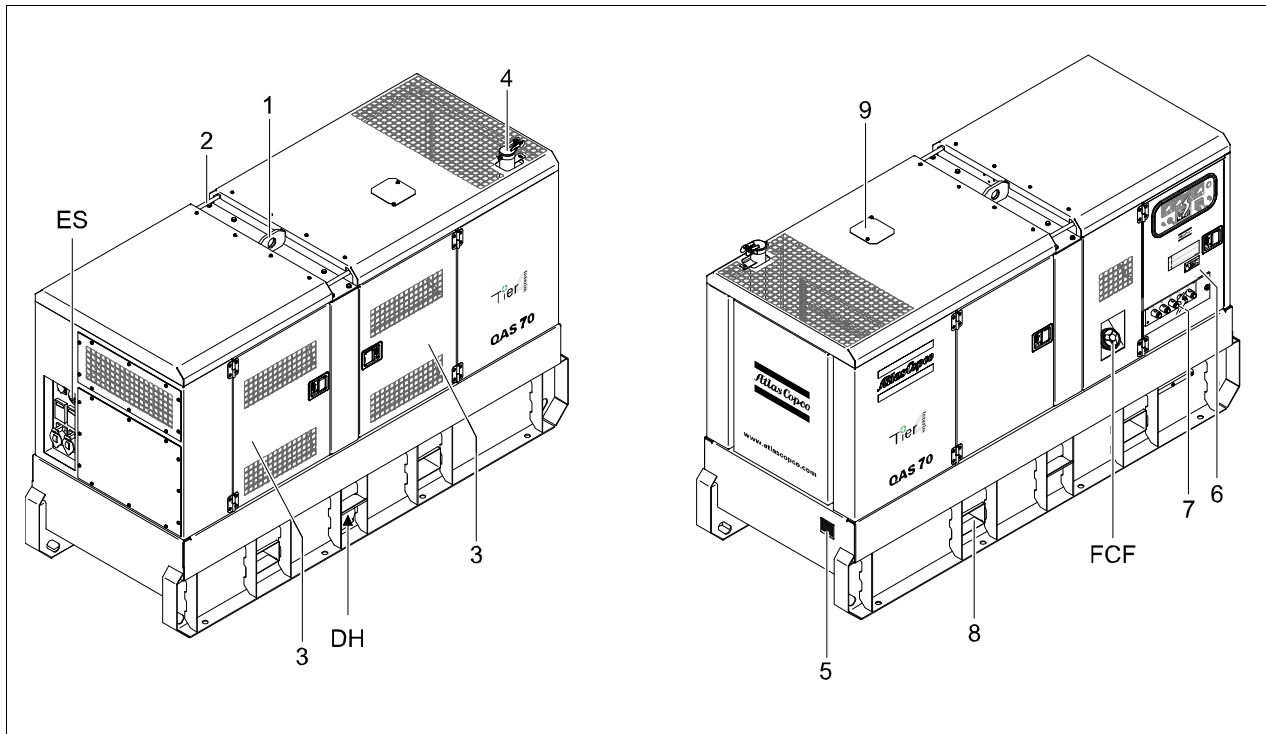
When servicing batteries, always wear protecting clothing and glasses.

- 1 The electrolyte in batteries is a sulphuric acid solution which is fatal if it hits your eyes, and which can cause burns if it contacts your skin. Therefore, be careful when handling batteries, e.g. when checking the charge condition.
- 2 Install a sign prohibiting fire, open flame and smoking at the post where batteries are being charged.
- 3 When batteries are being charged, an explosive gas mixture forms in the cells and might escape through the vent holes in the plugs.  
Thus an explosive atmosphere may form around the battery if ventilation is poor, and can remain in and around the battery for several hours after it has been charged. Therefore:
  - never smoke near batteries being, or having recently been, charged,
  - never break live circuits at battery terminals, because a spark usually occurs.
- 4 When connecting an auxiliary battery (AB) in parallel to the unit battery (CB) with booster cables: connect the + pole of AB to the + pole of CB, then connect the - pole of CB to the mass of the unit. Disconnect in the reverse order.

## Leading particulars

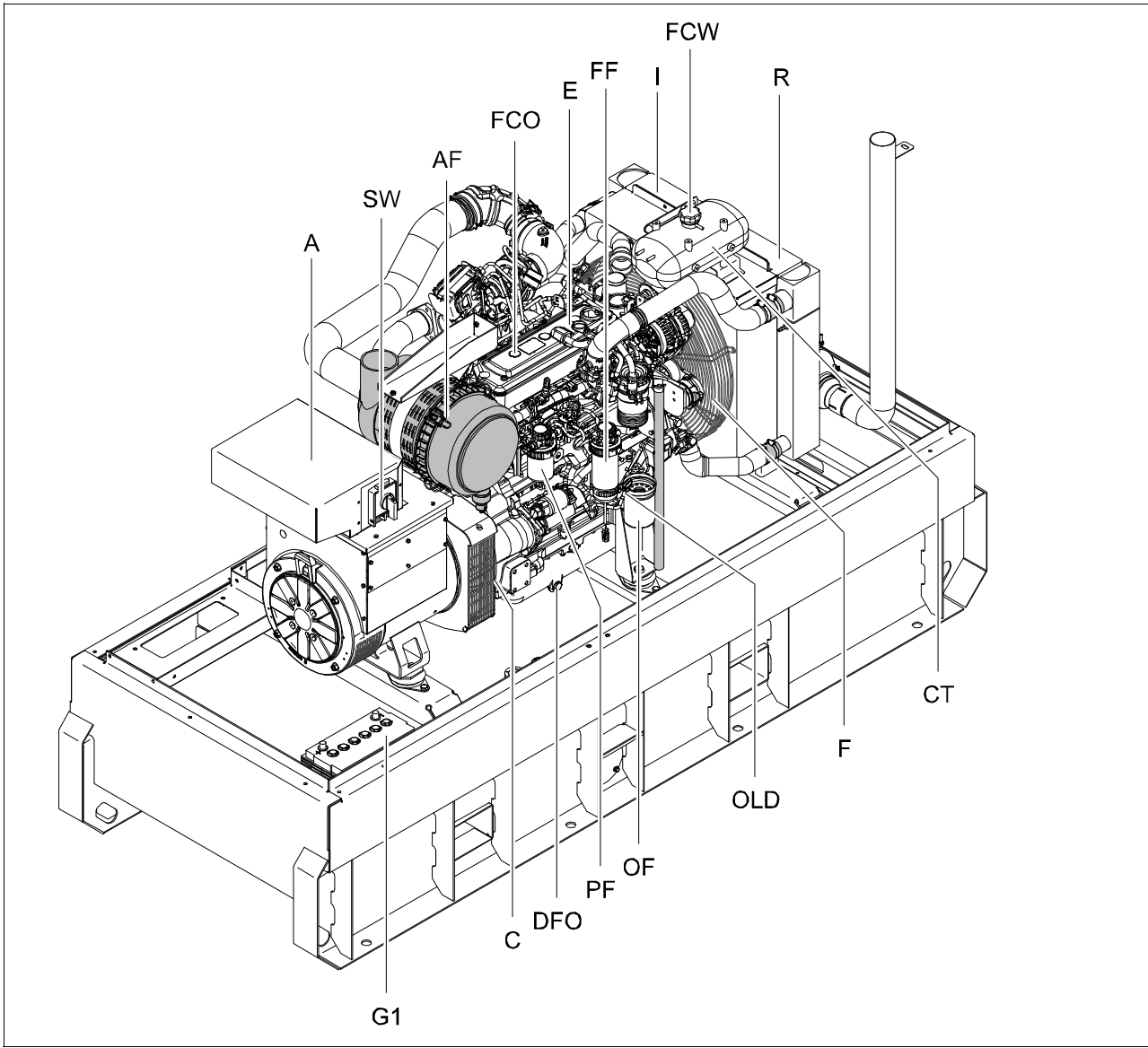
### General description

The QAS 70-90-120 John Deere is an AC generator, built for continuous running at sites where no electricity is available or as stand-by in cases of interruption of the mains. The generator can run in 3 different modes: 60Hz, 480 V - 3 phase, 60Hz, 208 V - 3 phase lower voltage and 60 Hz, 240 V - 1 phase. The QAS 70-90-120 generator is driven by an EPA interim tier 4 compliant watercooled diesel engine, manufactured by John Deere. An overview of the main parts is given in the diagram below.



- |     |   |
|-----|---|
| 1   | Lifting beam                                |
| 2   | Guiding rod                                 |
| 3   | Side doors                                  |
| 4   | Engine exhaust                              |
| 5   | Data plate                                  |
| 6   | Door, access to control and indicator panel |
| 7   | Output terminal board                       |
| 8   | Hole for forklift                           |
| 9   | Coolant filler access                       |
| DH  | Drain and access hole (in the frame)        |
| FCF | Filler cap fuel                             |





- A Alternator
- AF Air filter
- C Coupling
- DFO Drain flexible engine oil
- E Engine
- F Fan
- FCO Filler cap engine oil
- FCW Filler cap cooling water
- FF Fuel filter
- G1 Battery
- I Intercooler
- OF Oil filter
- OLD Engine oil level dipstick
- PF Pre-Filter
- R Radiator
- CT Coolant tank
- SW Selector switch

## Bodywork

The alternator, the engine, the cooling system, etc. are enclosed in a sound-insulated bodywork that can be opened by means of side doors (and service plates).

The lifting beam, to lift the generator by means of a crane, is integrated in the bodywork and easily accessible from the outside. The recesses in the roof have guiding rods at both sides.



**Never use the guiding rods to lift the generator.**

To be able to lift the generator by means of a forklift, rectangular holes are provided at the bottom of the frame.

The earthing rod, connected to the generator's earth terminal is located at the bottom of the frame on the outside.

## Markings

A brief description of all markings provided on the generator is given hereafter.



Indicates that an electric voltage, dangerous to life, is present. Never touch the electric terminals during operation.



Indicates that the engine exhaust is a hot and harmful gas, which is toxic in case of inhalation. Always make sure that the unit is operated outside or in a well-ventilated room.



Indicates that these parts can become very hot during operation (e.g. engine, cooler, etc.). Always make sure that these parts are cooled down before touching them.



Indicates that the guiding rods may not be used to lift the generator. Always use the lifting rod in the roof of the generator to lift it.



Indicates a lifting point of the generator.



Indicates that the generator may be refuelled with diesel fuel only.



Indicates the drain for the engine oil.



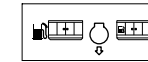
Indicates the drain for the coolant.



Indicates the drain plug for the engine fuel.

PAROIL E Mission green

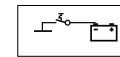
**Use PAROIL E Mission green.**



Indicates the external fuel tank.



Indicates that the alternator should not be cleaned with high pressurised water.



Indicates the battery switch.



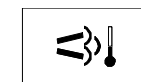
Indicates that the unit may start automatically and that the instruction book has to be consulted prior to use.



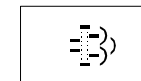
Indicates the 3-way valve.



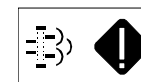
Indicates the partnumbers of the different service packs and of the engine oil. These parts can be ordered to the factory.



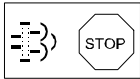
Exhaust Filter Cleaning Indicator



Exhaust Filter Indicator



Exhaust Filter and Warning Indicator



Exhaust Filter and Stop Indicator



Auto Cleaning and Disabled Indicator



Label Tier 4 Interim



Label Engine Oil Requirements

### **Drain plugs and filler caps**

The drain holes for the engine oil, the coolant and the plug for the fuel, are located and labelled on the frame, the fuel drain plug at the front, the others at the service side.

The drain flexibles for the engine oil and the engine coolant can be brought to the outside of the generator through the drain hole.

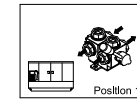


**The drain hole can also be used to guide external fueltank connections. When connecting an external fueltank, use the 3-way valves.**

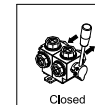
### **External fuel tank connection**

The external fuel tank connection allows to bypass the internal fuel tank and to connect an external fuel tank to the unit.

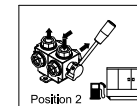
Make sure to connect the fuel supply line as well as the fuel return line. Connections to fuellines ought to be air-tight to prevent air from entering the fuel system.



Position 1: Indicates that the fuel supply line to the engine is connected to the internal fueltank.



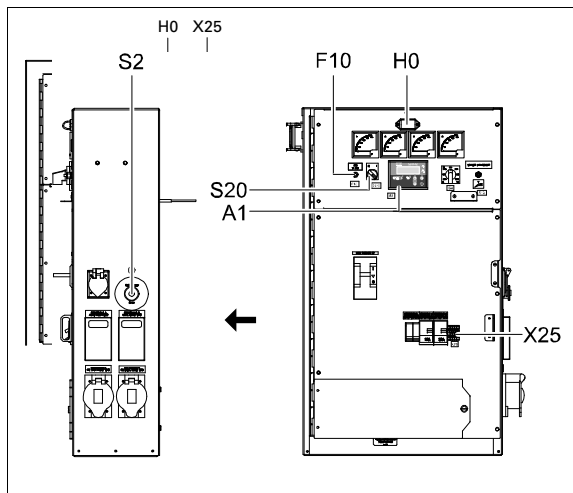
Position closed: Indicates that the fuel supply line to the engine is closed.



Position 2: Indicates that the fuel supply line to the engine is connected to the external fueltank.

## Control and indicator panel Qc1002™

### General description Qc1002™ control panel



A1 .... Qc1002™ display

F10... Fuse

The fuse activates when the current from the battery to the engine control circuit exceeds its setting. The fuse can be reset by pushing the button.

H0 .... Panel light

S2..... Emergency stop button

Push the button to stop the generator in case of an emergency. When the button is pressed, it must be unlocked, before the generator can be restarted. The emergency stop button can be secured in the locked position with the key, to avoid unauthorized use.

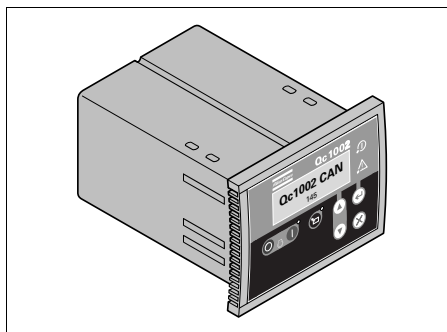
S20... ON/OFF switch

Position O: No voltage is applied to the Qc1002™ module, the generator will not start.

Position I: Voltage is applied to the Qc1002™ module, it is possible to start up the generator.

X25 .. Terminal strip

## Qc1002™ Module



The Qc1002™ module is located inside the control panel. This control module will carry out all necessary tasks to control and protect a generator, regardless of the use of the generator.

This means that the Qc1002™ module can be used for several applications.

### Pushbutton and LED functions

#### Following pushbuttons are used on the Qc1002™



**ENTER:** Is used to select and confirm changed settings in the Parameter list.



**UP:** Is used to scroll through the display information and to adjust parameter value upwards.



**DOWN:** Is used to scroll through the display information and to adjust parameter value downwards.



**BACK:** Is used to leave the Alarm pop-up window, to leave the Parameter list and to leave menu's without change.



**REMOTE MODE:** Is used to activate the remote mode. The LED indicates if the gen-set is put in Remote Mode.

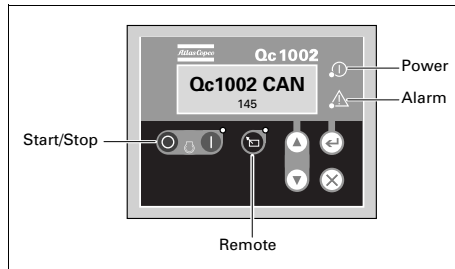


**START:** Is used to start the unit in Manual Mode.



**STOP:** Is used to stop the unit in Manual or Remote Mode (without cooldown). When the unit is stopped with the STOP button in Remote mode, it will automatically go to Manual Mode.

**Following LEDs are used on the Qc1002™**



|                   |  |
|-------------------|--|
| <b>Power</b>      | Green LED indicates that the unit is powered up.   |
| <b>Remote</b>     | Green LED indicates that the Remote Mode is selected.  |
| <b>Start/Stop</b> | Green LED indicates that the engine is running.  |
| <b>Alarm</b>      | Flashing red LED indicates that an alarm is present. A continuous red LED indicates that the alarm has been acknowledged by the user. The exact alarm is shown on the display. |

**Qc1002™ Menu Overview**

At Qc1002™, the LCD will show following information:  
 – in **Normal** condition (scroll through the information using **UP** and **DOWN**):

- Status (eg: preheat, crank, cooldown, extended stop time, ...) (pop-up: this display is only shown when a Special status comes up)
- Controller type & version
- Parameter list
- Alarm list
- LOG list
- Service Timer 1 & Service Timer 2
- Battery Voltage
- Coolant temperature
- Oil pressure
- RPM (speed)
- Fuel level

- Voltage - frequency - running hours
- in **Alarm** condition (scroll through the information using **UP** and **DOWN**):
  - a list of all active Alarms

It's possible to scroll through the views, using the **UP** and **DOWN** buttons. The scrolling is continuous.

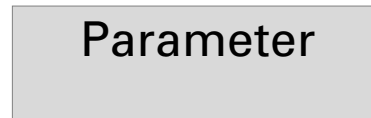
If a Special status comes up, the Status Display is shown. If an Alarm comes up, the Alarm Display is shown.

**Controller type and version display**



This view shows the controller type and the ASW version number.

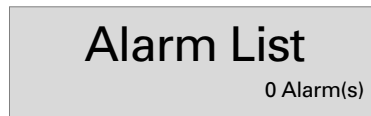
**Parameter display**



This view shows a number of Parameter settings and gives access to them.

An overview is given in “Parameter list” on page 18.

**Alarm list display**



This view shows the number of active alarms and gives access to them.

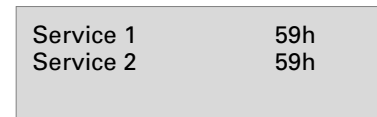
An overview is given in “Alarm Display (pop-up window)” on page 20.

**LOG list display**



This view shows the alarm memory and gives access to it. An overview is given in “LOG list” on page 21.

**Service timer 1 & Service timer 2 display**



This view shows both Service timers. The service timer indication is shown when service time has run out. It can be removed by resetting the timers or acknowledging the Service timer indication.

The service timer indications count upwards and give an alarm when the set value is reached.

Resetting the Service Timers can be done through the Parameter display.

### **Battery Voltage display**

Battery 25.2 V  
00168.1h

This view shows the Battery voltage and the running hours.

### **Coolant temperature display**

Water 62°C  
00168.1h

This view shows the Coolant temperature and the running hours.

See also “Parameter list” on page 18 for selection between °C and °F.

### **Oil pressure display**

Oil 3.2bar  
00168.1h

This view shows the Oil pressure and the running hours.

See also “Parameter list” on page 18 for selection between bar and psi.

### **Fuel level display**

Fuel 75%  
00168.1h

This view shows the Fuel level and the running hours.

### **Voltage - frequency - running hours display**

480V 60Hz  
00168.1h

This view shows the voltage, frequency and running hours.

### **Engine speed display**

RPM 1800  
00168.1h

This view shows the engine speed and running hours.

### **Diagnostic menu**

Diagnostics  
OFF OFF ON

This menu is used to power up the engine electronics without starting the engine. When this setting is switched on, electric power will be supplied to the engine electronics after half a minute delay. The unit can not be started as long as this parameter is switched on.

### **DPF - Diesel Particulate Filter**

DPF  
OFF AUTO AUTO

This view shows the DPF mode selected. When AUTO is selected the DPF will regenerate automatically. When OFF is selected, regeneration is disabled. When ON is selected manual regeneration is partially enabled (see STATION REGEN).

It is highly recommended that the genset be left in the AUTO mode at all times to prevent engine de-rate and possible shutdown due to high soot level.

### **Station Regen.**

Station. Regen.  
OFF OFF ON

Stationary or manual DPF regeneration. This view shows the stationary regeneration mode selected. When OFF is selected, manual regeneration is disabled. When ON is selected manual regeneration is enabled. The views DPF and STATION REGEN. must be set to ON for the unit to perform a stationary (manual) regeneration.

DPF and STATION REGEN. are password protected.

Note: Unit will not regenerate until soot level is ~72%

### **Soot Load Indicator**

%  
Soot Load

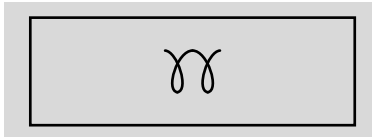
Available in EXTRA VIEWS on control panel

Only visible when unit is operating. This screen has been provided for the operator to monitor the soot load of the DPF (read in percent of load)

For stationary/manual regeneration instructions See page 22.

## Qc1002™ Menu Description

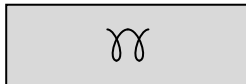
### Status Display (pop-up window)



In case special statuses are entered, a pop-up window will automatically be entered for as long as the status is active. The background screen is not updated when the status pop-up window is active.

*These special statuses are:*

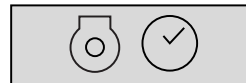
PREHEAT



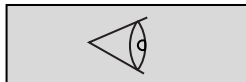
START OFF/  
EXTENDED  
STOP TIMER



COOLDOWN



DIAGNOSTIC



If a special status has elapsed, the active view will be entered again automatically.

If an Alarm comes up, the Alarm Display is shown.

### Parameter list

The Parameter Menu's are pre-programmed!

A password will be asked for when an attempt to change a setting is about to be done (user password = 2003).

By entering the parameter list, pushbutton REMOTE is disposed of its normal operations and will not perform any functionality.

Menu's shown on the Parameter list LCD:

- Running hours adjust
- This menu is used to adjust the amount of running hours. The running hours can only be raised, not lowered.
- Unit Type



### Unit type 6 for QAS 70-90-120 John Deere!

- Service Timer 2 reset
- Service Timer 1 reset

These menus are used to reset the service timers. When a service timer alarm occurs and is acknowledged, the service timer will be reset automatically.

- Diagnostics Menu

This menu is used to power up the engine electronics without starting the engine. When this setting is switched 'on', electric power will be supplied to the engine electronics after half a minute delay. The unit can not be started as long as this parameter is switched 'on'.

- Unit Menu

This menu is used to select whether temperature and pressure should appear in °C/bar or °F/psi.

- Language selection

Icons is the default factory set language, but 6 other languages can be selected: English, French, German, Italian, Spanish and Cyrillic (Russian). All information in the Parameter List display is always in English.

- Generator Underfrequency: failclass, enable, delay, setpoint
- Generator Overfrequency: failclass, enable, delay, setpoint
- Generator Undervoltage: failclass, enable, delay, setpoint

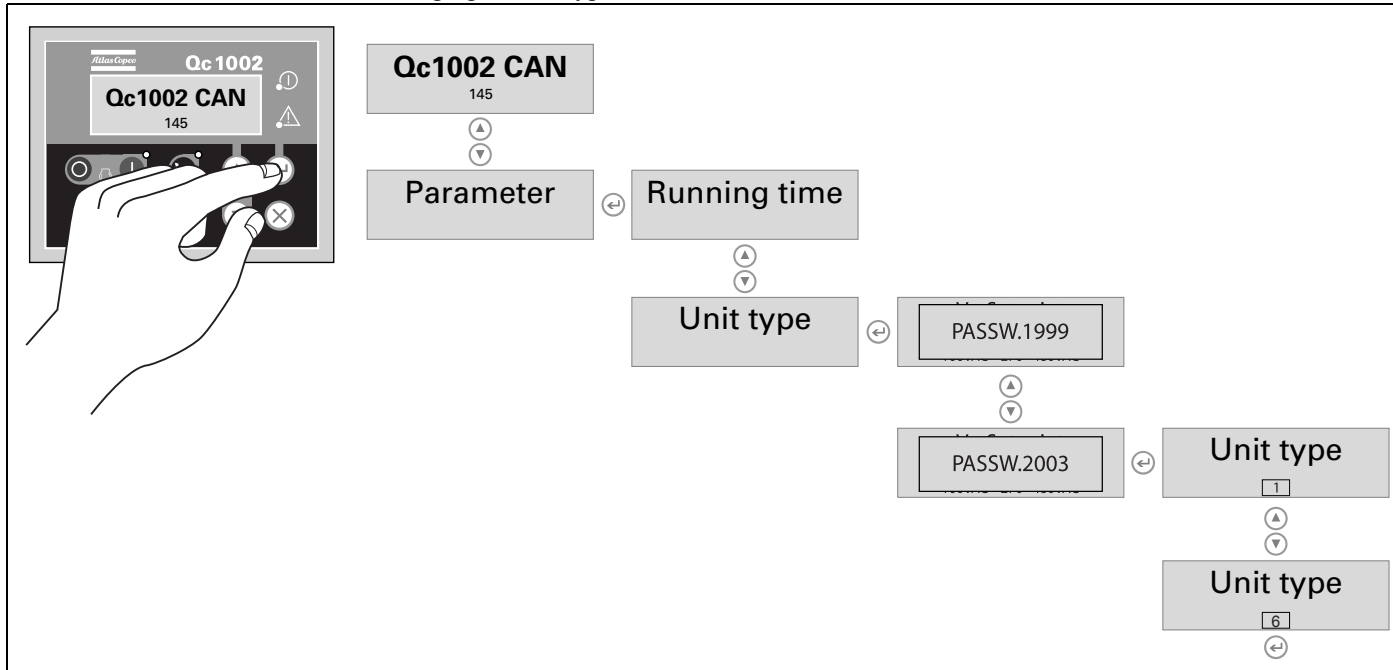
- Generator Overvoltage: failclass, enable, delay, setpoint
- Engine CAN communication

This menu is used to select the type of engine electronics, the Qc1002™ controller should communicate with via the Canbus.

It's possible to scroll between configuration menu's by using the pushbuttons UP and DOWN.

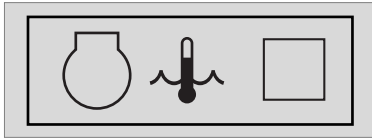
Pushing the ENTER button activates the configuration menu which is shown at the display.

This is the described menu flow for changing the unit type:





## Alarm Display (pop-up window)



In case an Alarm occurs, a pop-up window will automatically be displayed for as long as the alarm is active, no matter which view is active. The flashing red alarm LED will light up. The alarm icons will be shown together with an acknowledgement check-box. Push the ENTER button to acknowledge the alarm. When the alarm has been acknowledged, a V-marking will appear in the check-box and the red alarm LED will light up continuously.



**An alarm should always be acknowledged before solving the problem that causes the alarm.**

The Alarm Display can always be left by pushing the BACK button.

If more than one alarm comes up, it's possible to scroll through the alarm messages with the UP and DOWN pushbuttons. The newest alarm will be placed at the bottom of the list (meaning that the older alarm stays at the display when a newer alarm comes up).

If one or more than one alarm is present, an arrow at the right of the display will be shown.

### Following general groups of Alarms exist:

- Warning: Alarm LED lights up + Alarm pop-up appears on the display + Alarm relay is empowered (if configured)
- Trip of GB: 'Warning' actions + Generator Contactor opens
- Trip and Stop: 'Trip of GB' actions + unit stops after Cooldown
- Shutdown: 'Trip of GB' actions + unit stops immediately

### List of possible alarms:

LOW OIL PRESSURE



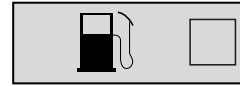
HIGH COOLANT TEMPERATURE



CHARGING ALTERNATOR



LOW FUEL LEVEL



LOW COOLANT LEVEL



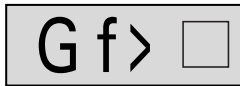
GENERATOR OVERVOLTAGE



GENERATOR UNDER-VOLTAGE



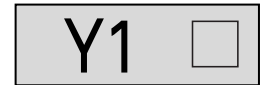
GENERATOR OVER-FREQUENCY



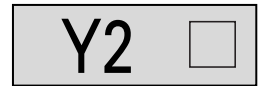
GENERATOR UNDER-FREQUENCY



SERVICE TIMER 1



SERVICE TIMER 2



ENGINE ALARM



EMERGENCY STOP



START FAILURE



STOP FAILURE



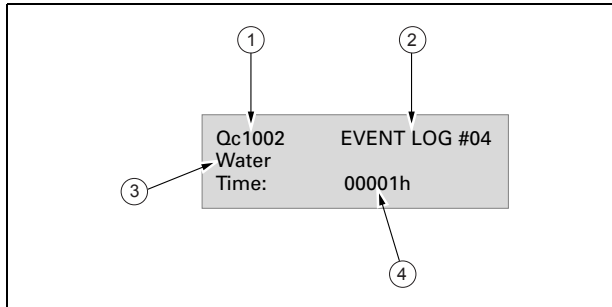
## LOG list

The unit will keep an event log of the latest 30 events.

Events are:

- shutdowns
- service timer 1/2 reset
- unit type changes

Together with each event, the running hours at the time of the event will be stored.



- |   |                 |
|---|-----------------|
| 1 | Controller type |
| 2 | Event number    |
| 3 | Event           |
| 4 | Running hours   |

## Remote start operation

Installation wirings:

- X25.1 & X25.2 to be wired for the remote start switch.
- X25.3 & X25.4 to be wired for the remote contactor (open/close).

## Fail classes

All the activated alarms of the Qc1002™ have their own pre-defined fail class.

All alarms are enabled according to one of these three statuses:

- disabled alarm, no supervision of alarm (OFF)
- enabled alarm, supervision of alarm all the time (ON)
- running alarm, only supervision when the machine is running (RUN)

## Stationary Regeneration Procedure

**Atlas Copco recommends that the DPF configuration be left in the AUTO mode at all times, however in the event that a stationary or manual regeneration is desired the following process should be followed.**

- Go to the "STATION REGEN" screen. For normal operation this should be in OFF mode.

§ Press the enter button, this function is password protected contact Atlas Copco service department.

§ Use the up or down arrow to change the selection to ON and press the enter button.

- Go to the "DPF" screen. For normal operation this should be in the AUTO mode.

§ Press the enter button

§ Use the up or down arrow to change the selection to ON and press the enter button.

§ This will set the unit up for regeneration, after a few moments the regeneration icon should appear confirming the unit is regenerating.

**Upon completion of the stationary/forced regeneration it is highly recommended to reset the unit to automatically regenerate to prevent engine derate & shutdown due to high soot load. Follow the process below to return the unit to AUTO mode for normal operation.**

- Go to the "STATION REGEN" screen. (For normal operation this should be in OFF mode).

§ Press the enter button, this function is password protected contact Atlas Copco service department.

§ Use the up or down arrow to change the selection to OFF and press the enter button.

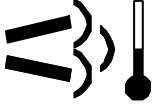
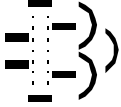
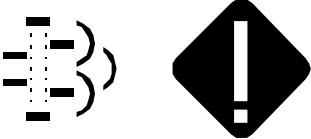
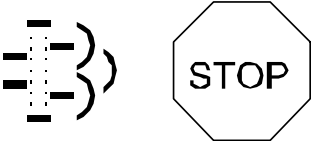
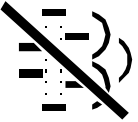
- Go to the "DPF" screen. For normal operation this should be in the AUTO mode.

§ Press the enter button,

§ Use the up or down arrow to change the selection to AUTO and press the enter button.

§ The unit is now ready for normal operation.

## DPF INFORMATION - INDICATORS

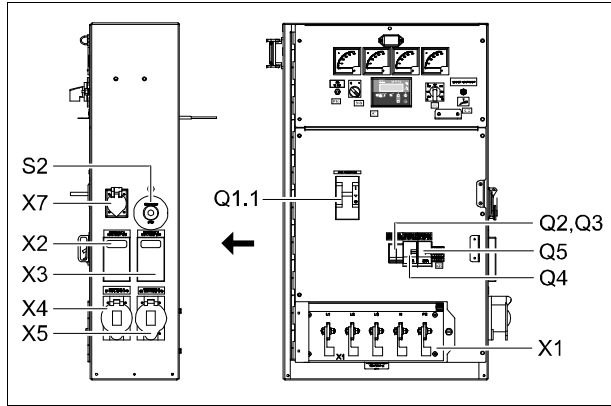
| Indicators   | Description   | Operator Action  |
|--|---|--|
| <p>Exhaust Filter Cleaning Indicator</p>      | <p>Active when:</p> <ol style="list-style-type: none"> <li>1. Exhaust gas temperature is high.</li> <li>2. Elevated idle is active.</li> <li>3. Exhaust filter cleaning is in process.</li> </ol> | <p>Machine can be operated as normal. If operating in an area where high exhaust temperature may be an issue, abort exhaust filter cleaning by using the disable feature. Only use disable feature in emergency situation.</p> |
| <p>Exhaust Filter Indicator</p>               | <p>Active when:<br/>Soot level in the exhaust filter indicates need for an exhaust filter cleaning.</p> <p>Warning will be present on controller</p>  | <p>Enable auto filter cleaning to allow a cleaning cycle.<br/>OR<br/>Begin a manual cleaning.</p>  |
| <p>Exhaust Filter and Warning Indicators</p>  | <p>Active when:<br/>Machine performance is reduced due to moderately high soot level.</p> <p>Warning will be present on controller</p>  | <p>Begin a manual cleaning.</p>  |
| <p>Exhaust Filter and Stop Indicators</p>    | <p>Active when:<br/>Exhaust filter requires service, Machine performance is reduced due to Extremely High soot level and a stop engine request is made.</p>                                       | <p>Service the exhaust filter.<br/>Contact your servicing dealer.</p>  |
| <p>Auto Cleaning Disabled Indicator</p>     | <p>Active when:<br/>Auto exhaust filter cleaning is disabled.</p>   | <p>If possible, enable auto cleaning.</p>  |



**Always leave machine in auto cleaning mode unless forced to use a manual cleaning.  
Do not let machine operate unloaded excessively, exhaust filter performance is reduced.**

## Output terminal board

The cubicle provides a terminal board for easier connection of cables. It is situated below the control and indicator panel.



**S2.....Emergency stop button**

**X1..... Terminal board**

Provides a more easy connection of cables.

**X2..... 1-phase outlet socket (125 V)**

Provides phase L2, neutral and earthing.

**X3..... 1-phase outlet socket (125 V)**

Provides phase L1, neutral and earthing.

**X4..... 2-phase outlet socket (125/250 V)**

Provides phases L1, L2, neutral and earthing.

**X5..... 2-phase outlet socket (125/250 V)**

Provides phases L1, L2, neutral and earthing.

**X7 ... Flanged Inlet**

Used to supply power to the available coolant heater or battery charger (if ordered).

## Q1.1 . Main circuit breaker

Interrupts the voltage power supply towards X1 when a short-circuit occurs at the load side or when the overcurrent protection limit is activated. It must be reset manually after eliminating the problem.

## Q2 .... Circuit breaker for X2

Interrupts the power supply to X2 when a short-circuit occurs at the load side, or when the overcurrent protection (20 A) is activated. When activated, Q2 interrupts one phase towards X2. It can be activated again after eliminating the problem.

## Q3 .... Circuit breaker for X3

Interrupts the power supply to X3 when a short-circuit occurs at the load side, or when the overcurrent protection (20 A) is activated. When activated, Q3 interrupts 2 phases towards X3. It can be activated again after eliminating the problem.

## Q4 .... Circuit breaker for X4

Interrupts the power supply to X4 when a short-circuit occurs at the load side, or when the overcurrent protection (50 A) is activated. When activated, Q4 interrupts 2 phases towards X4. It can be activated again after eliminating the problem.

## Q5 .... Circuit breaker for X5

Interrupts the power supply to X5 when a short-circuit occurs at the load side, or when the overcurrent protection (50 A) is activated. When activated, Q5 interrupts 2 phases towards X5. It can be activated again after eliminating the problem.



**Make sure to switch on circuit breakers Q1.1 or Q2, Q3, Q4 and Q5 after starting the generator when power supply is done by means of X2, X3, X4 or X5.**

## Triple voltage (3V)

The generator can run in three different modes:

– 1 phase

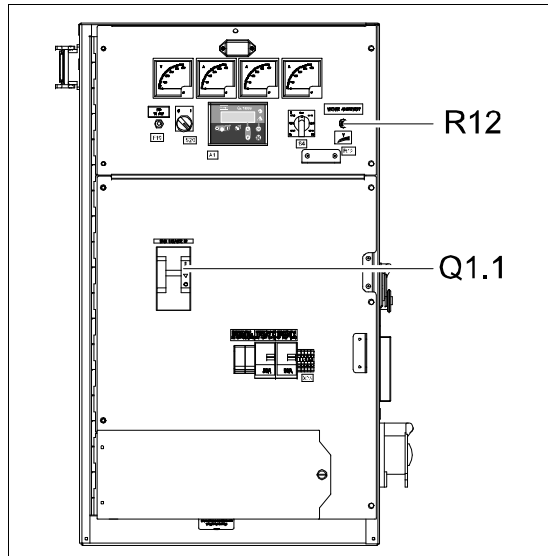
When using this selection, the generator provides a 120/240 V output voltage.

– 3 phase, lower voltage

When using this selection, the generator provides a 208/240 V output voltage.

– 3 phase, higher voltage

When using this selection, the generator provides a 416/480 V output voltage.



### Q1.1. Circuit breaker for

Interrupts the voltage power supply towards X1 when a short-circuit occurs at the load side or when the overcurrent protection is activated. It must be reset manually after eliminating the problem.

### R12... Output voltage adjust potentiometer

Allows to adjust the output voltage.

The selection between the three modes is done by means of S10.

### S10 .. Output voltage selection switch

Allows to select a 1 phase output voltage, a 3 phase high output voltage or a 3 phase low output voltage. Selector switch S10 is located on the alternator.



**Changing the output voltage is only allowed after shutdown.**

**After changing the output voltage by means of the selection switch S10, adjust the output voltage by means of potentiometer R12 to the required value.**

### Spillage free skid

A spillage free skid with forklift slots allows the customer to transport the generator easily with a forklift.

It avoids accidental spilling of engine fluids.

### Engine coolant heater

To make sure that the engine can start and accept load immediately, an external cooling water heater (2000 W, 240 V) is provided which keeps the engine temperature between 38°C (100°F) and 49°C (120°F).

## Operating instructions

**⚠ In your own interest, always strictly observe all relevant safety instructions.**

**Do not operate the generator in excess of the limitations mentioned in the Technical Specifications.**

**Local rules concerning the setting up of low voltage power installations (below 1000 V) must be respected when connecting site distribution panels, switch gear or loads to the generator.**

### Installation

**⚠ For information about indoor installation, consult your local Atlas Copco dealer.**

- Place the generator on a horizontal, even and solid floor. The generator can operate in a slant position not exceeding 15° (in both senses: front/rear and left/right).
- The generator should be kept with the doors closed, in order to avoid the ingress of water and dust. Dust ingress reduces the lifetime of filters and may reduce your generator's performance.
- Check that the engine exhaust is not directed towards people. If the generator is operated indoors, install an exhaust pipe of sufficient diameter to duct the engine exhaust towards the outside. Check for sufficient ventilation so that the cooling air is not recirculated. If necessary, consult Atlas Copco.
- Leave enough space for operation, inspection and maintenance (at least 1 meter at each side).
- Check that the inner earthing system is in compliance with the local legislation.
- Use coolant for the engine cooling system. Refer to the Engine instruction book for the proper coolant mixture.
- Check the tightness of the bolts and nuts.
- Install the earthing rod as near as possible to the generator and measure its diffusion resistance (max. 1 kΩ) in order not to have a contact voltage higher than 25 V at 30 mA leakage current.

- Check that the cable end of the earthing rod is connected to the earth terminal.

### Connecting the generator

#### Precautions for non-linear and sensitive loads



**Non-linear loads draw currents with high contents in harmonics, causing distortion in the wave form of the voltage generated by the alternator.**

The most common non-linear, 3-phase loads are thyristor/rectifier-controlled loads, such as convertors supplying voltage to variable speed motors, uninterruptable power supplies and Telecom supplies. Gas-discharge lighting arranged in single-phase circuits generate high 3rd harmonics and risk for excessive neutral current.

Loads most sensitive to voltage distortion include incandescent lamps, discharge lamps, computers, X-ray equipment, audio amplifiers and elevators.

Consult Atlas Copco for measures against the adverse influence of non-linear loads.

#### Quality, minimum section and maximum length of cables

The cable connected to the terminal board of the generator must be selected in accordance with local legislation. The type of cable, its rated voltage and current carrying capacity are determined by installation conditions, stress and ambient temperature. For flexible wiring, rubber-sheathed, flexible core conductors of the type H07 RN-F (Cenelec HD.22) or better must be used.

The following table indicates the maximum allowable 3-phase currents (in A), in an ambient temperature of 40°C (104°F), for cable types (multiple and single core PVC insulated conductors and H07 RN-F multiple core conductors) and wire sections as listed, in accordance with VDE 0298 installation method C3. Local regulations

remain applicable if they are stricter than those proposed below.

| Wire section<br>(mm <sup>2</sup> ) | Max. current (A) |             |          |
|------------------------------------|------------------|-------------|----------|
|                                    | Multiple core    | Single core | H07 RN-F |
| 25                                 | 94               | 101         | 88       |
| 35                                 | 114              | 123         | 110      |
| 50                                 | 138              | 155         | 138      |
| 70                                 | 176              | 191         | 170      |
| 95                                 | 212              | 228         | 205      |
| 120                                | 245              | 273         | 239      |
| 150                                | 282              | 314         | 275      |
| 185                                | 323              | 358         | 313      |
| 240                                | 379              | 421         | 371      |
| 300                                | 429              | 477         | 428      |

The lowest acceptable wire section and the corresponding maximum cable or conductor length for multiple core cable or H07 RN-F, at rated current, for a voltage drop e lower than 5% and at a power factor of 0.80, are respectively 10 mm<sup>2</sup> (0.39 in<sup>2</sup>) and 146 m (179 ft). In case electric motors must be started, oversizing the cable is advisable.

The voltage drop across a cable can be determined as follows:

$$e = \frac{\sqrt{3} \cdot I \cdot L \cdot (R \cdot \cos\phi + X \cdot \sin\phi)}{1000}$$

e = Voltage drop (V)

I = Rated current (A)

L = Length of conductors (m)

R = Resistance (Ω/km to VDE 0102)

X = Reactance (Ω/km to VDE 0102)

### Connecting the load

#### Site distribution panel

If outlet sockets are required, they must be mounted on a site distribution panel supplied from the terminal board of the generator and in compliance with local regulations for power installations on building sites.

## **Protection**



**For safety reasons, it is necessary to provide an isolating switch or circuit breaker in each load circuit. Local legislation may impose the use of isolating devices which can be locked.**

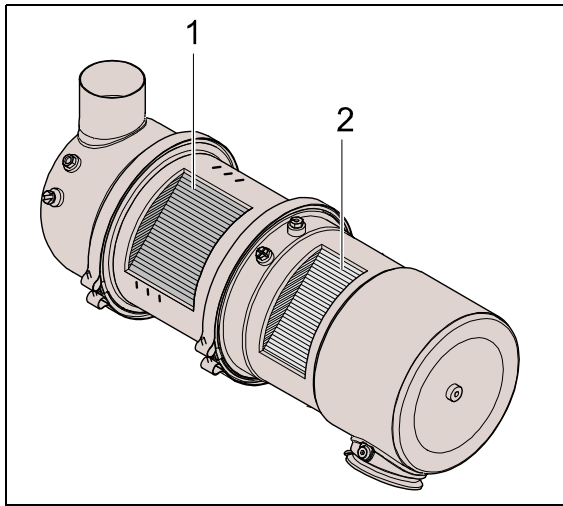
- Check whether frequency, voltage and current comply with the ratings of the generator.
- Provide for the load cable, without excessive length, and lay it out in a safe way without forming coils.
- Open the door of the control and indicator panel and the transparent door in front of the terminal board X1.
- Provide the wire ends with cable lugs suited for the cable terminals.
- Loosen the cable clamp and push the wire ends of the load cable through the orifice and clamp.
- Connect the wires to the proper terminals (L1, L2, L3, N and PE) of X1 and tighten the bolts securely.
- Tighten the cable clamp.
- Close the transparent door in front of X1.

## **Before starting**

- With the generator standing level, check the engine oil level and top up if necessary. The oil level must be near to, but not exceed the high mark on the engine oil level dipstick.
- Check the coolant level in the expansion tank of the engine cooling system. The coolant level must be near to the FULL mark. Add coolant if necessary.
- Drain any coolant and sediment from the fuel pre-filter. Check the fuel level and top up if necessary. It is recommended to fill the tank after the day's operation to prevent coolantdamp in a nearly empty tank from condensing.
- Check the vacuum indicator of the air filter. If the red part shows completely, replace the filter element.
- Press the vacuator valve of the air filter to remove dust.
- Check the generator for leakage, tightness of wire terminals, etc. Correct if necessary.
- Check that fuse F10 has not tripped and that the emergency stop is in the OUT position.
- Check that the load is switched off.
- Check that circuit breaker Q1.1/Q1.2 are switched off.



## EXHAUST FILTER



1. Diesel Particulate Filter (DPF)
2. Diesel Oxidation Catalyst (DOC)

## EXHAUST FILTER SYSTEM

An exhaust filter consisting of a diesel oxidation catalyst (DOC) and a diesel particulate filter (DPF) specifically to meet the demands of offhighway applications. The DOC reduces carbon monoxide, hydrocarbons, and some particulate matter. The downstream DPF traps and holds particulates remaining in the exhaust stream. Trapped particles are eventually oxidized within the DPF through a process known as regeneration or exhaust filter cleaning.

Under normal machine operation and with the system in AUTO mode, the exhaust filter system requires minimal operator interaction.

To avoid unnecessary buildup of diesel particulates or soot in the exhaust filter system;

1. Utilize the Automatic (AUTO) Exhaust Filter Cleaning mode.
2. Avoid operating for extended periods unloaded.

3. Use Atlas Copco “PAROIL E mission Green Low SAPS” engine oil.
4. Use only ultra low sulfur fuel.

In addition to soot, ash deposits will also slowly build up in the DPF and cannot be removed through the engine exhaust filter cleaning process.

When the exhaust filter has run several thousand hours, these ash deposits can restrict engine performance due to increased back pressure.



**To correct this situation, replace the exhaust filter or have the exhaust filter cleaned in specialized equipment.**



**Do not power wash the filter assembly when external skin temperature of assembly exceeds 50° C (120° F).**

## DIESEL PARTICULATE FILTER MAINTENANCE AND SERVICE

The Exhaust Filter includes the Diesel Oxidation Catalyst (DOC) and Diesel Particulate Filter (DPF). The DPF is designed to retain residual ash, which is a noncombustible result of additives used in crankcase lubrication oils and the fuel. The DPF provides many hours of maintenance free operation. At some point the DPF will require professional service to remove the accumulated ash. The exact number of hours of operation before service is required will vary depending upon the engine’s power category, duty cycle and operating conditions, engine oil ash content, and fuel quality.

The exhaust filter’s dash lamp indicator or the diagnostic codes will indicate when the DPF needs ash removal service.

The removal of DPF ash must be done by removing the DPF from the machine and placing it into specialized equipment. Do not remove ash by using water or other chemicals. Removing ash by these methods may damage the material securing the DPF in its canister, resulting in the loosening of the DPF element in the canister and subjecting it to damage from vibration.

## EXHAUST FILTER / DIESEL PARTICULATE FILTER ASH HANDLING AND DISPOSAL



**Under federal, state, and/or local laws or regulations, Diesel Particulate Filter ash may be classified as a hazardous waste. Hazardous wastes must be disposed of in accordance with all applicable federal, state and local laws or regulations governing hazardous waste disposal. Only a qualified service provider should remove ash from the DPF. Personal protective equipment and clothing, maintained in a sanitary and reliable condition, should be used when handling and cleaning a DPF. See your John Deere dealer or qualified service provider for assistance.**

## EXHAUST FILTER DISPOSAL



**Proper management of an Exhaust Filter that has reached the end of its useful life is required, since the ash or catalyst material in the device may be classified as hazardous waste under federal, state, and/or local laws or regulations. Used Exhaust Filters, which include the Diesel Particulate Filter, may be exchanged at any Engine manufacturer’s dealer or qualified service provider.**



**See Engine operator’s manual for further information regarding the Exhaust Filter.**


## Operating Qc1002™

### Starting Qc1002™

#### **To start up the unit locally, proceed as follows:**

- Switch on the battery switch.
- Switch off circuit breaker Q1.1. This is not necessary when a plant contactor is installed between Q1.1 and the load.
- Put the starter switch S20 in position I (ON). Voltage is applied to the Qc1002™ module.
- The unit can be started manually by pressing the START button on the Qc1002™ module.
- The unit starts a preheating cycle which takes 12 seconds.
- After the preheating period, the unit will start. The starting attempt will take maximum 12 seconds.
- Switch on circuit breaker Q1.1 in case no contactor is installed.

#### **To start up the unit from a remote location, proceed as follows:**

- Put the starter switch S20 in position I (ON). Voltage is applied to the Qc1002™ module.
- The unit can be started from a remote location by pressing the remote mode button  on the Qc1002™ module.
- Switch on circuit breaker Q1.1.
- Put the remote start/stop switch in position start.
- The unit starts a preheating cycle which takes 12 seconds.
- After the preheating period, the unit will start. The starting attempt will take maximum 12 seconds.

### During operation Qc1002™

Following points should be carried out regularly:

- Check the engine gauges and the lamps for normal readings.



**Avoid to let the engine run out of fuel. If it happened, priming will speed up the starting.**

- Check for leakage of oil, fuel or coolant.
- Avoid long low-load periods (< 30%). In this case, an output drop and higher oil consumption of the engine could occur.
- Check, by means of the generator gauges, that the voltage between the phases is identical and that the rated current in the third phase (L3) is not exceeded.
- When single-phase loads are connected to the generator output terminals, keep all loads well-balanced.

If circuit breakers are activated during operation, switch off the load and stop the generator. Check and, if necessary, decrease the load.



**The generator's doors may only remain opened for short periods during operation, to carry out checks for example.**

### Stopping Qc1002™

#### **To stop the unit locally, proceed as follows:**

- Switch off the load.
- Switch off circuit breaker Q1.1.
- Let the engine run for about 5 minutes.
- Stop the engine by using the STOP button on the Qc1002™ module.
- Put the starter switch S20 in position O (OFF) to shut down the voltage apply towards the Qc1002™ module.
- Lock the side doors and the door of the indicators and control panel to avoid unauthorized access.

#### **To stop the unit when the starter switch is in position , proceed as follows:**

- Switch off the load.
- Stop the engine by putting the remote start/stop switch in position stop or by using the STOP button on the Qc1002™ module. When the unit is stopped with the STOP button in Remote Mode, it will automatically go to Manual Mode.
- Put the starter switch S20 in position O (OFF) to shut down the voltage apply towards the Qc1002™ module.
- Lock the side doors and the door of the indicators and control panel to avoid unauthorized access.


# Maintenance

## Maintenance schedule



Before carrying out any maintenance activity, check that the start switch is in position O and that no electrical power is present on the terminals.

| Maintenance schedule  | Daily | Every 250 hours | Every 500 hours     | Every 1000 hours or yearly |
|---|-------|-----------------|---------------------|----------------------------|
| <b>Service pak</b>  | -     | -               | <b>1310 3004 42</b> | <b>1310 3004 43</b>        |
| <i>For the most important subassemblies, Atlas Copco has developed service kits that combine all wear parts. These service kits offer you the benefits of genuine parts, save on administration costs and are offered at reduced price, compared to the loose components. Refer to the parts list for more information on the contents of the service kits.</i> |       |                 |                     |                            |
| Check for air, fuel, coolant and oil leakage  | x     | x               | x                   | x                          |
| Check oil and coolant level   | x     | x               | x                   | x                          |
| Check or drain water in fuel filter/water separator   | x     | x               | x                   | x                          |
| Inspect air cleaner / Dust bowl   | x     | x               | x                   | x                          |
| Check vacuum indicator  | x     | x               | x                   | x                          |
| Visual walk around the unit   | x     | x               | x                   | x                          |
| Replace engine oil (1)  |       |                 | x                   | x                          |
| Replace engine oil filter (1)   |       |                 | x                   | x                          |
| Check/clean radiator/cooler fins  |       | x               | x                   | x                          |
| Check tension and condition of the drive belt (4)   |       |                 | x                   | x                          |
| Grease door hinges and locks  |       |                 | x                   | x                          |
| Replace fuel filter element   |       |                 | x                   | x                          |
| Replace fuel prefilter element  |       |                 | x                   | x                          |
| Check electrolyte level and terminals of battery  |       |                 | x                   | x                          |
| Check engine mounts   |       |                 | x                   | x                          |
| Check crankcase ventilation system  |       |                 | x                   | x                          |
| Check condition of cooling fan assembly   |       |                 | x                   | x                          |
| Pressure test cooling system  |       |                 | x                   | x                          |
| Check engine electrical ground connection   |       |                 | x                   | x                          |
| Replace air filter element  |       |                 | x                   | x                          |
| Replace safety cartridge  |       |                 | x                   | x                          |
| Measure alternator insulation resistance (*)  |       |                 | x                   | x                          |
| Check glycol level in coolant   |       |                 | x                   | x                          |
| Check PH level of engine coolant  |       |                 | x                   | x                          |
| Check and adjust engine inlet and outlet valves   |       |                 |                     | x                          |
| Check alternator and starter motor  |       |                 |                     | x                          |

|   |   |   |  |   |
|---|---|---|--|---|
| Check electrical system for security of cables and wear |   |   |  | x |
| Test thermostats  |   |   |  | x |
| Test glow plugs   |   |   |  | x |
| Verify that safety circuits work                        |   |   |  | x |
| Inspection by Atlas Copco Service technician            |  | <b>Generators in standby application have to be tested on a regular basis. At least once a month the engine should run for minimum 30 minutes at a high load ( 50% - 70% ) that the engine reaches its operating temperature.</b> |  |   |

**Notes:**

In highly dusty environments, these service intervals do not apply. Check and/or replace filters and clean radiator on a regular basis.

- (1) During engine break-in, change the oil and oil filter for the first time after max. 100 hours of operation. Use PAROIL Extra only.
- (2) Rocker cover gaskets can be re-used after valve clearance.
- (3) Replace crankshaft damper every 4500 Hrs or 60 months, whichever occurs first
- (4) Belt not loose and no signs or cracks or wear.

## Engine maintenance

Refer to the engine's operator manual for full maintenance, including instructions for changing the oil and coolant and replacing the fuel, oil and air filters.

### (\* Measuring the alternator insulation resistance

A 500 V megger is required to measure the alternator insulation resistance.

If the N-terminal is connected to the earthing system, it must be disconnected from the earth terminal. Disconnect the AVR.

Connect the megger between the earth terminal and terminal L1 and generate a voltage of 500 V. The scale must indicate a resistance of at least 5 MΩ.

Refer to the alternator operating and maintenance instructions for more details.

## Engine fuel specifications

For fuel specifications, please contact your Atlas Copco Customer Center.

## Engine oil specifications



**It is strongly recommended to use Atlas Copco branded lubrication oils.**

High-quality, mineral, hydraulic or synthesized hydrocarbon oil with rust and oxidation inhibitors, anti-foam and anti-wear properties is recommended.

The viscosity grade should correspond to the ambient temperature and ISO 3448, as follows.

| Engine  | Type of lubricant   |
|---|---------------------|
| <i>between -15°C (5°F) and 40°C (104°F)</i>   | <i>PAROIL E</i>     |
| <i>between -25°C (-13°F) and 40°C (104°F)</i> | <i>PAROIL Extra</i> |



**Never mix synthetic with mineral oil.**

**Remark:**

**When changing from mineral to synthetic oil (or the other way around), you will need to do an extra rinse.**

**After doing the complete change procedure to synthetic oil, run the unit for a few minutes to allow good and complete circulation of the synthetic oil. Then drain the synthetic oil again and fill again with new synthetic oil. To set correct oil levels, proceed as in normal instruction.**

## Specifications PAROIL

PAROIL from Atlas Copco is the ONLY oil tested and approved for use in all engines built into Atlas Copco compressors and generators.

Extensive laboratory and field endurance tests on Atlas Copco equipment have proven PAROIL to match all lubrication demands in varied conditions. It meets stringent quality control specifications to ensure your equipment will run smoothly and reliably.

The quality lubricant additives in PAROIL allow for extended oil change intervals without any loss in performance or longevity.

PAROIL provides wear protection under extreme conditions. Powerful oxidation resistance, high chemical stability and rust-inhibiting additives help reduce corrosion, even within engines left idle for extended periods.

PAROIL contains high quality anti-oxidants to control deposits, sludge and contaminants that tend to build up under very high temperatures.

PAROIL's detergent additives keep sludge forming particles in a fine suspension instead of allowing them to clog your filter and accumulate in the valve/rocker cover area.

PAROIL releases excess heat efficiently, whilst maintaining excellent bore-polish protection to limit oil consumption.

PAROIL has an excellent Total Base Number (TBN) retention and more alkalinity to control acid formation.

PAROIL prevents Soot build-up.

PAROIL is optimized for the latest low emission EURO - 3 & -2, EPA TIER II & III engines running on low sulphur diesel for lower oil and fuel consumption.

## PAROIL Extra and PAROIL E

### **Synthetic engine oil PAROIL Extra**

PAROIL Extra is a Synthetic ultra high performance diesel engine oil with a high viscosity- index. Atlas Copco PAROIL Extra is designed to provide excellent lubrication from start-up in temperatures as low as -25°C.

|               | <b>Liter</b> | <b>US gal</b> | <b>Imp gal</b> | <b>cu.ft</b> | <b>Order number</b> |
|---------------|--------------|---------------|----------------|--------------|---------------------|
| <i>can</i>    | 5            | 1.3           | 1.1            | 0.175        | 1630 0135 00        |
| <i>barrel</i> | 20           | 5.3           | 4.4            | 0.7          | 1630 0136 00        |

### **Mineral engine oil PAROIL E**

PAROIL E is a mineral based high performance diesel engine oil with a high viscosity- index. Atlas Copco PAROIL E is designed to provide a high level of performance and protection in standard ambient conditions as from -15°C.

|               | <b>Liter</b> | <b>US gal</b> | <b>Imp gal</b> | <b>cu.ft</b> | <b>Order number</b> |
|---------------|--------------|---------------|----------------|--------------|---------------------|
| <i>can</i>    | 5            | 1.3           | 1.1            | 0.175        | 1615 5953 00        |
| <i>can</i>    | 20           | 5.3           | 4.4            | 0.7          | 1615 5954 00        |
| <i>barrel</i> | 209          | 55.2          | 46             | 7.32         | 1615 5955 00        |
| <i>barrel</i> | 1000         | 264           | 220            | 35           | 1630 0096 00        |

### **Engine oil level check**

Consult the Engine Operation Manual for the oil specifications, viscosity recommendations and oil change intervals.

For intervals, see section “Maintenance schedule” on page 30.

Check engine oil level according to the instructions in the Engine Operation Manual and if necessary top up with oil.

### **Engine oil and oil filter change**

See section “Maintenance schedule” on page 30.

## Engine coolant specifications



Never remove the cooling system filler cap while coolant is hot.

The system may be under pressure. Remove the cap slowly and only when coolant is at ambient temperature. A sudden release of pressure from a heated cooling system can result in personal injury from the splash of hot coolant.

It is strongly recommended to use Atlas Copco branded coolant.

The use of the correct coolant is important for good heat transfer and protection of liquid-cooled engines. Coolants used in these engines must be mixtures of good quality water (distilled or de-ionised), special coolant additives and if necessary freeze protection. Coolant that is not to manufacturer's specification will result in mechanical damage of the engine.

The freezing point of the coolant must be lower than the freezing point that can occur in the area. The difference must be at least 5°C (41°F). If the coolant freezes, it may crack the cylinder block, radiator or coolant pump.

Consult the engine's operation manual and follow the manufacturer's directions.



Never mix different coolants and mix the coolant components outside the cooling system.

### Specifications PARCOOL EG

PARCOOL EG is the only coolant that has been tested and approved by all engine manufacturers currently in use in Atlas Copco compressors and generators.

Atlas Copco's PARCOOL EG extended life coolant is the new range of organic coolants purpose designed to meet the needs of modern engines. PARCOOL EG can help prevent leaks caused by corrosion. PARCOOL EG is also fully compatible with all sealants and gasket types developed to join different materials used within an engine.

PARCOOL EG is a ready to use Ethylene Glycol based coolant, premixed in an optimum 50/50 dilution ratio, for antifreeze protection guaranteed to -40°C (-40°F).

Because PARCOOL EG inhibits corrosion, deposit formation is minimized. This effectively eliminates the problem of restricted flow through the engine coolant ducts and the radiator, minimizing the risk for engine overheating and possible failure.

It reduces water pump seal wear and has excellent stability when subjected to sustained high operating temperatures.

PARCOOL EG is free of nitride and amines to protect your health and the environment. Longer service life reduces the amount of coolant produced and needing disposal to minimise environmental impact.

|        | Liter | US gal | Imp gal | cu.ft | Order number |
|--------|-------|--------|---------|-------|--------------|
| can    | 5     | 1.3    | 1.1     | 0.175 | 1604 5308 00 |
| can    | 25    | 6.5    | 4.4     | 0.7   | 1604 5307 00 |
| barrel | 209   | 55     | 46      | 7.35  | 1604 5306 00 |

To ensure protection against corrosion, cavitation and formation of deposits, the concentration of the additives in the coolant must be kept between certain limits, as stated by the manufacturer's guidelines. Topping up the coolant with water only, changes the concentration and is therefore not allowed.

Liquid-cooled engines are factory-filled with this type of coolant mixture.

## Coolant check

### Monitoring coolant condition

In order to guarantee the lifetime and quality of the product, thus to optimise engine protection, regular coolant-condition-analysis is advisable.

The quality of the product can be determined by three parameters.

### Visual check

- Verify the outlook of the coolant regarding colour and make sure that no loose particles are floating around.

### pH measurement

- Check the pH value of the coolant using a pH-measuring device.
- The pH-meter can be ordered from Atlas Copco with part number 2913 0029 00.
- Typical value for EG = 8.6.
- If the pH-level is below 7 or above 9.5, the coolant should be replaced.

### Glycol concentration measurement

- To optimise the unique engine protection features of the PARCOOL EG the concentration of the Glycol in the water should be always above 33 vol.%.
- Mixtures with more than 68 vol.% mix ratio in water are not recommended, as this will lead to high engine operating temperatures.
- A refractometer can be ordered from Atlas Copco with part number 2913 0028 00.



In case of a mix of different coolant products this type of measurement might provide incorrect values.

## Topping up of coolant

- Verify if the engine cooling system is in a good condition (no leaks, clean,...).
- Check the condition of the coolant.
- If the condition of the coolant is outside the limits, the complete coolant should be replaced (see section “Replacing the coolant”).
- Always top-up with PARCOOL EG.
- Topping up the coolant with water only, changes the concentration of additives and is therefore not allowed.

## Replacing the coolant

### Drain

- Completely drain the entire cooling system.
- Used coolant must be disposed or recycled in accordance with laws and local regulations.

### Flush

- Flush twice with clean water. Used coolant must be disposed or recycled in accordance with laws and local regulations.
- From the Atlas Copco Instruction book, determine the amount of PARCOOL EG required and pour into the radiator top tank.
- It should be clearly understood that the risk for contamination is reduced in case of proper cleaning.
- In case a certain content of ‘other’ coolant remains in the system, the coolant with the lowest properties influences the quality of the ‘mixed’ coolant.

### Fill

- To assure proper operation and the release of trapped air, run the engine until normal engine operation temperature is reached. Turn off the engine and allow to cool.
- Recheck coolant level and add if necessary.

## Storage of the generator

### Storage

- Store the generator in a dry, frost-free room which is well ventilated.
- Run the engine regularly, e.g. once a week, until it is warmed up. If this is impossible, extra precautions must be taken:
  - Consult the engine’s operator manual.
  - Remove the battery. Store it in a dry, frost-free room. Keep the battery clean and its terminals lightly covered with petroleum jelly. Recharge the battery regularly.
  - Clean the generator and protect all electrical components against moisture.
  - Place silica gel bags, VCI paper (Volatile Corrosion Inhibitor) or another drying agent inside the generator and close the doors.
  - Stick sheets of VCI paper with adhesive tape on the bodywork to close off all openings.
  - Wrap the generator, except the bottom, with a plastic bag.

### Preparing for operation after storage

Before operating the generator again, remove the wrapping, VCI paper and silica gel bags and check the generator thoroughly (go through the checklist “Before starting” on page 27).

- Consult the engine’s operator manual.
- Check that the insulation resistance of the generator exceeds 5 MΩ.
- Replace the fuel filter and fill the fuel tank. Vent the fuel system.
- Reinstall and connect the battery, if necessary after being recharged.
- Submit the generator to a test run.

## Checks and trouble shooting



Never perform a test run with connected power cables. Never touch an electrical connector without a voltage check.

When a failure occurs, always report what you experienced before, during and after the failure. Information with regard to the load (type, size, power factor, etc.), vibrations, exhaust gas colour, insulation check, odours, output voltage, leaks and damaged parts, ambient temperature, daily and normal maintenance and altitude might be helpful to quickly locate the problem. Also report any information regarding the humidity and location of the generator (e.g. close to sea).

### Checking voltmeter P4

- Put a voltmeter in parallel with voltmeter P4 on the control panel.
- Check that the read-out of both voltmeters is the same.
- Stop the generator and disconnect one terminal.
- Check that the internal resistance of the voltmeter is high.

### Checking ammeters P1, P2 and P3

- Measure by means of a clamp-on probe the outgoing current during the load.
- Compare the measured currents with the currents on the corresponding ammeters. Both readings should be the same.

### Engine troubleshooting

Refer to the engine’s operator manual for the engine troubleshooting. An extensive Engine troubleshooting manual is available at John Deere. For more information contact John Deere.



## Alternator troubleshooting

| <i>Symptom</i>  | <i>Possible cause</i>   | <i>Corrective action</i>   |
|---|---|--|
| <i>Alternator gives 0 Volt</i>                                | Blown fuse.<br>No residual voltage.   | Replace fuse.<br>Excite the alternator by applying a 12V battery voltage with a 30 W resistor in series on the + and - terminals of the electronic regulator, respecting the polarities. |
| <i>After being excited the alternator still gives 0 Volt.</i> | Connections are interrupted.  | Check connection cables, measure winding resistances and compare with values mentioned in the alternator manual.   |
| <i>Low voltage at no load</i>                                 | Voltage potentiometer out of setting.<br>Intervention of protection.<br>Winding failure.                              | Reset voltage.<br>Check frequency/voltage regulator.<br>Check windings.  |
| <i>High voltage at no load</i>                                | Voltage potentiometer out of setting.<br>Failed regulator.  | Reset voltage.<br>Substitute regulator.  |
| <i>Lower than rated voltage at load</i>                       | Voltage potentiometer out of setting.<br>Intervention by protection.<br>Failed regulator.<br>Rotating bridge failure. | Reset voltage potentiometer.<br>Current too high, power factor lower than 0.8; speed lower than 10% of rated speed.<br>Substitute regulator.<br>Check diodes, disconnect cables.         |
| <i>Higher than rated voltage at load</i>                      | Voltage potentiometer out of setting.<br>Failed regulator.  | Reset voltage potentiometer.<br>Substitute regulator.  |
| <i>Unstable voltage</i>                                       | Speed variation in engine.<br>Regulator out of setting.   | Check regularity of rotation.<br>Regulate stability of regulator by acting on STABILITY potentiometer.   |

## Options available for QAS 70-90-120 T4A John Deere units

### Circuit diagrams

The engine control circuit diagrams and the power circuit diagrams for the standard QAS 70-90-120 T4A John Deere units, for the units with options and for the units with combined options are:

#### Power circuit

| Unit              | Circuit      |
|-------------------|--------------|
| QAS 70-90-120 T4A | 1310 3200 29 |

#### Controller circuit

| Unit              | Circuit      |
|-------------------|--------------|
| QAS 70-90-120 T4A | 1310 3200 12 |

### Overview of the electrical options

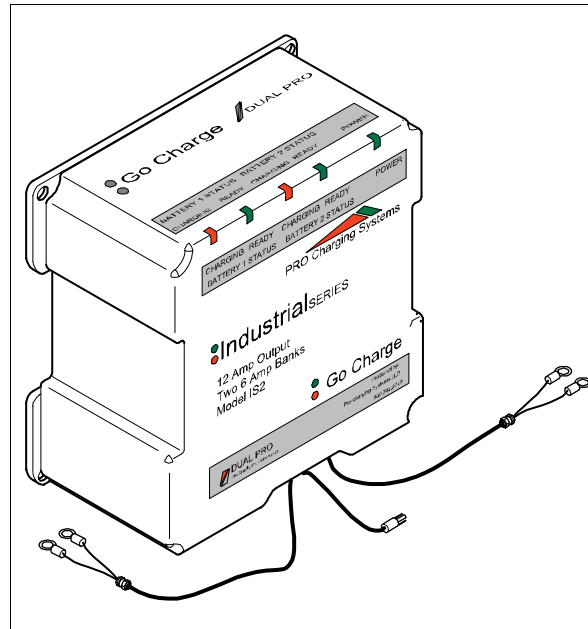
The following electrical options are available:

- Automatic battery charger

### Description of the electrical options

#### Automatic battery charger

The automatic battery charger charges the battery when external power is provided via the X7 connection. When the battery is fully charged the charger automatically changes to maintenance mode and provides a trickle charge to maintain the battery level. The charger has LED's on the front panel to identify when power is applied to the charger and when the batteries are being charged.



To use the battery charger:

- Provide external power (120V) to the X7 connector, located on the side of the power cubicle.

#### Battery switch

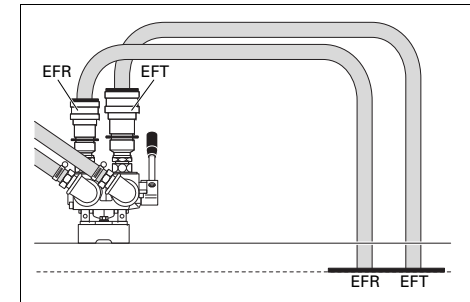
The battery switch is situated inside the sound-insulated bodywork. It allows to open or to close the electrical connection between the battery and the engine circuits.



**Never turn the battery switch to OFF during operation.**

### EFT - Quick Coupling

The option Quick couplings allows to bypass the internal fuel tank and to connect an external fuel tank to the unit.



EFT | External fuel tank connection  
EFR | External fuel tank return connection

Make sure that:

- the big size coupling is used for the inlet.
- the small size coupling is used for the outlet.



**An extra clamp needs to be used to guide the fuellines.**

### Engine coolant heater

To make sure that the engine can start and accept load immediately, an engine block heater (immersion style) is provided - 120V 1500W.

## Technical specifications

### Technical specifications for QAS 70-90-120 T4A

#### Readings on gauges

| Gauge                 | Reading           | Unit |
|-----------------------|-------------------|------|
| Ammeter L1-L3 (P1-P3) | Below max. rating | A    |
| Voltmeter (P4)        | Below max. rating | V    |

#### Settings of switches

| Switch                     | Function  | Activates at |
|----------------------------|-----------|--------------|
| Engine oil pressure        | Shut down | xxxx         |
| Engine coolant temperature | Shut down | xxxx         |

#### Specifications of the engine/alternator/unit

|                                  |  | QAS 70 T4A     |                | QAS 90 T4A     |                | QAS 120 T4A    |                |
|----------------------------------|--|----------------|----------------|----------------|----------------|----------------|----------------|
|                                  |  | US             | Metric         | US             | Metric         | US             | Metric         |
| <i>Reference conditions 1)</i>   | Rated frequency                                  | 60 Hz          | 60 Hz          | 60 Hz          | 60 Hz          | 60 Hz          | 60 Hz          |
|                                  | Rated speed                                      | 1800 rpm       | 1800 rpm       | 1800 rpm       | 1800 rpm       | 1800 rpm       | 1800 rpm       |
|                                  | Generator service duty                           | PRP            | PRP            | PRP            | PRP            | PRP            | PRP            |
|                                  | Absolute air inlet pressure                      | 100 kPa        | 100 kPa        | 100 kPa        | 100 kPa        | 100 kPa        | 100 kPa        |
|                                  | Relative air humidity                            | 30%            | 30%            | 30%            | 30%            | 30%            | 30%            |
|                                  | Air inlet temperature                            | 77°F           | 25°C           | 77°F           | 25°C           | 77°F           | 25°C           |
| <i>Limitations 2)</i>            | Maximum ambient temperature                      | 122°F          | 50°C           | 122°F          | 50°C           | 122°F          | 50°C           |
|                                  | Altitude capability                              | 13,123 ft      | 4000 m         | 13,123 ft      | 4000 m         | 13,123 ft      | 4000 m         |
|                                  | Maximum relative air humidity                    | 85%            | 85%            | 85%            | 85%            | 85%            | 85%            |
|                                  | Minimum starting temperature unaided             | 0°F            | -18°C          | 0°F            | -18°C          | 0°F            | -18°C          |
|                                  | Minimum starting temperature with coolant heater | -4°F           | -25°C          | -4°F           | -25°C          | -4°F           | -25°C          |
| <i>Performance data 2) 3) 5)</i> | Rated active power (PRP) 3ph                     | 75 hp          | 56 kW          | 100 hp         | 75 kW          | 127 hp         | 95 kW          |
|                                  | Rated active power (PRP) 3ph 240V                | NA             | NA             | NA             | NA             | NA             | NA             |
|                                  | Rated active power (PRP) 3ph 208V                | NA             | NA             | NA             | NA             | NA             | NA             |
|                                  | Rated active power (PRP) 1ph                     | 54 hp          | 40 kW          | 71 hp          | 53 kW          | 99 hp          | 74 kW          |
|                                  | Rated power factor (lagging) 3ph                 | 0.8 cos $\phi$ | 0.8 cos $\phi$ | 0.8 cos $\phi$ | 0.8 cos $\phi$ | 0.8 cos $\phi$ | 0.8 cos $\phi$ |
|                                  | Rated power factor (lagging) 1ph                 | 1.0 cos $\phi$ | 1.0 cos $\phi$ | 1.0 cos $\phi$ | 1.0 cos $\phi$ | 1.0 cos $\phi$ | 1.0 cos $\phi$ |
|                                  | Rated apparent power (PRP) 3ph                   | 70 kVA         | 70 kVA         | 94 kVA         | 94 kVA         | 120 kVA        | 120 kVA        |
|                                  | Rated apparent power (PRP) 3ph 240V              | NA             | NA             | NA             | NA             | NA             | NA             |
|                                  | Rated apparent power (PRP) 3ph 208V              | NA             | NA             | NA             | NA             | NA             | NA             |
|                                  | Rated apparent power (PRP) 1ph                   | 40 kVA         | 40 kVA         | 53 kVA         | 53 kVA         | 74 kVA         | 74 kVA         |
|                                  | Rated voltage 3ph line to line                   | 480 V          | 480 V          | 480 V          | 480 V          | 480 V          | 480 V          |

|                         |  | QAS 70 T4A       |                  | QAS 90 T4A       |                  | QAS 120 T4A      |                  |
|-------------------------|--|------------------|------------------|------------------|------------------|------------------|------------------|
|                         |  | US               | Metric           | US               | Metric           | US               | Metric           |
|                         | Rated voltage 3ph line to line lower voltage   | 240 V            | 240 V            | 240 V            | 240 V            | 240 V            | 240 V            |
|                         | Rated voltage 1ph line to line   | 240 V            | 240 V            | 240 V            | 240 V            | 240 V            | 240 V            |
|                         | Rated current 3 ph   | 84.2 A           | 84.2 A           | 112.8 A          | 112.8 A          | 142.8 A          | 142.8 A          |
|                         | Rated current 3 ph lower voltage   | 168.4 A          | 168.4 A          | 225.5 A          | 225.5 A          | 285.7 A          | 285.7 A          |
|                         | Rated current 3 ph 208V  | NA               | NA               | NA               | NA               | NA               | NA               |
|                         | Rated current 1 ph line to line  | 166.7 A          | 166.7 A          | 220.8A           | 220.8A           | 308.3 A          | 308.3 A          |
|                         | Performance class (acc.ISO 8528-5:1993)  | G2               | G2               | G2               | G2               | G2               | G2               |
|                         | Single step load acceptance (0-PRP)  | 80%              | 80%              | 80%              | 80%              | 80%              | 80%              |
|                         |  | 60 hp            | 45 kW            | 80 hp            | 60 kW            | 101 hp           | 76 kW            |
|                         | Frequency droop  | isochronous      | isochronous      | isochronous      | isochronous      | isochronous      | isochronous      |
|                         | Fuel consumption at 0% load  | - lb/h           | 1.17 gph         | - lb/h           | 1.20 gph         | - lb/h           | 1.50 gph         |
|                         | Fuel consumption at 50% load   | - lb/h           | 2.42 gph         | - lb/h           | 3.00 gph         | - lb/h           | 3.75 gph         |
|                         | Fuel consumption at 75% load   | - lb/h           | 3.20 gph         | - lb/h           | 4.00 gph         | - lb/h           | 5.50 gph         |
|                         | Fuel consumption at full load (100%)   | - lb/h           | 4.27 gph         | - lb/h           | 5.39 gph         | - lb/h           | 7.00 gph         |
|                         | Specific fuel consumption at full load (100%)  | 0.0 lb/kWh       | 0.262 kg/kWh     | 0.0 lb/kWh       | 0.262 kg/kWh     | 0.0 lb/kWh       | 0.262 kg/kWh     |
|                         | Fuel autonomy at full load with standard tank  | 37.5 h           | 37.5 h           | 30 h             | 30 h             | 24 h             | 24 h             |
|                         | Max. oil consumption at full load  | -                | -                | -                | -                | -                | -                |
|                         | Maximum sound pressurer level (LPA) measured according to Atlas Copco spec. 9822087700 | 69 dB(A)         | 69 dB(A)         | 69 dB(A)         | 69 dB(A)         | 69 dB(A)         | 69 dB(A)         |
|                         | Useful capacity of fuel tank   | 170 gal          | 643 l            | 170 gal          | 643 l            | 170 gal          | 643 l            |
|                         | Single step load acceptance  | 100%             | 100%             | 100%             | 100%             | 100%             | 100%             |
|                         |  | NA               | NA               | NA               | NA               | NA               | NA               |
| <b>Application data</b> | Mode of operation  | PRP              | PRP              | PRP              | PRP              | PRP              | PRP              |
|                         | Site   | land use         | land use         | land use         | land use         | land use         | land use         |
|                         | Operation  | single           | single           | single           | single           | single           | single           |
|                         | Start-up and control mode  | manual/automatic | manual/automatic | manual/automatic | manual/automatic | manual/automatic | manual/automatic |
|                         | Start-up time  | unspecified      | unspecified      | unspecified      | unspecified      | unspecified      | unspecified      |
|                         | Mobility/Config. acc. to ISO 8528-1:1993   | transportable/D  | transportable/D  | transportable/D  | transportable/D  | transportable/D  | transportable/D  |
|                         |  | mobile/E         | mobile/E         | mobile/E         | mobile/E         | mobile/E         | mobile/E         |
|                         | Mounting   | fully resilient  | fully resilient  | fully resilient  | fully resilient  | fully resilient  | fully resilient  |
|                         | Climatic exposure  | open air         | open air         | open air         | open air         | open air         | open air         |
|                         | Degree of protection (Cubicle)   | IP 54            | IP 54            | IP 54            | IP 54            | IP 54            | IP 54            |
|                         | Status of neutral  | earthed          | earthed          | earthed          | earthed          | earthed          | earthed          |
| <b>Alternator</b>       | Standard   | IEC 34-1         | IEC 34-1         | IEC 34-1         | IEC 34-1         | IEC 34-1         | IEC 34-1         |
|                         |  | ISO 8528-3       | ISO 8528-3       | ISO 8528-3       | ISO 8528-3       | ISO 8528-3       | ISO 8528-3       |

|                      |  | QAS 70 T4A       |                  | QAS 90 T4A       |                  | QAS 120 T4A      |                  |
|----------------------|--|------------------|------------------|------------------|------------------|------------------|------------------|
|                      |  | US               | Metric           | US               | Metric           | US               | Metric           |
|                      | Make   | LEROY SOMER      | LEROY SOMER      | LEROY SOMER      | LEROY SOMER      | LEROY SOMER      | LEROY SOMER      |
|                      | Model  | LSA 43.2 M45     | LSA 43.2 M45     | LSA 43.2 L8      | LSA 43.2 L8      | LSA 44.2 VS45    | LSA 44.2 VS45    |
|                      | Rated output, class H temperature rise                 | 71 kVA           | 71 kVA           | 96 kVA           | 96 kVA           | 131 kVA          | 131 kVA          |
|                      | rating type acc. ISO 8528-3                            | “BR”             | “BR”             | “BR”             | “BR”             | “BR”             | “BR”             |
|                      | Degree of protection                                   | IP 23            | IP 23            | IP 23            | IP 23            | IP 23            | IP 23            |
|                      | Insulation - stator                                    | H class          | H class          | H class          | H class          | H class          | H class          |
|                      | -rotor   | H class          | H class          | H class          | H class          | H class          | H class          |
|                      | Number of wires  | 12               | 12               | 12               | 12               | 12               | 12               |
|                      | Excitation   | -                | -                | -                | -                | -                | -                |
| <b>Engine</b>        | Standard   | ISO 3046         | ISO 3046         | ISO 3046         | ISO 3046         | ISO 3046         | ISO 3046         |
|                      |  | ISO 8528-2       | ISO 8528-2       | ISO 8528-2       | ISO 8528-2       | ISO 8528-2       | ISO 8528-2       |
|                      | Make   | John Deere       | John Deere       | John Deere       | John Deere       | John Deere       | John Deere       |
|                      | Model  | 4045HFG92        | 4045HFG92        | 4045HFG92        | 4045HFG92        | 4045HFG93        | 4045HFG93        |
|                      | Rated net output                                       | 96.5 hp          | 72 kW            | 120.6 hp         | 90 kW            | 151.5 hp         | 113 kW           |
|                      | rating type acc. ISO 3046-7                            | ICXN             | ICXN             | ICXN             | ICXN             | ICXN             | ICXN             |
|                      | Coolant  | water            | water            | water            | water            | water            | water            |
|                      | Combustion system                                      | direct injection | direct injection | direct injection | direct injection | direct injection | direct injection |
|                      | Aspiration   | turbocharged     | turbocharged     | turbocharged     | turbocharged     | turbocharged     | turbocharged     |
|                      |  | intercooled      | intercooled      | intercooled      | intercooled      | intercooled      | intercooled      |
|                      | Number of cylinders                                    | 4                | 4                | 4                | 4                | 4                | 4                |
|                      | Swept volume   | 1.18 US gal      | 4.5 l            | 1.18 US gal      | 4.5 l            | 1.18 US gal      | 4.5 l            |
|                      | Speed governing  | electronic       | electronic       | electronic       | electronic       | electronic       | electronic       |
|                      |  | -                | -                | -                | -                | -                | -                |
|                      | Capacity of oil sump                                   | 5.41 US gal      | 20.5 l           | 5.41 US gal      | 20.5 l           | 5.41 US gal      | 20.5 l           |
|                      | Capacity of cooling system                             | 5.81 US gal      | 22 l             | 5.81 US gal      | 22 l             | 5.81 US gal      | 22 l             |
|                      | Electrical system                                      | 12 Vdc           | 12 Vdc           | 12 Vdc           | 12 Vdc           | 12 Vdc           | 12 Vdc           |
|                      | Emission compliance                                    | -                | -                | -                | -                | -                | -                |
| <b>Power circuit</b> | Circuit-breaker, 3ph.                                  |                  |                  |                  |                  |                  |                  |
|                      | Number of poles  | 3                | 3                | 3                | 3                | 3                | 3                |
|                      | Thermal release It (thermal release is higher at 25°C) | 200 A            | 200 A            | 400 A            | 400 A            | 400 A            | 400 A            |
|                      | Magnetic release Im                                    | 3,5 x In         | 3,5 x In         | 3,5 x In         | 3,5 x In         | 3,5 x In         | 3,5 x In         |
|                      | Outlet sockets (optional)                              | GFCL duplex (2x) | GFCL duplex (2x) | GFCL duplex (2x) | GFCL duplex (2x) | GFCL duplex (2x) | GFCL duplex (2x) |

|  |  | QAS 70 T4A       |                 | QAS 90 T4A      |                 | QAS 120 T4A     |                 |
|--|--|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|  |  | <i>US</i>        | <i>Metric</i>   | <i>US</i>       | <i>Metric</i>   | <i>US</i>       | <i>Metric</i>   |
|  |  | 2p+E             | 2p+E            | 2p+E            | 2p+E            | 2p+E            | 2p+E            |
|  |  | 20A 125V         | 20A 125V        | 20A 125V        | 20A 125V        | 20A 125V        | 20A 125V        |
|  |  | Temp Power (2x)  | Temp Power (2x) | Temp Power (2x) | Temp Power (2x) | Temp Power (2x) | Temp Power (2x) |
|  |  | 2p+N+E           | 2p+N+E          | 2p+N+E          | 2p+N+E          | 2p+N+E          | 2p+N+E          |
|  |  | 50A 125/<br>250V | 50A 125/250V    | 50A 125/250V    | 50A 125/250V    | 50A 125/250V    | 50A 125/250V    |

## Notes

- 1) Reference conditions for engine performance to ISO 3046-1.
- 2) See derating diagram or consult the factory for other conditions.
- 3) At reference conditions unless otherwise stated.  
Rating definition (ISO 8528-1):  
LTP: Limited Time Power is the maximum electrical power which a generating set is capable of delivering (at variable load), in the event of a utility power failure (for up to 500 hours per year of which a maximum of 300 hours is continuous running). No overload is permitted on these ratings. The alternator is peak continuous rated (as defined in ISO 8528-3) at 25°C.
- 4) PRP: Prime Power is the maximum power available during a variable power sequence, which may be run for an unlimited number of hours per year, between stated maintenance intervals and under the stated ambient conditions. A 10% overload is permitted for 1 hour in 12 hours. The permissible average power output during a 24h period shall not exceed the stated load factor of 70%.
- 5) Specific mass fuel used: 0.86 kg/l.
  - (a) optional equipment
  - (b) thermal release is higher at 25°C

Generating set

Nominal power output (kVA) at 40°C, 1000m: 33.0kVA

| derating factor % |      | temperature (°C) |     |     |     |     |     |     |     |     |     |    |    |    |
|-------------------|------|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|
| height (m)        |      | 0                | 5   | 10  | 15  | 20  | 25  | 30  | 35  | 40  | 45  | 50 | 55 |    |
|                   | 0    | 100              | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 97 | 94 | 91 |
|                   | 500  | 100              | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 97 | 94 | 91 |
|                   | 1000 | 100              | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 97 | 94 | 91 |
|                   | 1500 | 97               | 97  | 97  | 97  | 97  | 97  | 97  | 97  | 97  | 97  | 94 | 91 | 88 |
|                   | 2000 | 94               | 94  | 94  | 94  | 94  | 94  | 94  | 94  | 94  | 94  | 91 | 88 | 86 |
|                   | 2500 | 88               | 88  | 88  | 88  | 88  | 88  | 88  | 88  | 88  | 88  | 85 | 83 | 80 |
|                   | 3000 | 88               | 88  | 88  | 88  | 88  | 88  | 88  | 88  | 88  | 88  | 85 | 83 | 80 |
|                   | 3500 | 82               | 82  | 82  | 82  | 82  | 82  | 82  | 82  | 82  | 82  | 80 | 77 | 75 |
|                   | 4000 | 82               | 82  | 82  | 82  | 82  | 82  | 82  | 82  | 82  | 82  | 80 | 77 | 75 |

When nominal power is lower then 33kVA => 30kVA, the derating factor is different!

| derating factor % |      | temperature (°C) |     |     |     |     |     |     |     |     |     |    |    |    |
|-------------------|------|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|
| height (m)        |      | 0                | 5   | 10  | 15  | 20  | 25  | 30  | 35  | 40  | 45  | 50 | 55 |    |
|                   | 0    | 100              | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 97 | 94 | 91 |
|                   | 500  | 100              | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 97 | 94 | 91 |
|                   | 1000 | 100              | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 97 | 94 | 91 |
|                   | 1500 | 97               | 97  | 97  | 97  | 97  | 97  | 97  | 97  | 97  | 97  | 94 | 91 | 88 |
|                   | 2000 | 94               | 94  | 94  | 94  | 94  | 94  | 94  | 94  | 94  | 94  | 91 | 88 | 86 |
|                   | 2500 | 88               | 88  | 88  | 88  | 88  | 88  | 88  | 88  | 88  | 88  | 85 | 83 | 80 |
|                   | 3000 | 88               | 88  | 88  | 88  | 88  | 88  | 88  | 88  | 88  | 88  | 85 | 83 | 80 |
|                   | 3500 | 82               | 82  | 82  | 82  | 82  | 82  | 82  | 82  | 82  | 82  | 80 | 77 | 75 |
|                   | 4000 | 82               | 82  | 82  | 82  | 82  | 82  | 82  | 82  | 82  | 82  | 80 | 77 | 75 |

For use of generator outside these conditions, please contact Atlas Copco.




## Conversion list of SI units into British units

## Dataplate

|                       |   |                               |
|-----------------------|---|-------------------------------|
| 1 bar                 | = | 14.504 psi                    |
| 1 g                   | = | 0.035 oz                      |
| 1 kg                  | = | 2.205 lb                      |
| 1 km/h                | = | 0.621 mile/h                  |
| 1 kW                  | = | 1.341 hp (UK and US)          |
| 1 l                   | = | 0.264 US gal                  |
| 1 l                   | = | 0.220 Imp gal (UK)            |
| 1 l                   | = | 0.035 cu.ft                   |
| 1 m                   | = | 3.281 ft                      |
| 1 mm                  | = | 0.039 in                      |
| 1 m <sup>3</sup> /min | = | 35.315 cfm                    |
| 1 mbar                | = | 0.401 in wc                   |
| 1 N                   | = | 0.225 lbf                     |
| 1 Nm                  | = | 0.738 lbf.ft                  |
| t <sub>°F</sub>       | = | 32 + (1.8 x t <sub>°C</sub> ) |
| t <sub>°C</sub>       | = | (t <sub>°F</sub> - 32)/1.8    |

A temperature difference of 1°C = a temperature difference of 1.8°F.

| AC GENERATOR  |              |
|---|--------------|
| Model   |              |
| Product Number  |              |
| Serial Number   |              |
| Year of Manufacture   | 20           |
| Max. Power (KW/KVA)   | 56/70        |
| Voltages 3-Phase  | 480/240/208  |
| Amperage Max. 3-Phase   | 84/168/194   |
| Voltages 1-Phase  | 240/120      |
| Amperage Max. 1-Phase   | 180          |
| Power Factor  | 0.8/0.8/1.0  |
| Max. Ambient Temp (F/C)   | 122/50       |
| Weight (LB/KG)  | 5310/2408    |
| Frequency (RPM/Hz)  | 1800/60      |
| Alternator Temp Class   |              |
| Neutral Bonded to Frame   |              |
| ATLAS COPCO   | U.S.A 239768 |
| ROCK HILL, SC   |              |
|  |              |
| 1310 0355 22 electrical equipment only  |              |

# **Disposal**

## **General**

When developing products and services, Atlas Copco tries to understand, address, and minimize the negative environmental effects that the products and services may have, when being manufactured, distributed, and used, as well as at their disposal.

Recycling and disposal policy are part of the development of all Atlas Copco products. Atlas Copco company standards determine strict requirements.

Selecting materials the substantial recyclability, the disassembly possibilities and the separability of materials and assemblies are considered as well as the environmental perils and dangers to health during the recycling and disposal of the unavoidable rates of not recyclable materials.

Your Atlas Copco generator consists for the most part of metallic materials, that can be remelted in steelworks and smelting works and that is therefore almost infinite recyclable. The plastic used is labelled; sorting and fractioning of the materials for recycling in the future is foreseen.



**This concept can only succeed with your help. Support us by disposing professionally. By assuring a correct disposal of the product you help to prevent possible negative consequences for environment and health, that can occur with an inappropriate waste handling.**

**Recycling and re-usage of material helps to preserve natural resources.**

## **Disposal of materials**

Dispose contaminated substances and material separately, according to local applicable environmental legislations.

Before dismantling a machine at the end of its operating lifetime drain all fluids and dispose of according the applicable local disposal regulations.

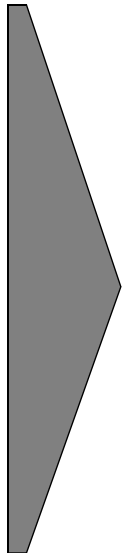
Remove the batteries. Do not throw batteries into the fire (explosion risk) or into the residual waste. Separate the machine into metal, electronics, wiring, hoses, insulation and plastic parts.

Dispose all components according to the applicable disposal regulations.

Remove spilled fluid mechanically; pick up the rest with absorbing agent (for example sand, sawdust) and dispose it according the applicable local disposal regulations. Do not drain into the sewage system or surface water.

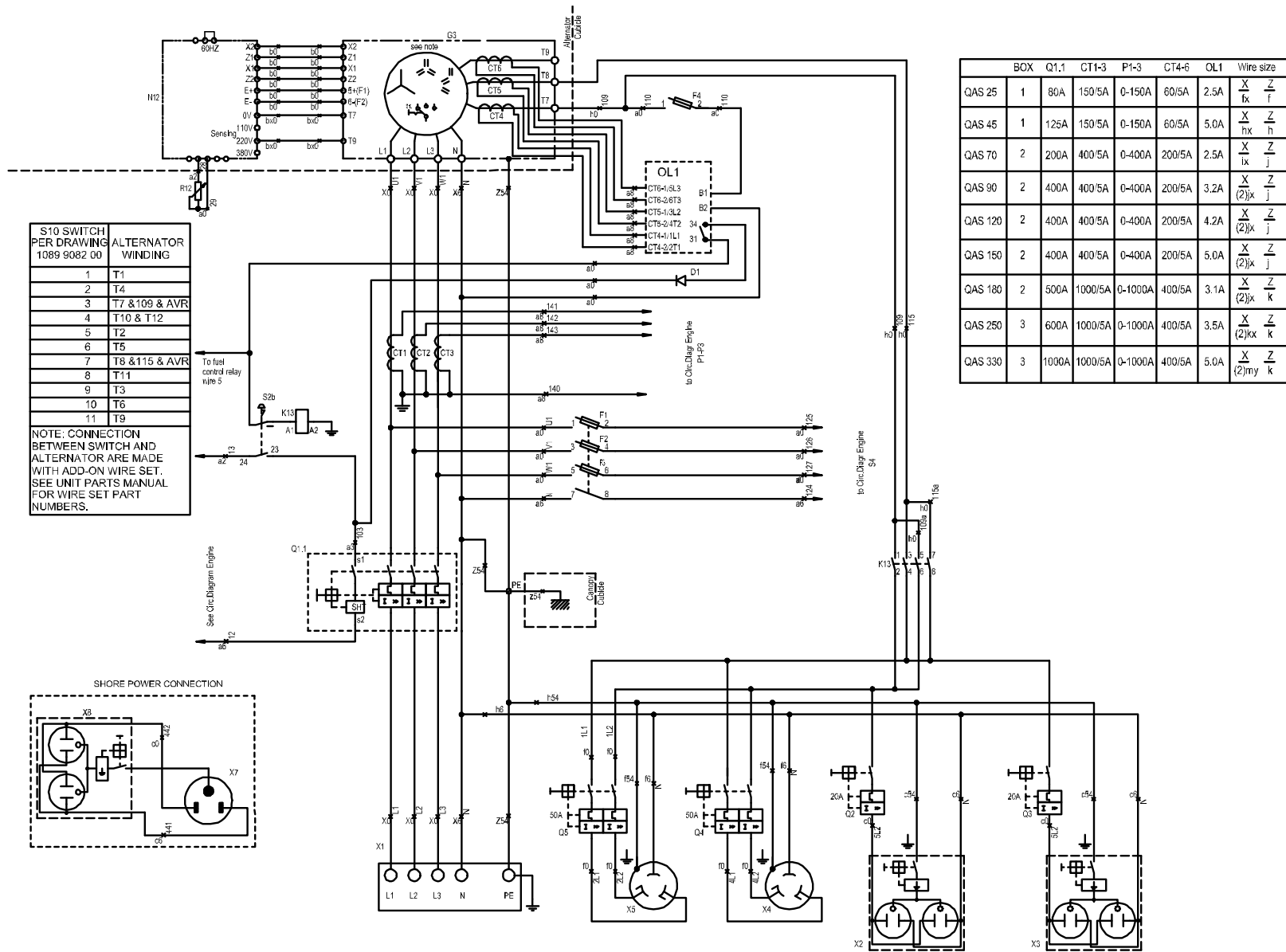


**Circuit diagrams**



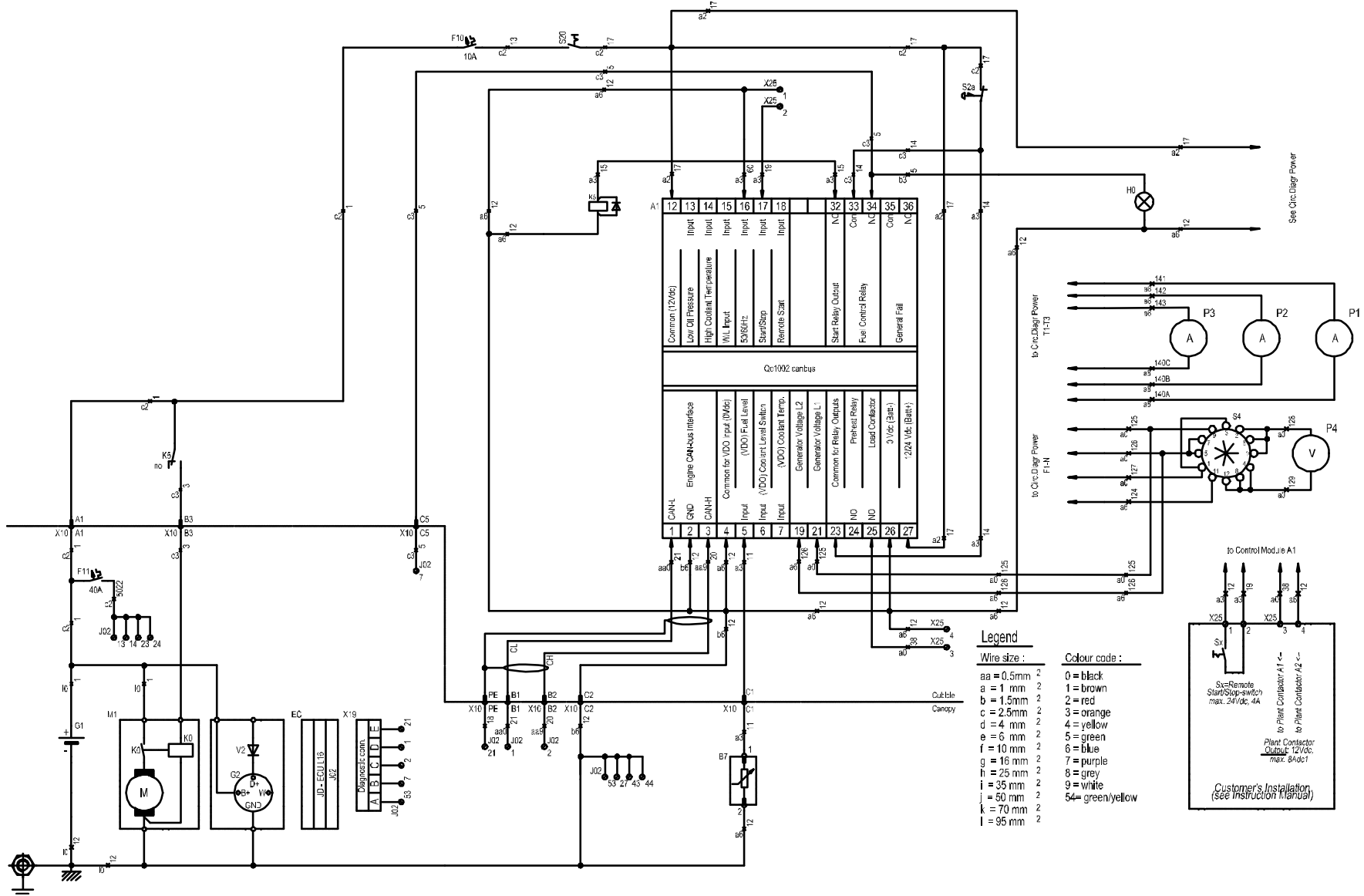
1310 3200 29/00

Applicable for QAS 70-90-120 John Deere - Power circuit



| Mark | Grid  | Name  |
|------|-------|---|
| A1   | b5    | Control Module                                    |
| B7   | f6    | Fuel Level Sensor                                 |
| EC   | f3    | Engine controller                                 |
| F10  | a4    | Fuse controller                                   |
| F11  | e1    | Fuse - ECU  |
| G1   | f1    | Battery 12V                                       |
| H0   | b9    | Panel Light                                       |
| J02  | e1-f5 | Engine connector                                  |
| K5   | b5    | Starter Relay                                     |
| M1   | f2    | Starter Motor                                     |
| P1-3 | c9-10 | A-Meters  |
| P4   | d10   | V-meter   |
| S2a  | a8    | Emergency Stop Button<br>(S2b: see Power Circuit) |
| S4   | d10   | Voltmeter change-over switch                      |
| S6   | f7    | Coolant Level Switch                              |
| S7   | f6    | Low Fuel Level Switch                             |
| S7   | f6    | Low Fuel Level Switch, Warning                    |
| S20  | a5    | ON/OFF Switch                                     |
| V2   | f2    | Diode   |
| X10  | d1-f7 | Terminal strip                                    |
| X17  | f6-g6 | Fuel Level Unit Connector                         |
| X19  | f3    | Motor Diagnostic Plug                             |
| X25  | a6,e7 | Terminal strip                                    |
| O    | (0)   | Optional Equipment                                |

**1310 3200 12/00**  
**Applicable for QAS 70-90-120 John Deere - Engine circuit Qc1002TM**



| Mark | Grid  | Name  |
|------|-------|---|
| A1   | b5    | Control Module                                    |
| B7   | f6    | Fuel Level Sensor                                 |
| EC   | f3    | Engine controller                                 |
| F10  | Q4    | Fuse  |
| F11  | e1    | Fuse  |
| G1   | f1    | Battery 12V                                       |
| H0   | b9    | Panel Light                                       |
| J02  | e1-f5 | Engine connector                                  |
| K5   | b5    | Starter Relay                                     |
| M1   | f2    | Starter Motor                                     |
| P1-3 | c9-10 | A-Meters  |
| P4   | d10   | V-meter   |
| R3   | e5    | Resistor 120 ohm                                  |
| S2a  | a8    | Emergency Stop Button<br>(S2b: see Power Circuit) |
| S4   | d10   | Voltmeter change-over switch                      |
| S6   | f7    | Coolant Level Switch                              |
| S7   | f6    | Low Fuel Level Switch                             |
| S7   | f6    | Low Fuel Level Switch, Warning                    |
| S20  | a5    | ON/OFF Switch                                     |
| V2   | f2    | Diode   |
| X10  | d1-f7 | Terminal strip                                    |
| X17  | f6-g6 | Fuel Level Unit Connector                         |
| X19  | f3    | Motor Diagnostic Plug                             |
| X25  | a6,e7 | Terminal strip                                    |
| (0)  | (0)   | Optional Equipment                                |







Parts List  
for Portable Generators  
English

QAS 70 JD T4A HOP  
QAS 90 JD T4A HOP  
QAS 120 JD T4A HOP

Engine JD 4045 HFG92

Engine JD 4045 HFG93



**QAS 70 JD T4A HOP**  
**QAS 90 JD T4A HOP**  
**QAS 120 JD T4A HOP**

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## **INSTRUCTION MANUAL**

### **Warranty and Liability Limitation**

Use only authorized parts.

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# SAFETY PRECAUTIONS FOR PORTABLE GENERATORS

To be read attentively and acted accordingly before towing, lifting, operating, performing maintenance or repairing the generator

## 0.1 INTRODUCTION

The policy of Atlas Copco is to provide the users of their equipment with safe, reliable and efficient products. Factors taken into account are among others:

- the intended and predictable future use of the products, and the environments in which they are expected to operate,
- applicable rules, codes and regulations,
- the expected useful product life, assuming proper service and maintenance,
- providing the manual with up-to-date information.

Before handling any product, take time to read the relevant instruction manual. Besides giving detailed operating instructions, it also gives specific information about safety, preventive maintenance, etc.

Keep the manual always at the unit location, easy accessible to the operating personnel.

See also the safety precautions of the engine and possible other equipment, which are separately sent along or are mentioned on the equipment or parts of the unit.

These safety precautions are general and some statements will therefore not always apply to a particular unit.

Only people that have the right skills should be allowed to operate, adjust, perform maintenance or repair on Atlas Copco equipment. It is the responsibility of management to appoint operators with the appropriate training and skill for each category of job.

### Skill level 1: Operator

An operator is trained in all aspects of operating the unit with the push-buttons, and is trained to know the safety aspects.

### Skill level 2: Mechanical technician

A mechanical technician is trained to operate the unit the same as the operator. In addition, the mechanical technician is also trained to perform maintenance and repair, as described in the instruction manual, and is allowed to change settings of the control and safety system. A mechanical technician does not work on live electrical components.

### Skill level 3: Electrical technician

An electrical technician is trained and has the same

qualifications as both the operator and the mechanical technician. In addition, the electrical technician may carry out

electrical repairs within the various enclosures of the unit. This includes work on live electrical components.

### Skill level 4: Specialist from the manufacturer

This is a skilled specialist sent by the manufacturer or its agent to perform complex repairs or modifications to the equipment.

In general it is recommended that not more than two people operate the unit, more operators could lead to unsafe operating conditions. Take necessary steps to keep unauthorized persons away from the unit and eliminate all possible sources of danger at the unit.

When handling, operating, overhauling and/or performing maintenance or repair on Atlas Copco equipment, the mechanics are expected to use safe engineering practices and to observe all relevant local safety requirements and ordinances. The following list is a reminder of special safety directives and precautions mainly applicable to Atlas Copco equipment.

Neglecting the safety precautions may endanger people as well as environment and machinery:

- endanger people due to electrical, mechanical or chemical influences,
- endanger the environment due to leakage of oil, solvents or other substances,
- endanger the machinery due to function failures.

All responsibility for any damage or injury resulting from neglecting these precautions or by non-observance of ordinary caution and due care required in handling, operating, maintenance or repair, also if not expressly mentioned in this instruction manual, is disclaimed by Atlas Copco.

The manufacturer does not accept any liability for any damage arising from the use of non-original parts and for modifications, additions or conversions made without the manufacturer's approval in writing.

If any statement in this manual does not comply with local legislation, the stricter of the two shall be applied.

Statements in these safety precautions should not be interpreted as suggestions, recommendations or inducements that it should be used in violation of any

applicable laws or regulations.

## 0.2 GENERAL SAFETY PRECAUTIONS

- 1 The owner is responsible for maintaining the unit in a safe operating condition. Unit parts and accessories must be replaced if missing or unsuitable for safe operation.
- 2 The supervisor, or the responsible person, shall at all times make sure that all instructions regarding machinery and equipment operation and maintenance are strictly followed and that the machines with all accessories and safety devices, as well as the consuming devices, are in good repair, free of abnormal wear or abuse, and are not tampered with.
- 3 Whenever there is an indication or any suspicion that an internal part of a machine is overheated, the machine shall be stopped but no inspection covers shall be opened before sufficient cooling time has elapsed; this to avoid the risk of spontaneous ignition of oil vapour when air is admitted.
- 4 Normal ratings (pressures, temperatures, speeds, etc.) shall be durably marked.
- 5 Operate the unit only for the intended purpose and within its rated limits (pressure, temperature, speeds, etc.).
- 6 The machinery and equipment shall be kept clean, i.e. as free as possible from oil, dust or other deposits.
- 7 To prevent an increase in working temperature, inspect and clean heat transfer surfaces (cooler fins, intercoolers, water jackets, etc.) regularly. See the maintenance schedule.
- 8 All regulating and safety devices shall be maintained with due care to ensure that they function properly. They may not be put out of action.
- 9 Pressure and temperature gauges shall be checked regularly with regard to their accuracy. They shall be replaced whenever outside acceptable tolerances.
- 10 Safety devices shall be tested as described in the maintenance schedule of the instruction manual to determine that they are in good operating condition.
- 11 Mind the markings and information labels on the unit.
- 12 In the event the safety labels are damaged or destroyed, they must be replaced to ensure operator safety.

- 13 Keep the work area neat. Lack of order will increase the risk of accidents.
- 14 When working on the unit, wear safety clothing. Depending on the kind of activities these are: safety glasses, ear protection, safety helmet (including visor), safety gloves, protective clothing, safety shoes. Do not wear the hair long and loose (protect long hair with a hairnet), or wear loose clothing or jewelry.
- 15 Take precautions against fire. Handle fuel, oil and anti-freeze with care because they are inflammable substances. Do not smoke or approach with naked flame when handling such substances. Keep a fire-extinguisher in the vicinity.
- 16a **Portable generators (with earthing pin):**  
Earth the generator as well as the load properly.
- 16b **Portable generators IT:**  
**Note:** This generator is built to supply a sheer alternating current IT network.  
Earth the load properly.

### 0.3 SAFETY DURING TRANSPORT AND INSTALLATION

To lift a unit, all loose or pivoting parts, e.g. doors and towbar, shall first be securely fastened.

Do not attach cables, chains or ropes directly to the lifting eye; apply a crane hook or lifting shackle meeting local safety regulations. Never allow sharp bends in lifting cables, chains or ropes.

Helicopter lifting is not allowed.

It is strictly forbidden to dwell or stay in the risk zone under a lifted load. Never lift the unit over people or residential areas. Lifting acceleration and retardation shall be kept within safe limits.

- 1 Before towing the unit:
  - check the towbar, the brake system and the towing eye. Also check the coupling of the towing vehicle,
  - check the towing and brake capability of the towing vehicle,
  - check that the towbar, jockey wheel or stand leg is safely locked in the raised position,
  - ascertain that the towing eye can swivel freely on the hook,
  - check that the wheels are secure and that the tyres are in good condition and inflated correctly,
  - connect the signalisation cable, check all lights and connect the pneumatic brake couplers,
  - attach the safety break-away cable or safety chain to the towing vehicle,
  - remove wheel chocks, if applied, and disengage the parking brake.
- 2 To tow a unit use a towing vehicle of ample capacity. Refer to the documentation of the towing vehicle.
- 3 If the unit is to be backed up by the towing vehicle, disengage the overrun brake mechanism (if it is not an automatic mechanism).
- 4 Never exceed the maximum towing speed of the unit (mind the local regulations).
- 5 Place the unit on level ground and apply the parking brake before disconnecting the unit from the towing vehicle. Unclip the safety break-away cable or safety chain. If the unit has no parking brake or jockey wheel, immobilize the unit by placing chocks in front of and/or behind the wheels. When the towbar can be positioned vertically, the locking device must be applied and kept

in good order.

- 6 To lift heavy parts, a hoist of ample capacity, tested and approved according to local safety regulations, shall be used.
- 7 Lifting hooks, eyes, shackles, etc., shall never be bent and shall only have stress in line with their design load axis. The capacity of a lifting device diminishes when the lifting force is applied at an angle to its load axis.
- 8 For maximum safety and efficiency of the lifting apparatus all lifting members shall be applied as near to perpendicular as possible. If required, a lifting beam shall be applied between hoist and load.
- 9 Never leave a load hanging on a hoist.
- 10 A hoist has to be installed in such a way that the object will be lifted perpendicular. If that is not possible, the necessary precautions must be taken to prevent load-swinging, e.g. by using two hoists, each at approximately the same angle not exceeding 30° from the vertical.
- 11 Locate the unit away from walls. Take all precautions to ensure that hot air exhausted from the engine and driven machine cooling systems cannot be recirculated. If such hot air is taken in by the engine or driven machine cooling fan, this may cause overheating of the unit; if taken in for combustion, the engine power will be reduced.
- 12 Generators shall be stalled on an even, solid floor, in a clean location with sufficient ventilation. If the floor is not level or can vary in inclination, consult Atlas Copco.
- 13 The electrical connections shall correspond to local codes. The machines shall be earthed and protected against short circuits by fuses or circuit breakers.
- 14 Never connect the generator outlets to an installation which is also connected to a public mains.
- 15 Before connecting a load, switch off the corresponding circuit breaker, and check whether frequency, voltage, current and power factor comply with the ratings of the generator.

## 0.4 SAFETY DURING USE AND OPERATION

- 1 When the unit has to operate in a fire-hazardous environment, each engine exhaust has to be provided with a spark arrestor to trap incendiary sparks.
- 2 The exhaust contains carbon monoxide which is a lethal gas. When the unit is used in a confined space, conduct the engine exhaust to the outside atmosphere by a pipe of sufficient diameter; do this in such a way that no extra back pressure is created for the engine. If necessary, install an extractor. Observe any existing local regulations. Make sure that the unit has sufficient air intake for operation. If necessary, install extra air intake ducts.
- 3 When operating in a dust-laden atmosphere, place the unit so that dust is not carried towards it by the wind. Operation in clean surroundings considerably extends the intervals for cleaning the air intake filters and the cores of the coolers.
- 4 Never remove a filler cap of the cooling water system of a hot engine. Wait until the engine has sufficiently cooled down.
- 5 Never refill fuel while the unit is running, unless otherwise stated in the Atlas Copco Instruction Book (AIB). Keep fuel away from hot parts such as air outlet pipes or the engine exhaust. Do not smoke when fuelling. When fuelling from an automatic pump, an earthing cable should be connected to the unit to discharge static electricity. Never spill nor leave oil, fuel, coolant or cleansing agent in or around the unit.
- 6 All doors shall be shut during operation so as not to disturb the cooling air flow inside the bodywork and/or render the silencing less effective. A door should be kept open for a short period only e.g. for inspection or adjustment.
- 7 Periodically carry out maintenance works according to the maintenance schedule.
- 8 Stationary housing guards are provided on all rotating or reciprocating parts not otherwise protected and which may be hazardous to personnel. Machinery shall never be put into operation, when such guards have been removed, before the guards are securely reinstalled.
- 9 Noise, even at reasonable levels, can cause irritation and disturbance which, over a long period of time, may cause severe injuries to the nervous system of human beings.  
When the sound pressure level, at any point where

- personnel normally has to attend, is:  
below 70 dB(A):no action needs to be taken,  
above 70 dB(A):noise-protective devices should be provided for people continuously being present in the room,  
below 85 dB(A):no action needs to be taken for occasional visitors staying a limited time only,  
above 85 dB(A):room to be classified as a noise-hazardous area and an obvious warning shall be placed permanently at each entrance to alert people entering the room, for even relatively short times, about the need to wear ear protectors,  
above 95 dB(A):the warning(s) at the entrance(s) shall be completed with the recommendation that also occasional visitors shall wear ear protectors,  
above 105 dB(A):special ear protectors that are adequate for this noise level and the spectral composition of the noise shall be provided and a special warning to that effect shall be placed at each entrance.
- 10 Insulation or safety guards of parts the temperature of which can be in excess of 80 °C (175 °F) and which may be accidentally touched by personnel shall not be removed before the parts have cooled to room temperature.
  - 11 Never operate the unit in surroundings where there is a possibility of taking in flammable or toxic fumes.
  - 12 If the working process produces fumes, dust or vibration hazards, etc., take the necessary steps to eliminate the risk of personnel injury.
  - 13 When using compressed air or inert gas to clean down equipment, do so with caution and use the appropriate protection, at least safety glasses, for the operator as well as for any bystander. Do not apply compressed air or inert gas to your skin or direct an air or gas stream at people. Never use it to clean dirt from your clothes.
  - 14 When washing parts in or with a cleaning solvent, provide the required ventilation and use appropriate protection such as a breathing filter, safety glasses, rubber apron and gloves, etc.
  - 15 Safety shoes should be compulsory in any workshop and if there is a risk, however small, of falling objects, wearing of a safety helmet should be included.
  - 16 If there is a risk of inhaling hazardous gases, fumes or dust, the respiratory organs must be protected and depending on the nature of the hazard, so must the eyes and skin.
  - 17 Remember that where there is visible dust, the finer,

- invisible particles will almost certainly be present too; but the fact that no dust can be seen is not a reliable indication that dangerous, invisible dust is not present in the air.
- 18 Never operate the generator in excess of its limits as indicated in the technical specifications and avoid long no-load sequences.
  - 19 Never operate the generator in a humid atmosphere. Excessive moisture causes worsening of the generator insulation.
  - 20 Do not open electrical cabinets, cubicles or other equipment while voltage is supplied. If such cannot be avoided, e.g. for measurements, tests or adjustments, have the action carried out by a qualified electrician only, with appropriate tools, and ascertain that the required bodily protection against electrical hazards is applied.
  - 21 Never touch the power terminals during operation of the machine.
  - 22 Whenever an abnormal condition arises, e.g. excessive vibration, noise, odour, etc., switch the circuit breakers to OFF and stop the engine. Correct the faulty condition before restarting.
  - 23 Check the electric cables regularly. Damaged cables and insufficient lightening of connections may cause electric shocks. Whenever damaged wires or dangerous conditions are observed, switch the circuit breakers to OFF and stop the engine. Replace the damaged wires or correct the dangerous condition before restarting. Make sure that all electric connections are securely tightened.
  - 24 Avoid overloading the generator. The generator is provided with circuit breakers for overload protection. When a breaker has tripped, reduce the concerned load before restarting.
  - 25 If the generator is used as stand-by for the mains supply, it must not be operated without control system which automatically disconnects the generator from the mains when the mains supply is restored.
  - 26 Never remove the cover of the output terminals during operation. Before connecting or disconnecting wires, switch off the load and the circuit breakers, stop the machine and make sure that the machine cannot be started inadvertently or there is any residual voltage on the power circuit.
  - 27 Running the generator at low load for long periods will reduce the lifetime of the engine.

## 0.5 SAFETY DURING MAINTENANCE AND REPAIR

Maintenance, overhaul and repair work shall only be carried out by adequately trained personnel; if required, under supervision of someone qualified for the job.

- 1 Use only the correct tools for maintenance and repair work, and only tools which are in good condition.
- 2 Parts shall only be replaced by genuine Atlas Copco replacement parts.
- 3 All maintenance work, other than routine attention, shall only be undertaken when the unit is stopped. Steps shall be taken to prevent inadvertent starting. In addition, a warning sign bearing a legend such as "work in progress; do not start" shall be attached to the starting equipment.  
On engine-driven units the battery shall be disconnected and removed or the terminals covered by insulating caps.  
On electrically driven units the main switch shall be locked in open position and the fuses shall be taken out. A warning sign bearing a legend such as "work in progress; do not supply voltage" shall be attached to the fuse box or main switch.
- 4 Prior to stripping an engine or other machine or undertaking major overhaul on it, prevent all movable parts from rolling over or moving.
- 5 Make sure that no tools, loose parts or rags are left in or on the machine. Never leave rags or loose clothing near the engine air intake.
- 6 Never use flammable solvents for cleaning (fire-risk).
- 7 Take safety precautions against toxic vapours of cleaning liquids.
- 8 Never use machine parts as a climbing aid.
- 9 Observe scrupulous cleanliness during maintenance and repair. Keep away dirt, cover the parts and exposed openings with a clean cloth, paper or tape.
- 10 Never weld on or perform any operation involving heat near the fuel or oil systems. Fuel and oil tanks must be completely purged, e.g. by steam-cleaning, before carrying out such operations. Never weld on, or in any way modify, pressure vessels. Disconnect the alternator cables during arc welding on the unit.
- 11 Support the towbar and the axle(s) securely if working underneath the unit or when removing a wheel. Do not

rely on jacks.

- 12 Do not remove any of, or tamper with, the sound-damping material. Keep the material free of dirt and liquids such as fuel, oil and cleansing agents. If any sound-damping material is damaged, replace it to prevent the sound pressure level from increasing.
- 13 Use only lubricating oils and greases recommended or approved by Atlas Copco or the machine manufacturer. Ascertain that the selected lubricants comply with all applicable safety regulations, especially with regard to explosion or fire-risk and the possibility of decomposition or generation of hazardous gases. Never mix synthetic with mineral oil.
- 14 Protect the engine, alternator, air intake filter, electrical and regulating components, etc., to prevent moisture ingress, e.g. when steam-cleaning.
- 15 When performing any operation involving heat, flames or sparks on a machine, the surrounding components shall first be screened with non-flammable material.
- 16 Never use a light source with open flame for inspecting the interior of a machine.
- 17 When repair has been completed, the machine shall be barred over at least one revolution for reciprocating machines, several revolutions for rotary ones to ensure that there is no mechanical interference within the machine or driver. Check the direction of rotation of electric motors when starting up the machine initially and after any alteration to the electrical connection(s) or switch gear, to check that the oil pump and the fan function properly.
- 18 Maintenance and repair work should be recorded in an operator's logbook for all machinery. Frequency and nature of repairs can reveal unsafe conditions.
- 19 When hot parts have to be handled, e.g. shrink fitting, special heat-resistant gloves shall be used and, if required, other body protection shall be applied.
- 20 When using cartridge type breathing filter equipment, ascertain that the correct type of cartridge is used and that its useful service life is not surpassed.
- 21 Make sure that oil, solvents and other substances likely to pollute the environment are properly disposed of.
- 22 Before clearing the generator for use after maintenance or overhaul, submit it to a testrun, check that the AC power performance is correct and that the control and shutdown devices function correctly.

## 0.6 TOOL APPLICATIONS SAFETY

Apply the proper tool for each job. With the knowledge of correct tool use and knowing the limitations of tools, along with some common sense, many accidents can be prevented.

Special service tools are available for specific jobs and should be used when recommended. The use of these tools will save time and prevent damage to parts.

## 0.7 SPECIFIC SAFETY PRECAUTIONS

### Batteries

When servicing batteries, always wear protecting clothing and glasses.

- 1 The electrolyte in batteries is a sulphuric acid solution which is fatal if it hits your eyes, and which can cause burns if it contacts your skin. Therefore, be careful when handling batteries, e.g. when checking the charge condition.
- 2 Install a sign prohibiting fire, open flame and smoking at the post where batteries are being charged.
- 3 When batteries are being charged, an explosive gas mixture forms in the cells and might escape through the vent holes in the plugs.  
Thus an explosive atmosphere may form around the battery if ventilation is poor, and can remain in and around the battery for several hours after it has been charged. Therefore:
  - never smoke near batteries being, or having recently been, charged,
  - never break live circuits at battery terminals, because a spark usually occurs.
- 4 When connecting an auxiliary battery (AB) in parallel to the unit battery (CB) with booster cables: connect the + pole of AB to the + pole of CB, then connect the - pole of CB to the mass of the unit. Disconnect in the reverse order.



## **ORDERING SPARE PARTS**

### **ORDERING SPARE PARTS**

Always quote the part number, the designation and the quantity of the parts required, as well as the type and the serial number of the machine.

### **EXPLANATION OF THE COLUMNS**

#### ***REF : REFERENCE CODE***

Establishes the connection between a part in the list and a part in the illustration.

"-" means that the part is not shown in the illustration.

#### ***PART NUMBER***

If no part number is given, the part cannot be obtained as a spare part.

Parts marked with a dot are part of the assembly listed right above them.

#### ***DESIGNATION***

Usually this is the name of the part. For standard parts, in addition to the name, a number of characteristics are given.

#### ***QTY : QUANTITY***

Indicates the quantity of the part concerned. "AR" stands for "As Required".

### **COMMANDE DE PIÈCES DETACHEES**

Toujours indiquer le numéro de pièce, la désignation, la quantité désirée ainsi que le type et le numéro de série du groupe.

### **EXPLICATION DES INTITULES DES COLONNES**

#### ***REF : CODE DE REFERENCE***

Réfère à la pièce détachée spécifiée dans la liste et sur l'illustration. "-" implique que la pièce n'est pas indiquée sur l'illustration.

#### ***PART NUMBER : NUMERO DE PIECE DETACHEE***

Si le numéro n'est pas indiqué, la pièce n'est pas disponible en tant que pièce de rechange.

Les pièces indiquées par un point gras font partie de l'ensemble se trouvant au-dessus des pièces détachées correspondantes.

#### ***DESIGNATION***

En général, le nom de la pièce. S'il s'agit de pièces standard, outre la désignation, un certain nombre de caractéristiques sont indiquées.

#### ***QTY : QUANTITE***

Indique la quantité de la pièce détachée. "AR" indique "As required", c'est-à-dire la quantité à déterminer selon le cas.

### **PEDIDO DE PARTES**

Siempre comunicar el número de parte, la designación y la cantidad deseada así como el tipo y el número de serie de la máquina.

### **INFORMACIONES SOBRE LAS COLUMNAS**

#### ***REF : CODIGO DE REFERENCIA***

Establece la conexión entre una parte en la lista y una parte en la ilustración.

"-" quiere decir que la parte no está ilustrada.

#### ***PART NUMBER : NUMERO DE PARTE***

Si no se da ningún número, quiere decir que la parte no está disponible como parte de recambio.

Partes marcadas con un punto son partes del conjunto indicado más arriba.

#### ***DESIGNATION : DESIGNACION***

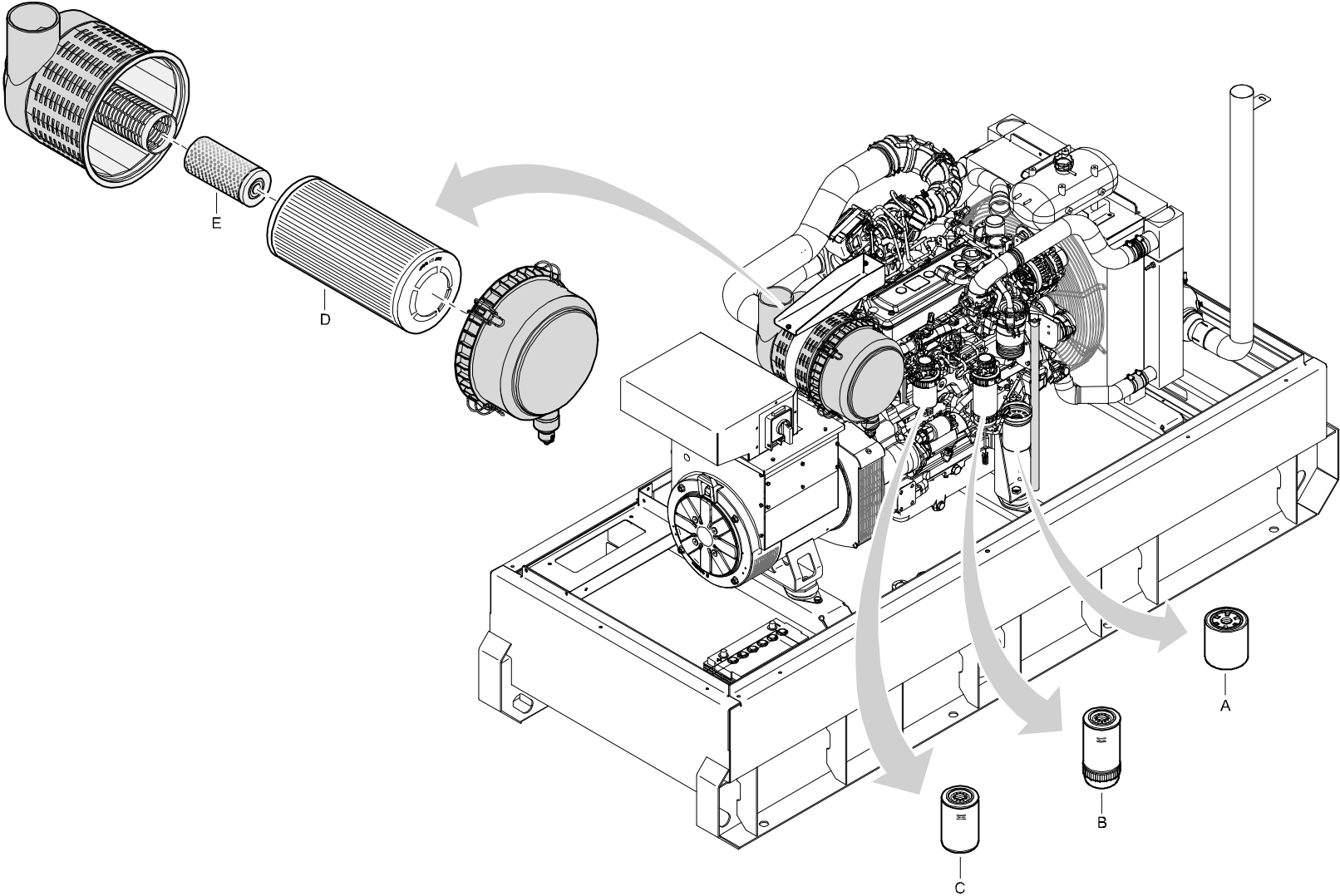
Principalmente el nombre de la parte. En caso de partes estándares, el nombre es seguido por especificaciones.

#### ***QTY : CANTIDAD***

Indica la cantidad de la parte correspondiente. La indicación "AR" significa "As Required" (como sea requerido).

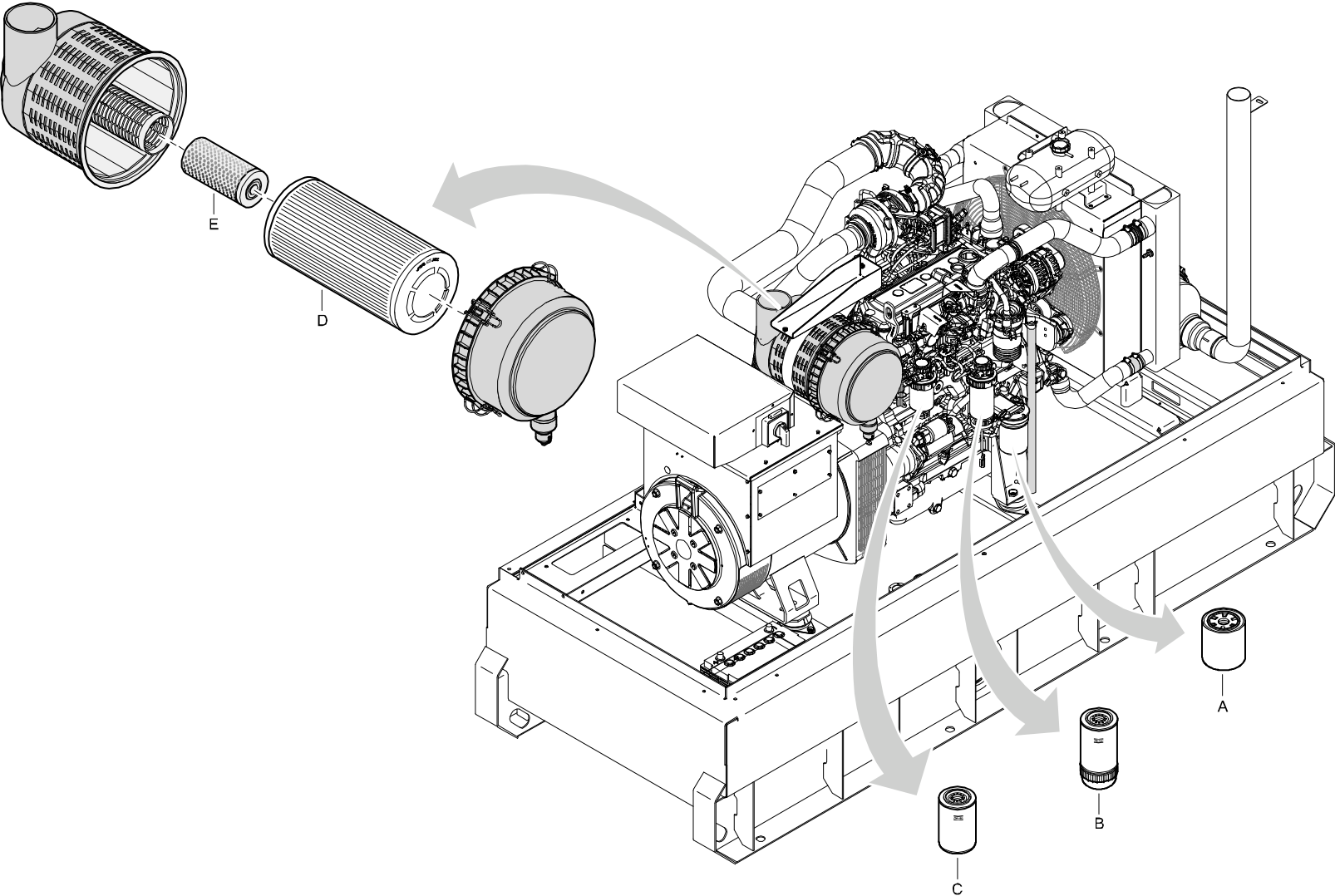






**SERVICE PAK - QAS-70-90**

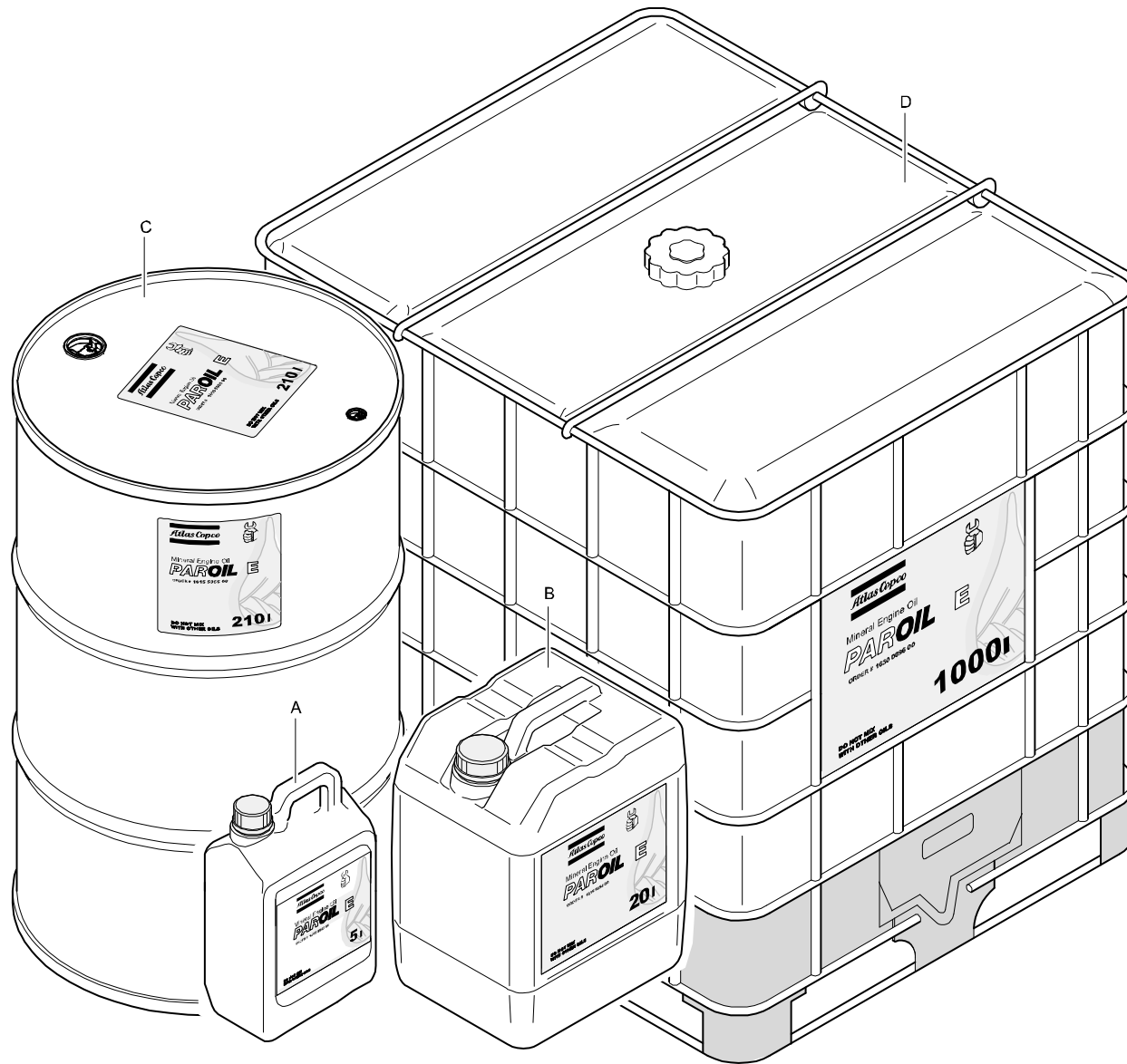
| REF | PART NUMBER  | DESIGNATION                  | QTY | REF | PART NUMBER | DESIGNATION | QTY | REF | PART NUMBER | DESIGNATION | QTY |
|-----|--------------|------------------------------|-----|-----|-------------|-------------|-----|-----|-------------|-------------|-----|
| -   | 1310 3004 42 | SERVICE PAK 500HR            |     |     |             |             |     |     |             |             |     |
| A   | -            | OIL FILTER                   | 1   |     |             |             |     |     |             |             |     |
| B   | -            | FUEL FILTER                  | 1   |     |             |             |     |     |             |             |     |
| C   | -            | FUEL FILTER                  | 1   |     |             |             |     |     |             |             |     |
| D   | -            | AIR FILTER ELEMENT           | 1   |     |             |             |     |     |             |             |     |
|     |              |                              |     |     |             |             |     |     |             |             |     |
| -   | 1310 3004 43 | SERVICE PAK 1000HR OR YEARLY |     |     |             |             |     |     |             |             |     |
| A   | -            | OIL FILTER                   | 1   |     |             |             |     |     |             |             |     |
| B   | -            | FUEL FILTER                  | 1   |     |             |             |     |     |             |             |     |
| C   | -            | FUEL FILTER                  | 1   |     |             |             |     |     |             |             |     |
| D   | -            | AIR FILTER ELEMENT           | 1   |     |             |             |     |     |             |             |     |
| E   | -            | SAFETY CARTRIDGE             | 1   |     |             |             |     |     |             |             |     |



## SERVICE PAK - QAS-120

| REF | PART NUMBER  | DESIGNATION                  | QTY | REF | PART NUMBER | DESIGNATION | QTY | REF | PART NUMBER | DESIGNATION | QTY |
|-----|--------------|------------------------------|-----|-----|-------------|-------------|-----|-----|-------------|-------------|-----|
| -   | 1310 3004 42 | SERVICE PAK 500HR            |     |     |             |             |     |     |             |             |     |
| A   | -            | OIL FILTER                   | 1   |     |             |             |     |     |             |             |     |
| B   | -            | FUEL FILTER                  | 1   |     |             |             |     |     |             |             |     |
| C   | -            | FUEL FILTER                  | 1   |     |             |             |     |     |             |             |     |
| D   | -            | AIR FILTER ELEMENT           | 1   |     |             |             |     |     |             |             |     |
|     |              |                              |     |     |             |             |     |     |             |             |     |
| -   | 1310 3004 43 | SERVICE PAK 1000HR OR YEARLY |     |     |             |             |     |     |             |             |     |
| A   | -            | OIL FILTER                   | 1   |     |             |             |     |     |             |             |     |
| B   | -            | FUEL FILTER                  | 1   |     |             |             |     |     |             |             |     |
| C   | -            | FUEL FILTER                  | 1   |     |             |             |     |     |             |             |     |
| D   | -            | AIR FILTER ELEMENT           | 1   |     |             |             |     |     |             |             |     |
| E   | -            | SAFETY CARTRIDGE             | 1   |     |             |             |     |     |             |             |     |

**ENGINE OIL - PAROIL E**



| REF | PART NUMBER  | DESIGNATION      | QTY |
|-----|--------------|------------------|-----|
| A   | 1615 5953 00 | OIL CAN 5 L      | 1   |
| B   | 1615 5954 00 | OIL CAN 20 L     | 1   |
| C   | 1615 5955 00 | STEEL DRUM 209 L | 1   |
| D   | 1630 0096 00 | CONTAINER 1000 L | 1   |

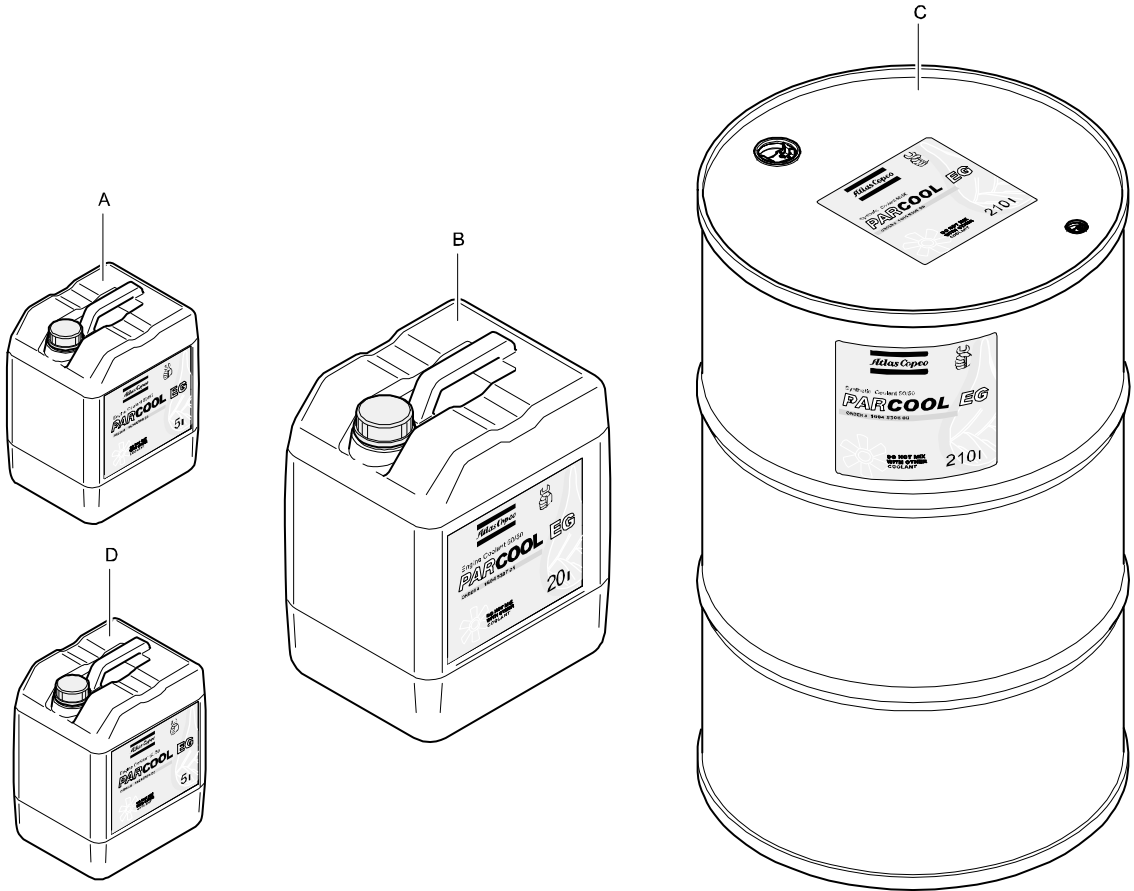
# ENGINE OIL - PAROIL E XTRA

| REF | PART NUMBER  | DESIGNATION  | QTY |
|-----|--------------|--------------|-----|
| A   | 1630 0135 00 | OIL CAN 5 L  | 1   |
| B   | 1630 0136 00 | OIL CAN 20 L | 1   |



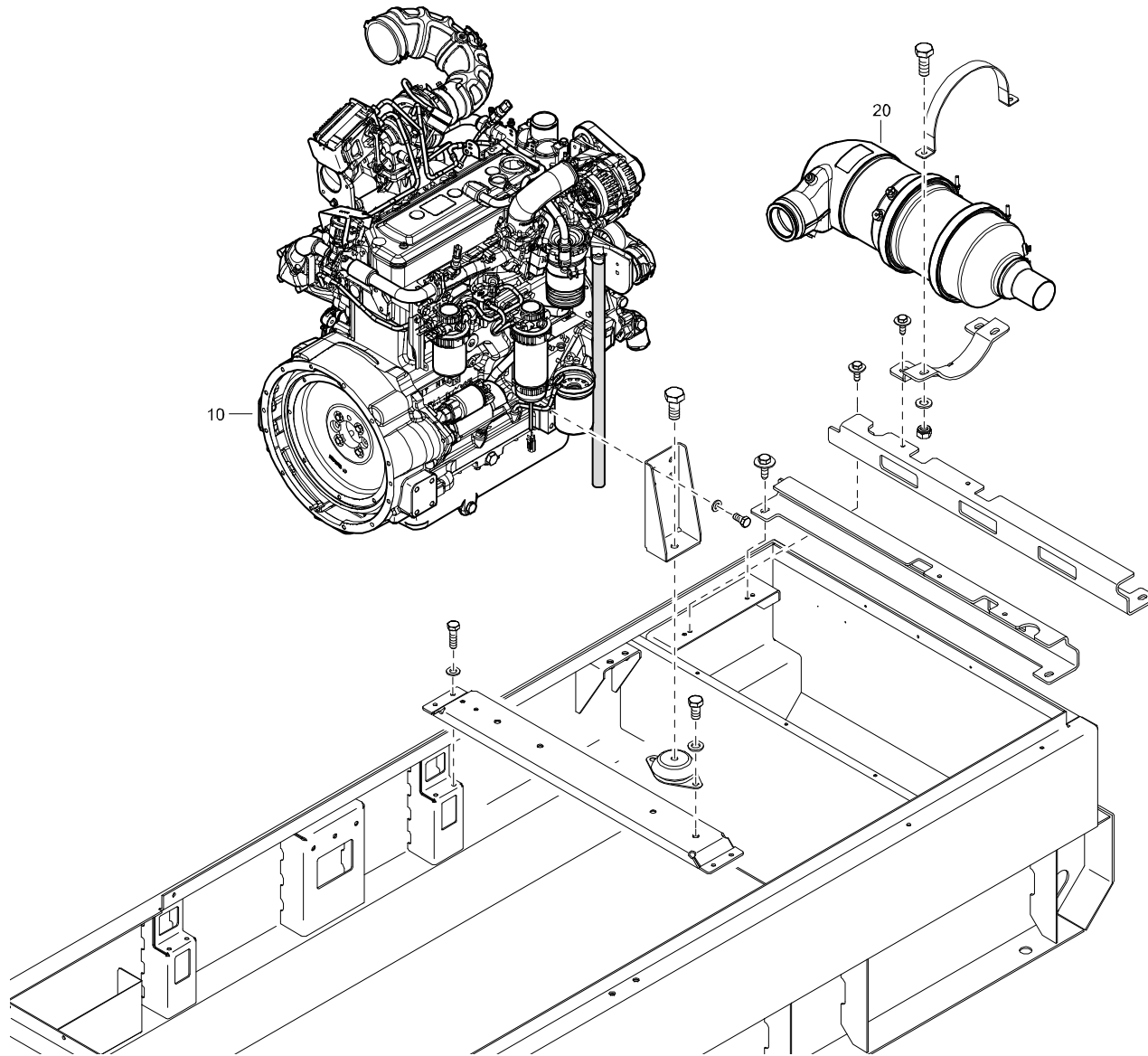
**ENGINE COOLANT - PARCOOL EG**

| REF | PART NUMBER  | DESIGNATION                           | QTY |
|-----|--------------|---------------------------------------|-----|
| A   | 1604 5308 00 | PARCOOL EG 5 LITER CAN                | 1   |
| B   | 1604 5307 01 | PARCOOL EG 20 LITER CAN               | 1   |
| C   | 1604 5306 00 | PARCOOL EG 210 LITER BARREL           | 1   |
| D   | 1604 8159 00 | PARCOOL EG CONCENTRATE<br>5 LITER CAN | 1   |



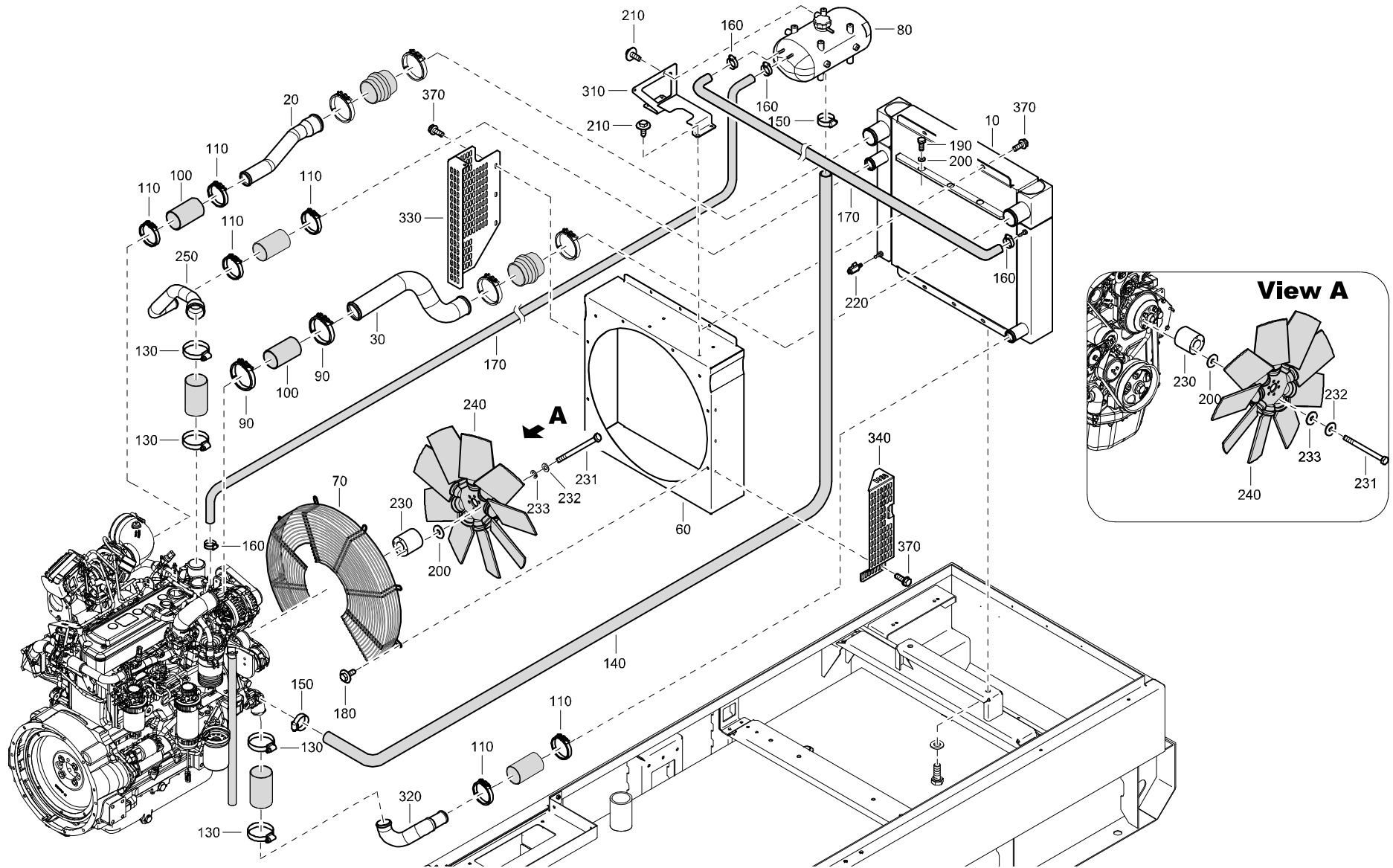


**ENGINE - QAS 70-90 - STANDARD**



| REF | PART NUMBER  | DESIGNATION     | QTY |
|-----|--------------|-----------------|-----|
| 10  | 1310 0723 90 | ENGINE          | 1   |
| 20  | 1310 0724 76 | AFTER TREATMENT | 1   |

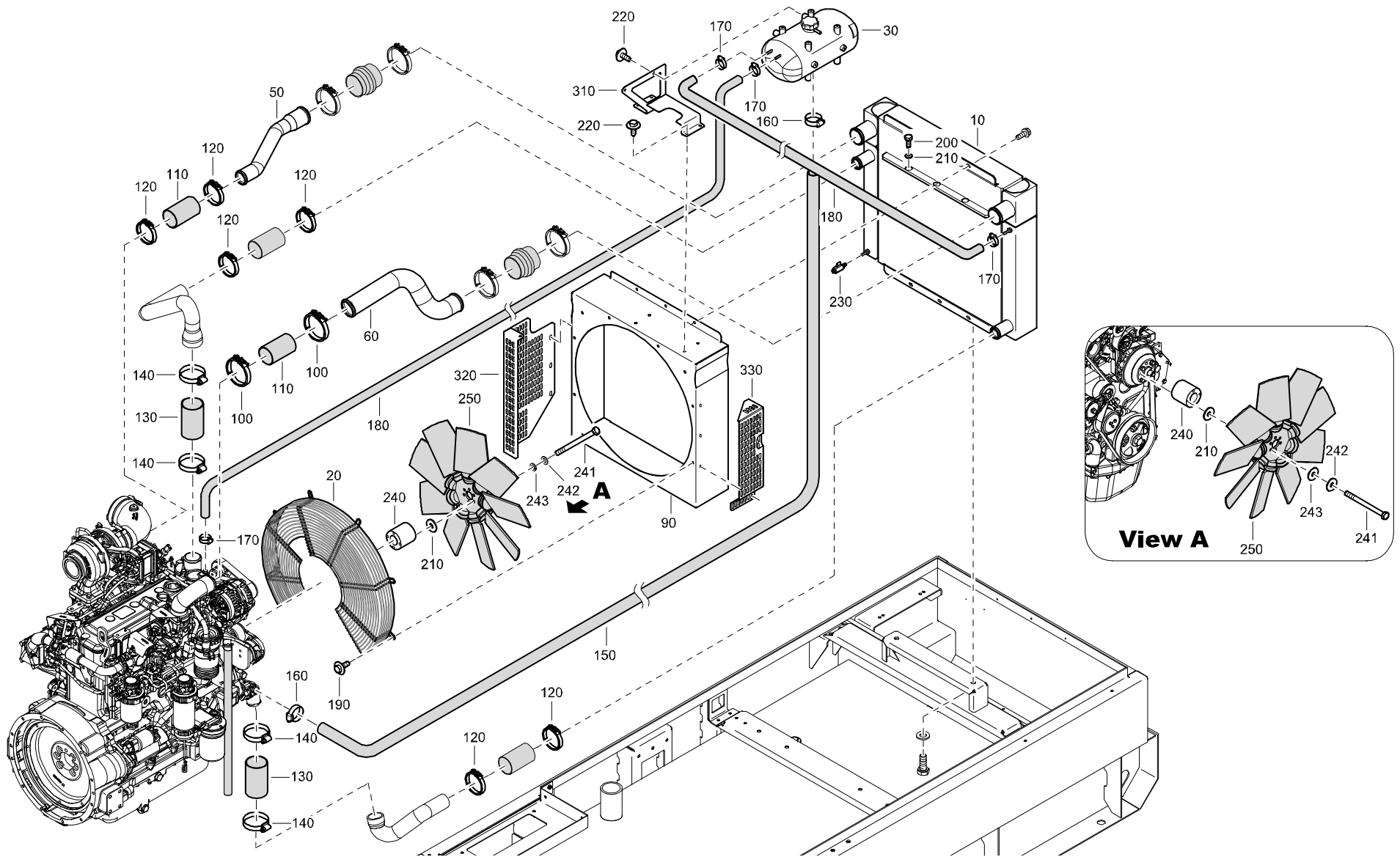
**COOLING SYSTEM - QAS 70-90 - STANDARD**



**COOLING SYSTEM - QAS 70-90 - STANDARD**

| REF | PART NUMBER  | DESIGNATION | QTY | REF | PART NUMBER | DESIGNATION | QTY | REF | PART NUMBER | DESIGNATION | QTY |
|-----|--------------|-------------|-----|-----|-------------|-------------|-----|-----|-------------|-------------|-----|
| 10  | 1310 0730 64 | COOLER      | 1   |     |             |             |     |     |             |             |     |
| 20  | 1310 5011 00 | PIPE        | 1   |     |             |             |     |     |             |             |     |
| 30  | 1310 5012 00 | PIPE        | 1   |     |             |             |     |     |             |             |     |
| 60  | 1310 6916 01 | FAN BOX     | 1   |     |             |             |     |     |             |             |     |
| 70  | 1310 0363 00 | GUARD       | 1   |     |             |             |     |     |             |             |     |
| 80  | 1310 0789 02 | TOP TANK    | 1   |     |             |             |     |     |             |             |     |
| 90  | 1310 0360 38 | CLAMP       | 2   |     |             |             |     |     |             |             |     |
| 100 | 1310 0370 04 | CONNECTOR   | 2   |     |             |             |     |     |             |             |     |
| 110 | 1310 0370 05 | CLAMP       | 6   |     |             |             |     |     |             |             |     |
| 130 | 0347 6113 00 | CLAMP       | 4   |     |             |             |     |     |             |             |     |
| 140 | 1310 0723 07 | HOSE        | 2   |     |             |             |     |     |             |             |     |
| 150 | 0347 6109 00 | HOSE CLAMP  | 2   |     |             |             |     |     |             |             |     |
| 160 | 1310 0323 84 | CLAMP       | 4   |     |             |             |     |     |             |             |     |
| 170 | 1310 0311 97 | HOSE        | 5   |     |             |             |     |     |             |             |     |
| 180 | 1615 5664 00 | BOLT        | 6   |     |             |             |     |     |             |             |     |
| 190 | 0147 1327 03 | SCREW       | 6   |     |             |             |     |     |             |             |     |
| 200 | 0300 8019 00 | WASHER      | 12  |     |             |             |     |     |             |             |     |
| 210 | 1615 5664 00 | BOLT        | 6   |     |             |             |     |     |             |             |     |
| 220 | 1615 7072 00 | VALVE       | 1   |     |             |             |     |     |             |             |     |
| 230 | 1310 0354 82 | SPACER      | 1   |     |             |             |     |     |             |             |     |
| 231 | 0147 1340 03 | SCREW       | 4   |     |             |             |     |     |             |             |     |
| 232 | 0301 2335 00 | WASHER      | 4   |     |             |             |     |     |             |             |     |
| 233 | 0333 2225 00 | WASHER      | 4   |     |             |             |     |     |             |             |     |
| 240 | 1310 0354 80 | FAN         | 1   |     |             |             |     |     |             |             |     |
| 250 | 1310 8802 00 | PIPE        | 0   |     |             |             |     |     |             |             |     |
| 310 | 1310 8658 00 | BRACKET     | 1   |     |             |             |     |     |             |             |     |
| 320 | 1310 8803 00 | PIPE        | 0   |     |             |             |     |     |             |             |     |
| 330 | 1310 8821 01 | GUARD       | 0   |     |             |             |     |     |             |             |     |
| 340 | 1310 8822 01 | GUARD       | 0   |     |             |             |     |     |             |             |     |
| 370 | 1619 2766 00 | SCREW       | 2   |     |             |             |     |     |             |             |     |
| 380 | 1310 8803 00 | PIPE        | 1   |     |             |             |     |     |             |             |     |

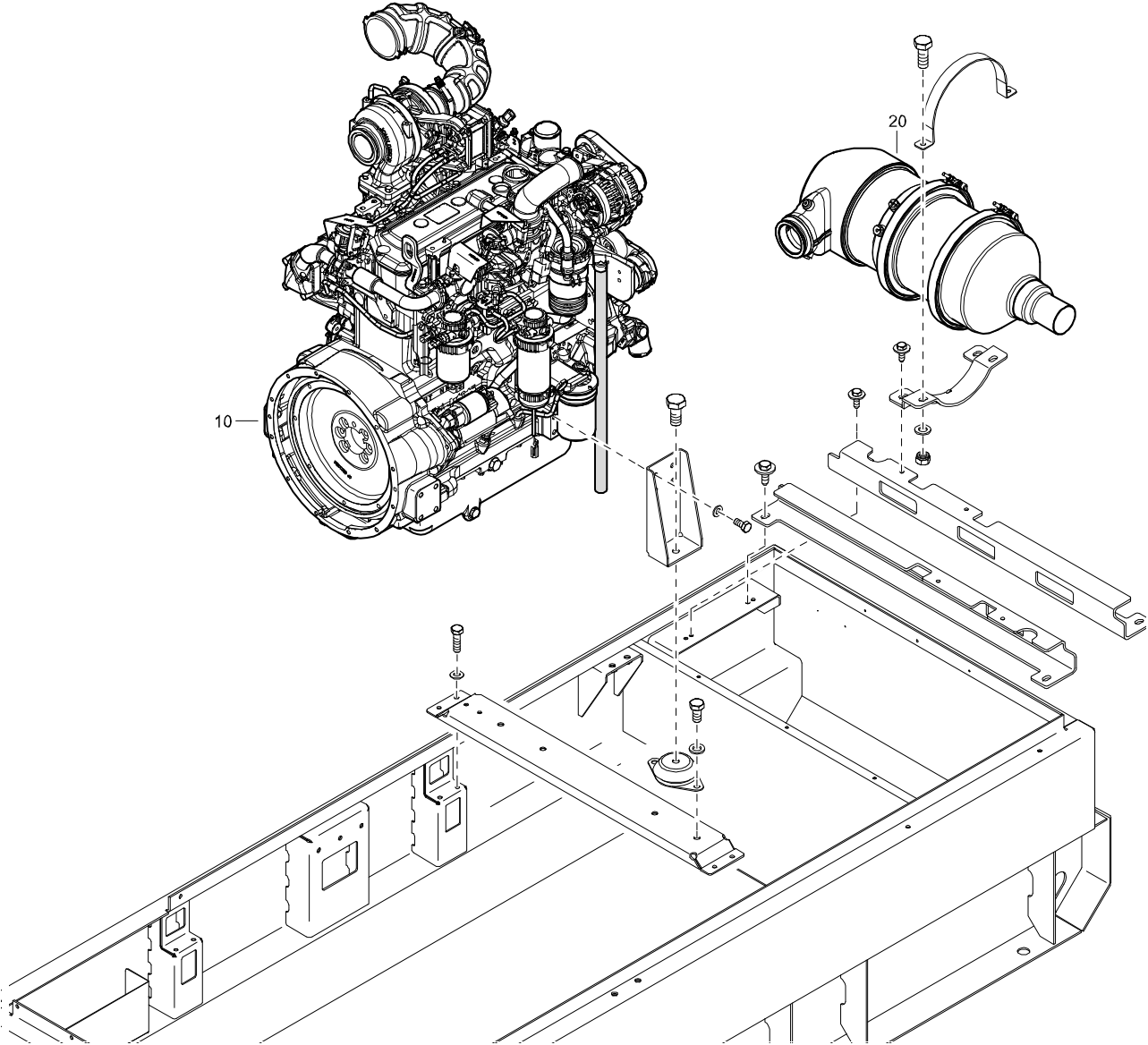
**COOLING SYSTEM - QAS 120 - STANDARD**



**COOLING SYSTEM - QAS 120 - STANDARD**

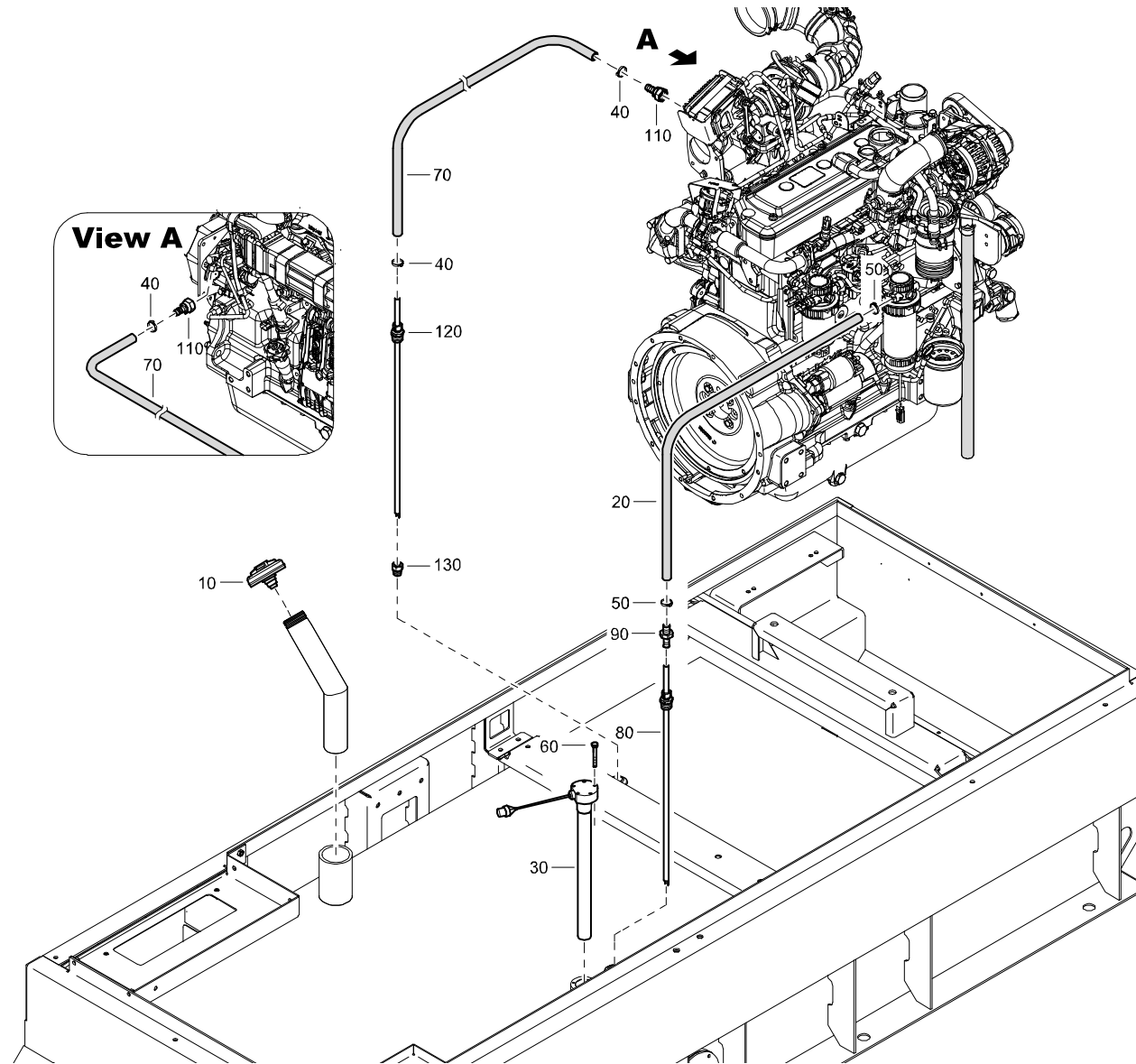
| REF | PART NUMBER  | DESIGNATION | QTY | REF | PART NUMBER | DESIGNATION | QTY | REF | PART NUMBER | DESIGNATION | QTY |
|-----|--------------|-------------|-----|-----|-------------|-------------|-----|-----|-------------|-------------|-----|
| 10  | 1310 0730 65 | COOLER      | 1   |     |             |             |     |     |             |             |     |
| 20  | 1310 0363 00 | GUARD       | 1   |     |             |             |     |     |             |             |     |
| 30  | 1310 0789 02 | TOP TANK    | 1   |     |             |             |     |     |             |             |     |
| 50  | 1310 5011 02 | TUBE        | 1   |     |             |             |     |     |             |             |     |
| 60  | 1310 5012 00 | PIPE        | 1   |     |             |             |     |     |             |             |     |
| 90  | 1310 6916 01 | FAN BOX     | 1   |     |             |             |     |     |             |             |     |
| 100 | 1310 0360 38 | CLAMP       | 2   |     |             |             |     |     |             |             |     |
| 110 | 1310 0370 04 | CONNECTOR   | 2   |     |             |             |     |     |             |             |     |
| 120 | 1310 0370 05 | CLAMP       | 6   |     |             |             |     |     |             |             |     |
| 130 | 1310 0370 07 | HOSE        | AR  |     |             |             |     |     |             |             |     |
| 140 | 0347 6113 00 | CLAMP       | 4   |     |             |             |     |     |             |             |     |
| 150 | 1310 0723 07 | HOSE        | 2   |     |             |             |     |     |             |             |     |
| 160 | 0347 6109 00 | HOSE CLAMP  | 2   |     |             |             |     |     |             |             |     |
| 170 | 1310 0323 84 | CLAMP       | 4   |     |             |             |     |     |             |             |     |
| 180 | 1310 0311 97 | HOSE        | 5   |     |             |             |     |     |             |             |     |
| 190 | 1615 5664 00 | BOLT        | 6   |     |             |             |     |     |             |             |     |
| 200 | 0147 1327 03 | SCREW       | 6   |     |             |             |     |     |             |             |     |
| 210 | 0300 8019 00 | WASHER      | 12  |     |             |             |     |     |             |             |     |
| 220 | 1615 5664 00 | BOLT        | 6   |     |             |             |     |     |             |             |     |
| 230 | 1615 7072 00 | VALVE       | 1   |     |             |             |     |     |             |             |     |
| 240 | 1310 0354 82 | SPACER      | 1   |     |             |             |     |     |             |             |     |
| 241 | 0147 1340 03 | SCREW       | 4   |     |             |             |     |     |             |             |     |
| 242 | 0301 2335 00 | WASHER      | 4   |     |             |             |     |     |             |             |     |
| 243 | 0333 2225 00 | WASHER      | 4   |     |             |             |     |     |             |             |     |
| 250 | 1310 0354 80 | FAN         | 1   |     |             |             |     |     |             |             |     |
| 310 | 1310 8658 00 | BRACKET     | 1   |     |             |             |     |     |             |             |     |
| 320 | 1310 8821 01 | GUARD       | 1   |     |             |             |     |     |             |             |     |
| 330 | 1310 8822 01 | GUARD       | 1   |     |             |             |     |     |             |             |     |

**ENGINE - QAS 120 - STANDARD**



| REF | PART NUMBER  | DESIGNATION     | QTY |
|-----|--------------|-----------------|-----|
| 10  | 1310 0723 92 | ENGINE          | 1   |
| 20  | 1310 0724 74 | AFTER TREATMENT | 1   |

**FUEL SYSTEM - QAS 70-90 - STANDARD**

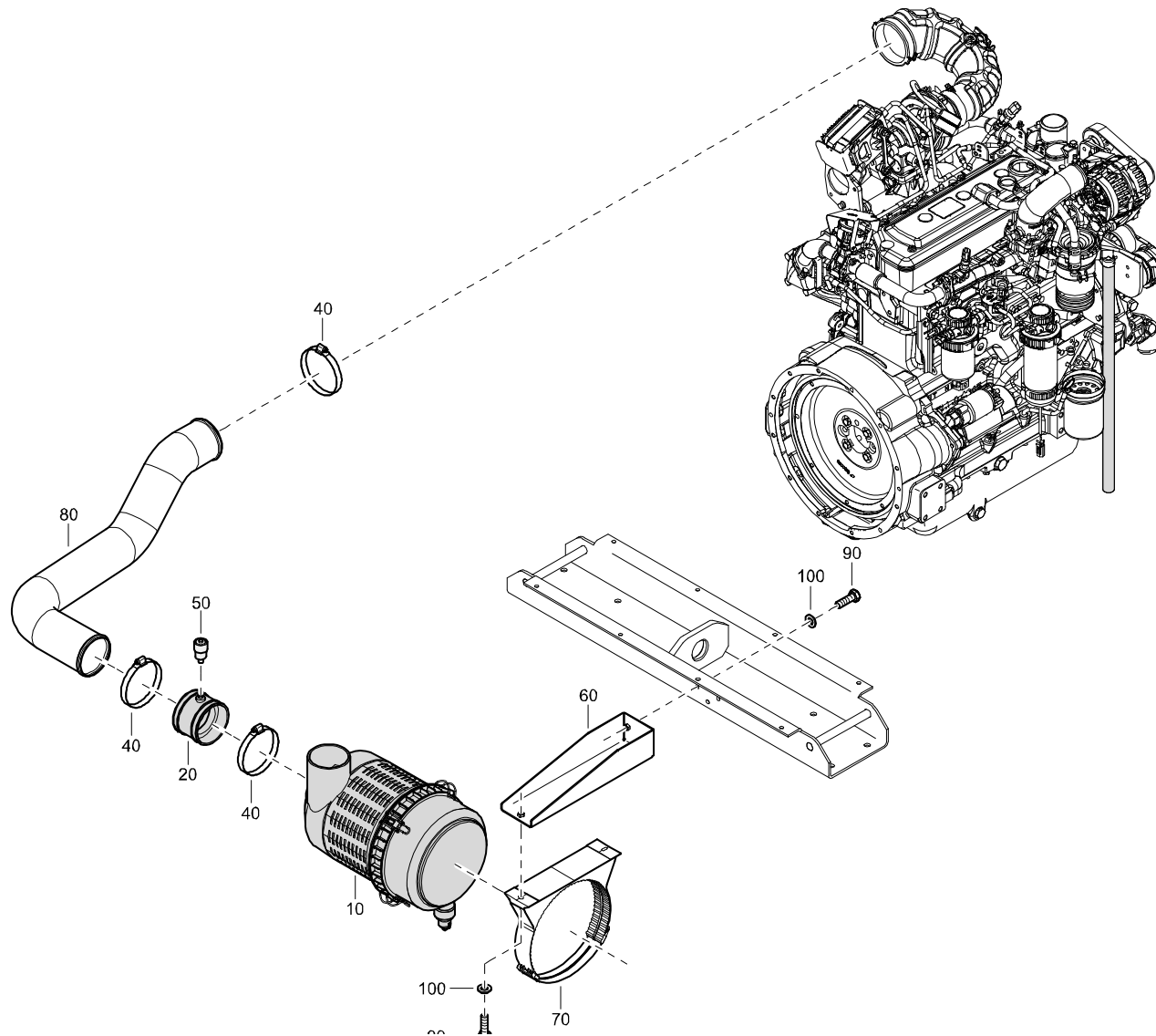


| REF | PART NUMBER  | DESIGNATION | QTY |
|-----|--------------|-------------|-----|
| 10  | 1615 6947 01 | FUEL CAP    | 1   |
| 20  | 1310 0311 98 | HOSE        | 4   |
| 30  | 1310 0332 68 | SENDER      | 1   |
| 40  | 1310 0323 84 | CLAMP       | 2   |
| 50  | 1310 0365 57 | CLAMP       | 2   |
| 60  | 5530 7681 00 | SCREW       | 5   |
| 70  | 1310 0311 97 | HOSE        | 4   |
| 80  | 1310 4526 00 | TUBE        | 1   |
| 90  | 1310 0724 07 | ADAPTER     | 1   |
| 110 | 1310 6002 26 | FITTING     | 1   |
| 120 | 1310 4951 00 | TUBE        | 1   |
| 130 | 1312 1003 25 | BUSHING     | 1   |



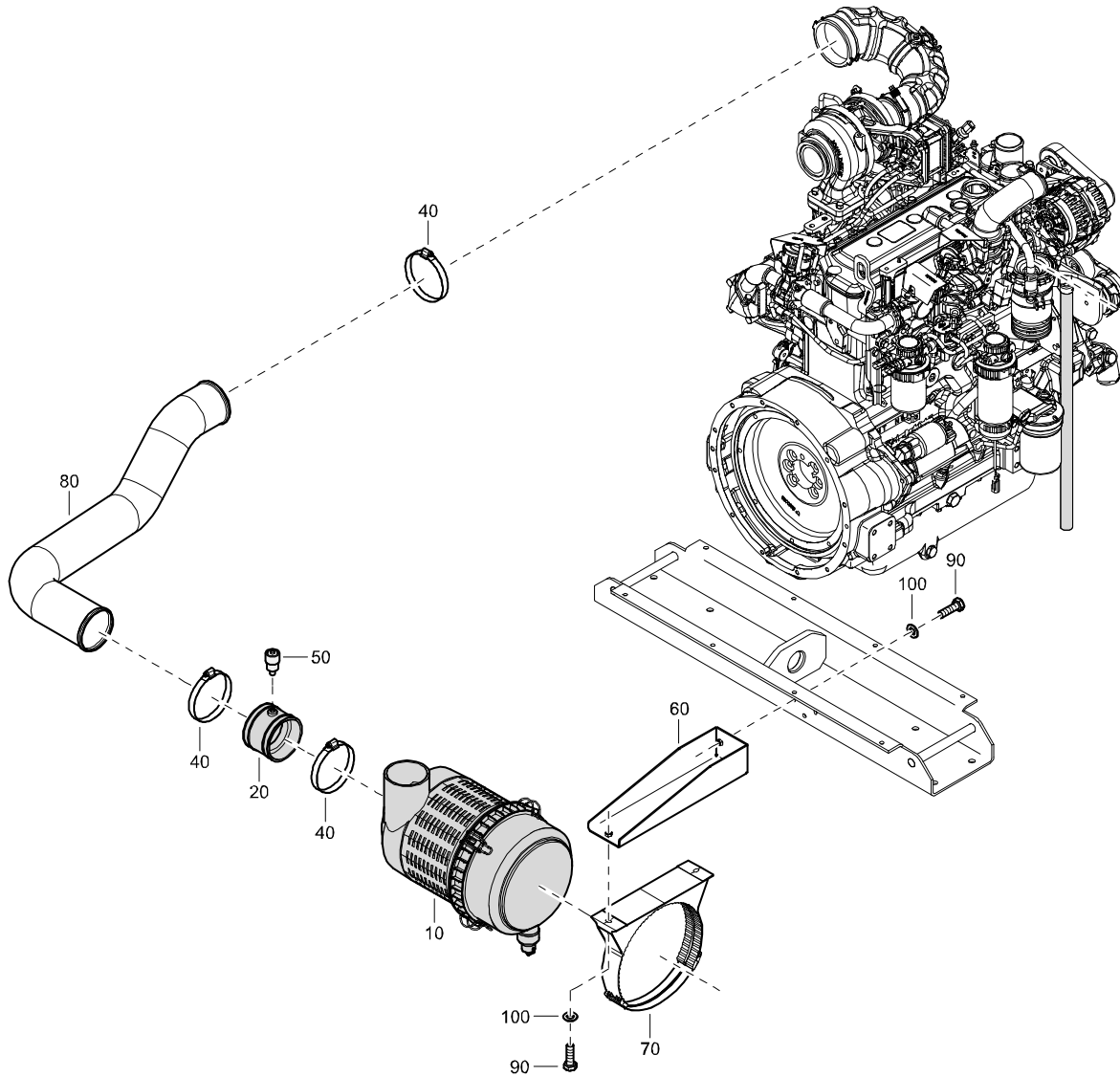


# AIR INLET - QAS 70-90 - STANDARD



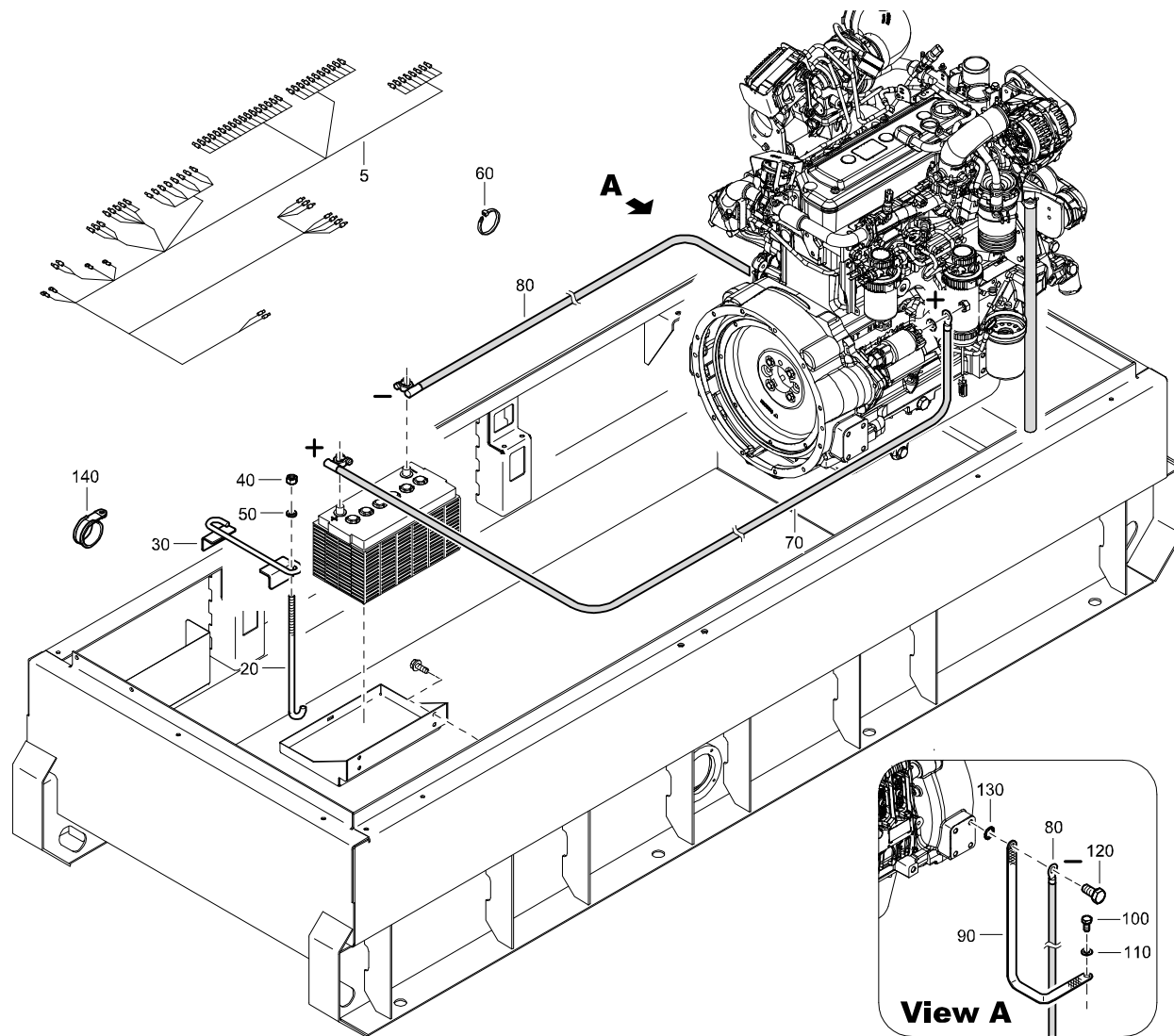
| REF | PART NUMBER  | DESIGNATION | QTY |
|-----|--------------|-------------|-----|
| 10  | 1615 7820 01 | AIR FILTER  | 1   |
| 20  | 1310 0728 61 | SLEEVE      | 1   |
| 40  | 0347 6100 23 | CLAMP       | 3   |
| 50  | 1310 0355 53 | GAUGE       | 1   |
| 60  | 1310 4981 00 | SUPPORT     | 1   |
| 70  | 1613 7401 00 | BRACKET     | 1   |
| 80  | 1310 4398 02 | PIPE        | 1   |
| 90  | 0147 1325 03 | SCREW       | 5   |
| 100 | 0301 2335 00 | WASHER      | 5   |

**AIR INLET - QAS 120 - STANDARD**



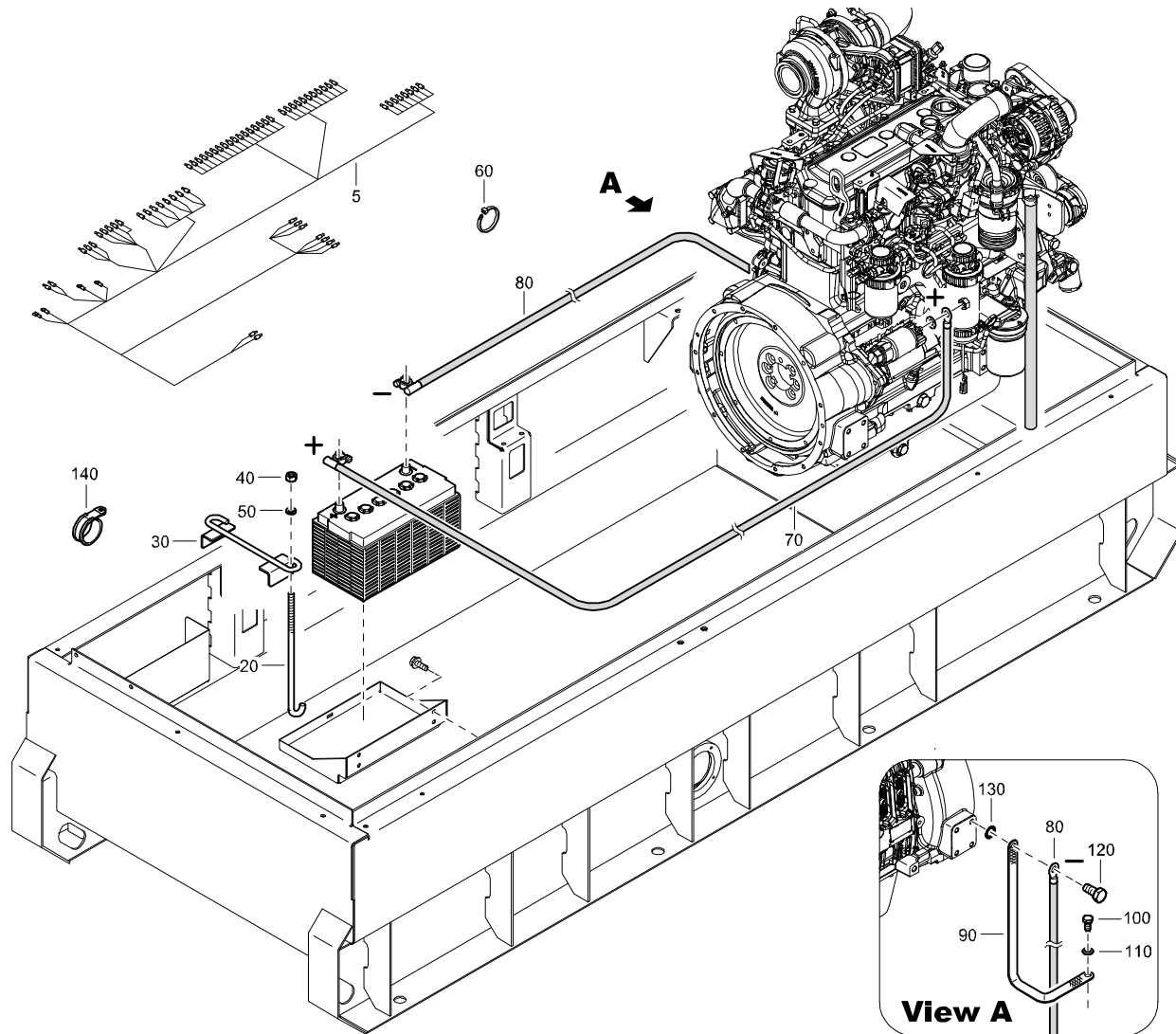
| REF | PART NUMBER  | DESIGNATION    | QTY |
|-----|--------------|----------------|-----|
| 10  | 1615 7820 01 | FILTER-AIR     | 1   |
| 20  | 1310 0728 61 | SLEEVE         | 1   |
| 40  | 0347 6100 23 | CLAMP-HOSE     | 3   |
| 50  | 1310 0355 53 | GAUGE-AIR CLE  | 1   |
| 60  | 1310 4981 00 | SUPPORT        | 1   |
| 70  | 1613 7401 00 | BRACKET        | 1   |
| 80  | 1310 4398 02 | PIPE-AIR INLET | 1   |
| 90  | 0147 1325 03 | SCREW          | 5   |
| 100 | 0301 2335 00 | WASHER         | 5   |

# ELECTRICAL SYSTEM - QAS 70-90 - STANDARD



| REF | PART NUMBER  | DESIGNATION  | QTY |
|-----|--------------|--------------|-----|
| 5   | 1310 8546 00 | WIRE HARNESS | 1   |
| 20  | 1310 0311 67 | BOLT-J       | 2   |
| 30  | 1310 0311 66 | CLAMP        | 1   |
| 40  | 0268 3205 00 | NUT          | 2   |
| 50  | 0333 2225 00 | WASHER       | 2   |
| 60  | 0348 0101 07 | CABLE TY     | 15  |
| 70  | 1310 0730 19 | CABLE        | 1   |
| 80  | 1310 0730 18 | CABLE        | 1   |
| 90  | 1310 4246 00 | STRAP        | 1   |
| 100 | 0147 1320 03 | SCREW        | 1   |
| 110 | 0301 2335 00 | WASHER       | 1   |
| 120 | 0147 1400 03 | SCREW        | 2   |
| 130 | 0333 3237 00 | LOCKWASHER   | 2   |
| 140 | 1310 0325 89 | CLAMP        | 2   |

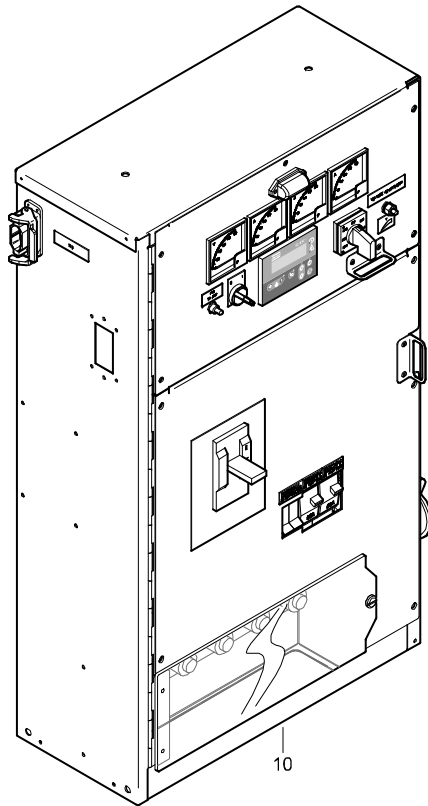
**ELECTRICAL SYSTEM - QAS 120 - STANDARD**



| REF | PART NUMBER  | DESIGNATION  | QTY |
|-----|--------------|--------------|-----|
| 5   | 1310 8546 00 | WIRE HARNESS | 1   |
| 20  | 1310 0311 67 | BOLT-J       | 2   |
| 30  | 1310 0311 66 | CLAMP        | 1   |
| 40  | 0268 3205 00 | NUT          | 2   |
| 50  | 0333 2225 00 | WASHER       | 2   |
| 60  | 0348 0101 07 | CABLE TY     | 15  |
| 70  | 1310 0730 19 | CABLE        | 1   |
| 80  | 1310 0730 18 | CABLE        | 1   |
| 90  | 1310 4246 00 | STRAP        | 1   |
| 100 | 0147 1320 03 | SCREW        | 1   |
| 110 | 0301 2335 00 | WASHER       | 1   |
| 120 | 0147 1400 03 | SCREW        | 2   |
| 130 | 0333 3237 00 | LOCKWASHER   | 2   |
| 140 | 1310 0325 89 | CLAMP        | 2   |

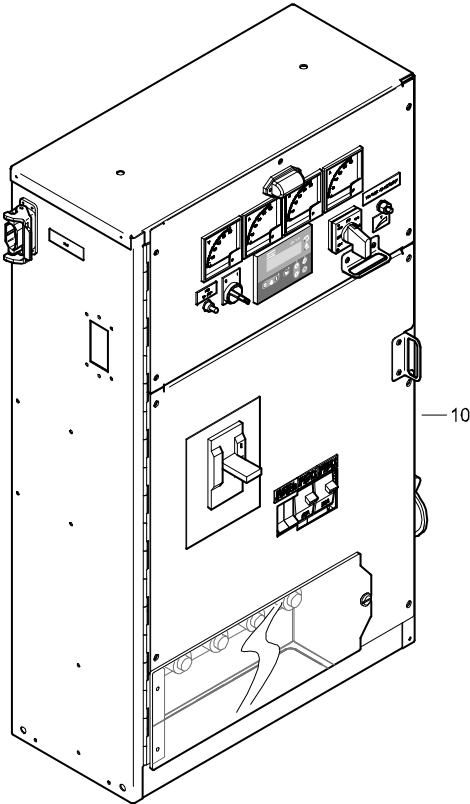
**CUBICLE ASSEMBLY - QAS 70 - STANDARD**

| <b>REF</b> | <b>PART NUMBER</b> | <b>DESIGNATION</b>  | <b>QTY</b> |
|------------|--------------------|---|------------|
| 10         | 1310 8014 81       | CUBICLE ASSY<br><a href="#">(For details see page 56)</a> | 1          |

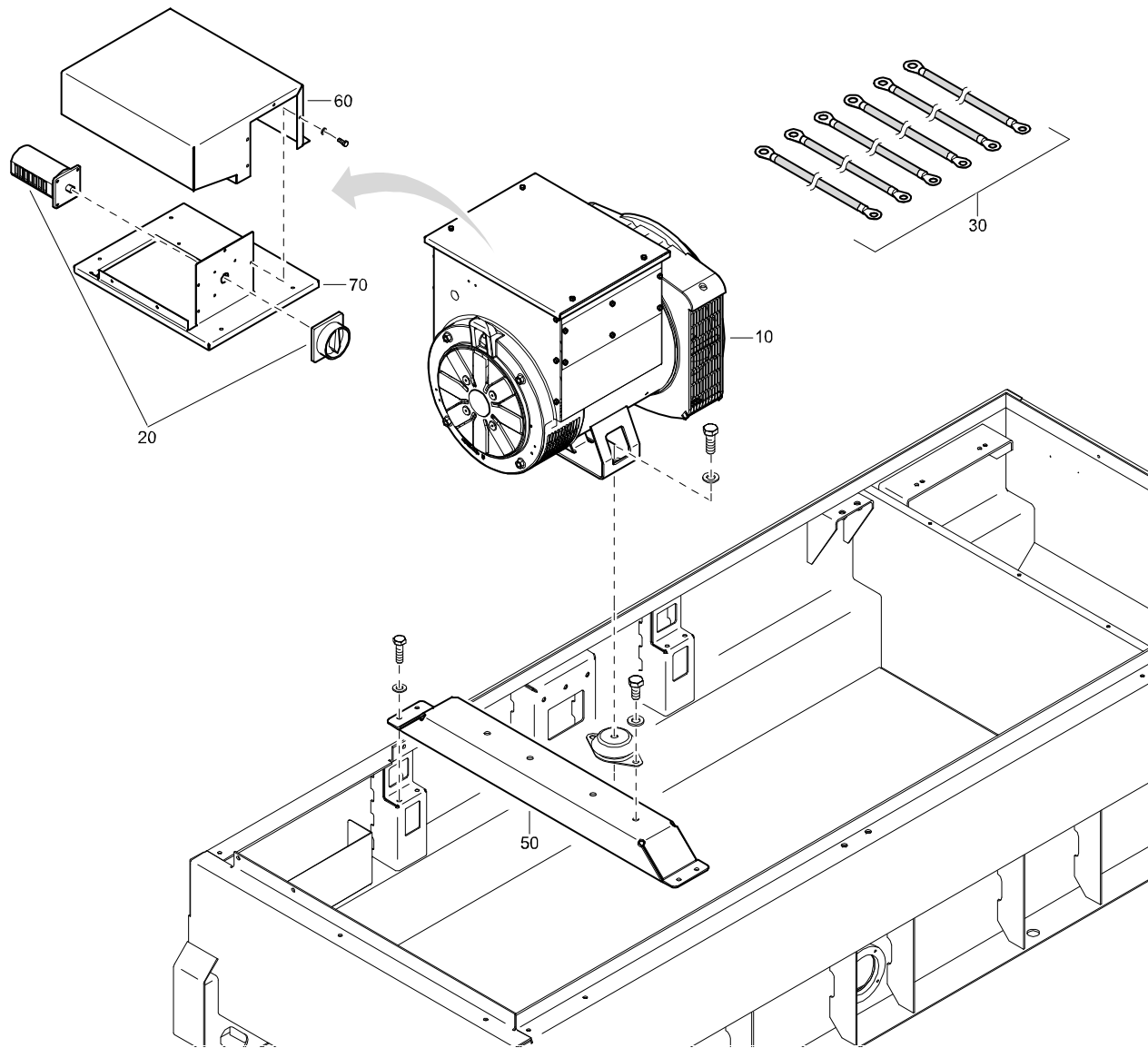


**CUBICLE ASSEMBLY - QAS 90-120 - STANDARD**

| <b>REF</b> | <b>PART NUMBER</b> | <b>DESIGNATION</b>  | <b>QTY</b> |
|------------|--------------------|---|------------|
| 10         | 1310 8015 81       | CUBICLE ASSY<br><a href="#">(For details see page 58)</a> | 1          |

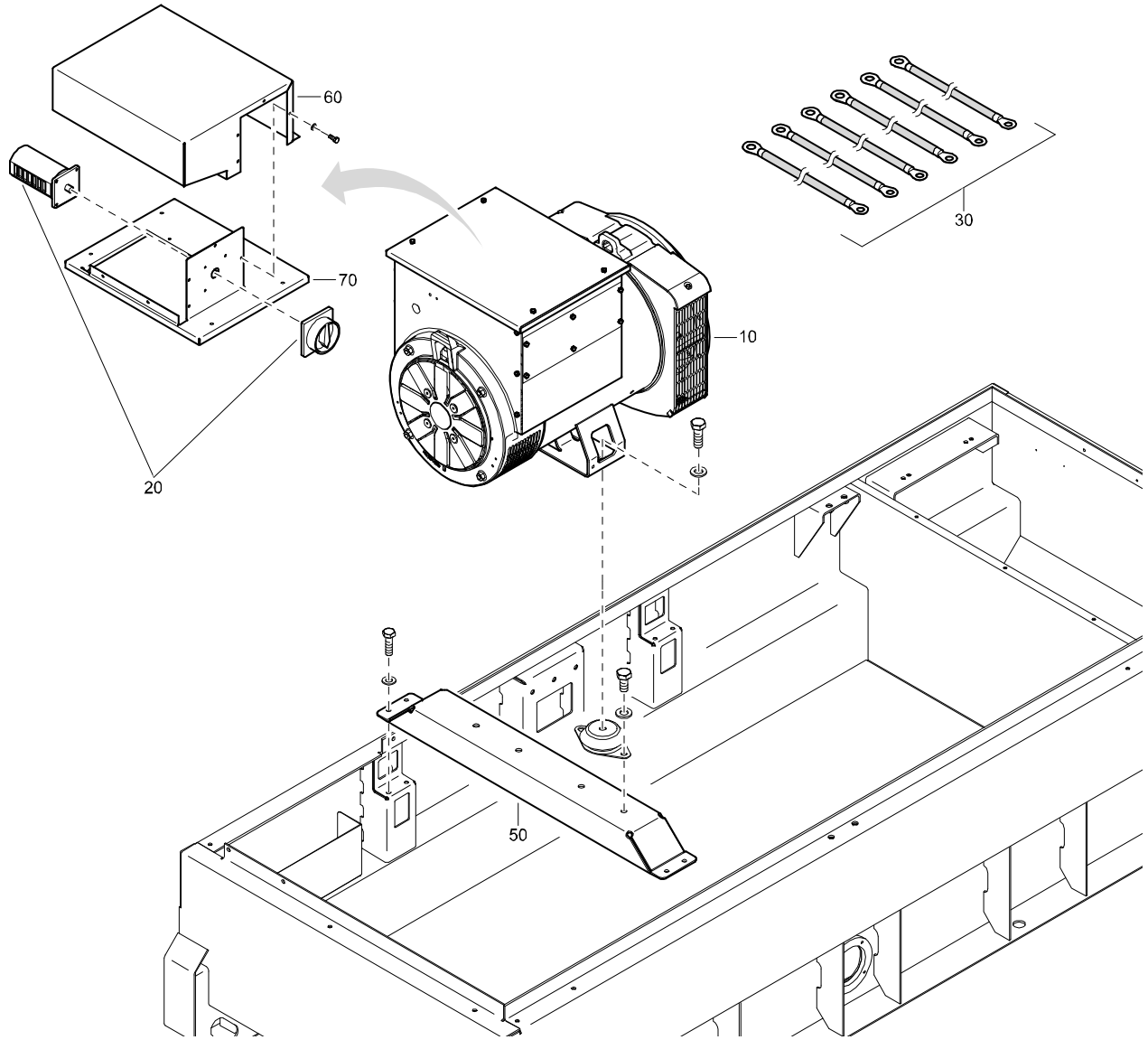


# ALTERNATOR ASSEMBLY - QAS 70 - STANDARD



| REF | PART NUMBER  | DESIGNATION | QTY |
|-----|--------------|-------------|-----|
| 10  | 1310 6066 22 | ALTERNATOR  | 1   |
| 20  | 1089 9378 25 | SWITCH      | 1   |
| 30  | 1310 4642 50 | WIRE SET    | 1   |
| 50  | 1310 4413 00 | SUPPORT     | 1   |
| 60  | 1310 8086 00 | PANEL       | 1   |
| 70  | 1310 8087 00 | COVER       | 1   |

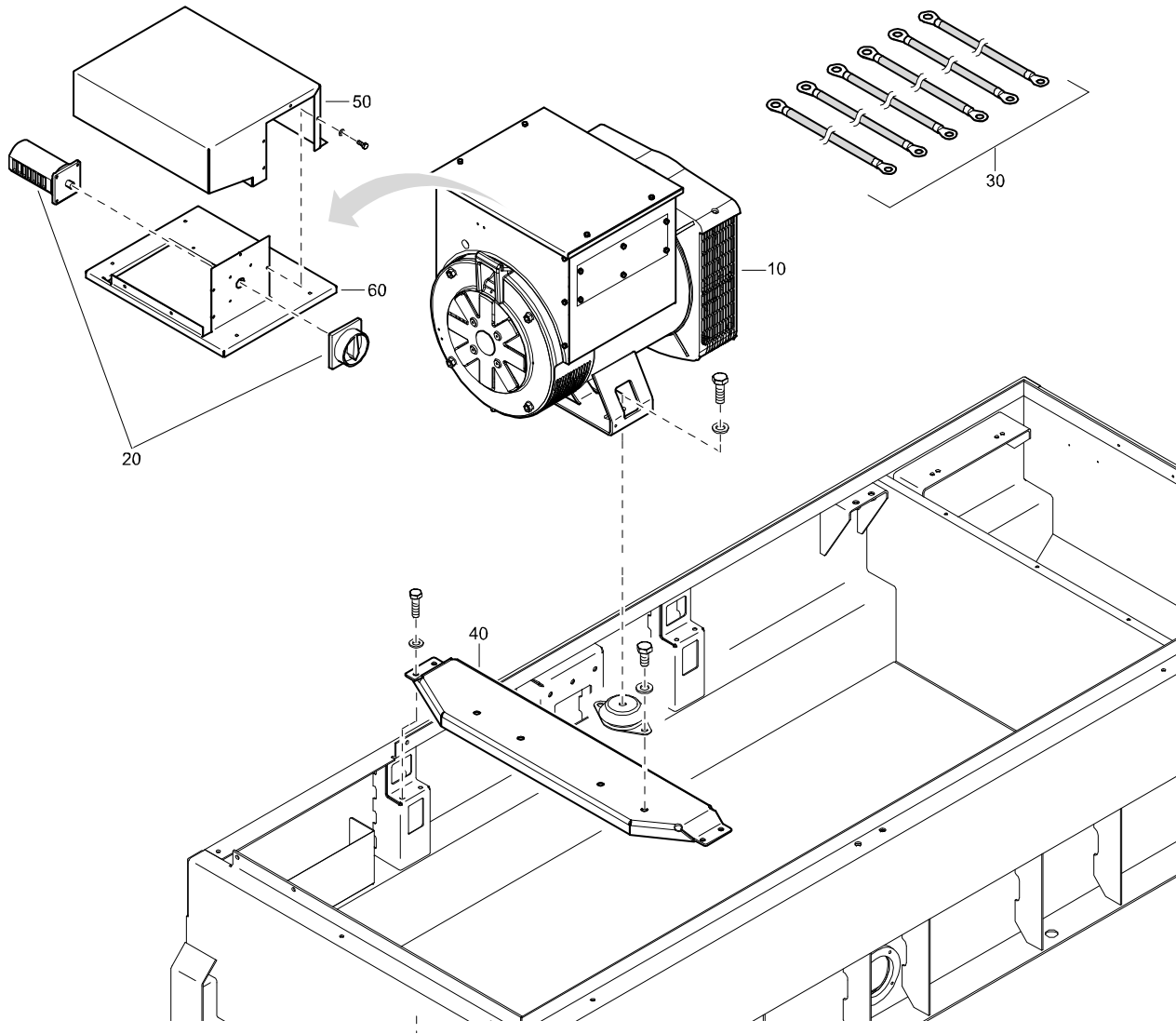
**ALTERNATOR ASSEMBLY - QAS 90 - STANDARD**



| REF | PART NUMBER  | DESIGNATION | QTY |
|-----|--------------|-------------|-----|
| 10  | 1310 6066 23 | ALTERNATOR  | 1   |
| 20  | 1089 9378 25 | SWITCH      | 1   |
| 30  | 1310 4642 50 | WIRE SET    | 1   |
| 50  | 1310 4413 00 | SUPPORT     | 1   |
| 60  | 1310 8086 00 | PANEL       | 1   |
| 70  | 1310 8087 00 | COVER       | 1   |

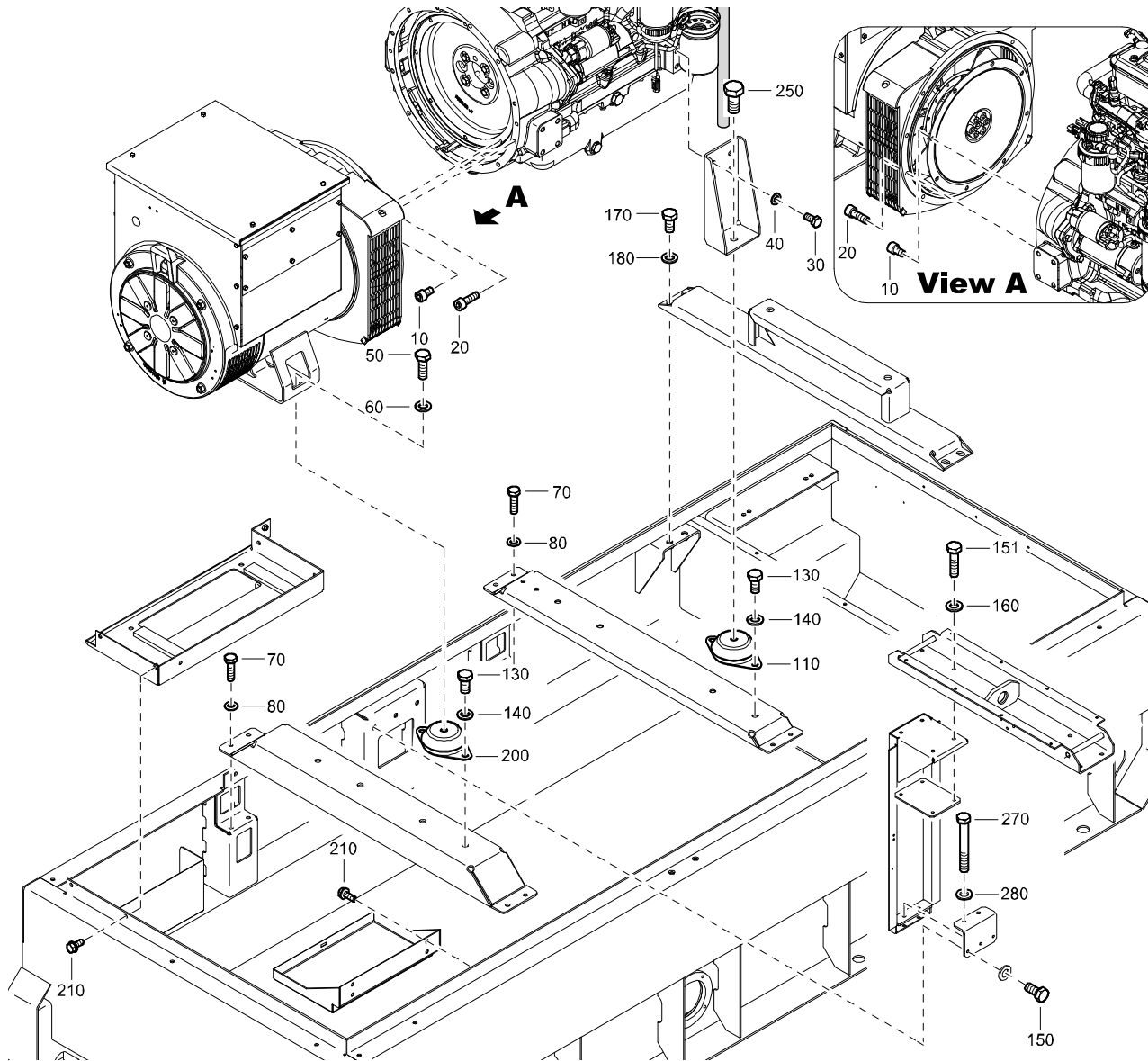


# ALTERNATOR ASSEMBLY - QAS 120 - STANDARD



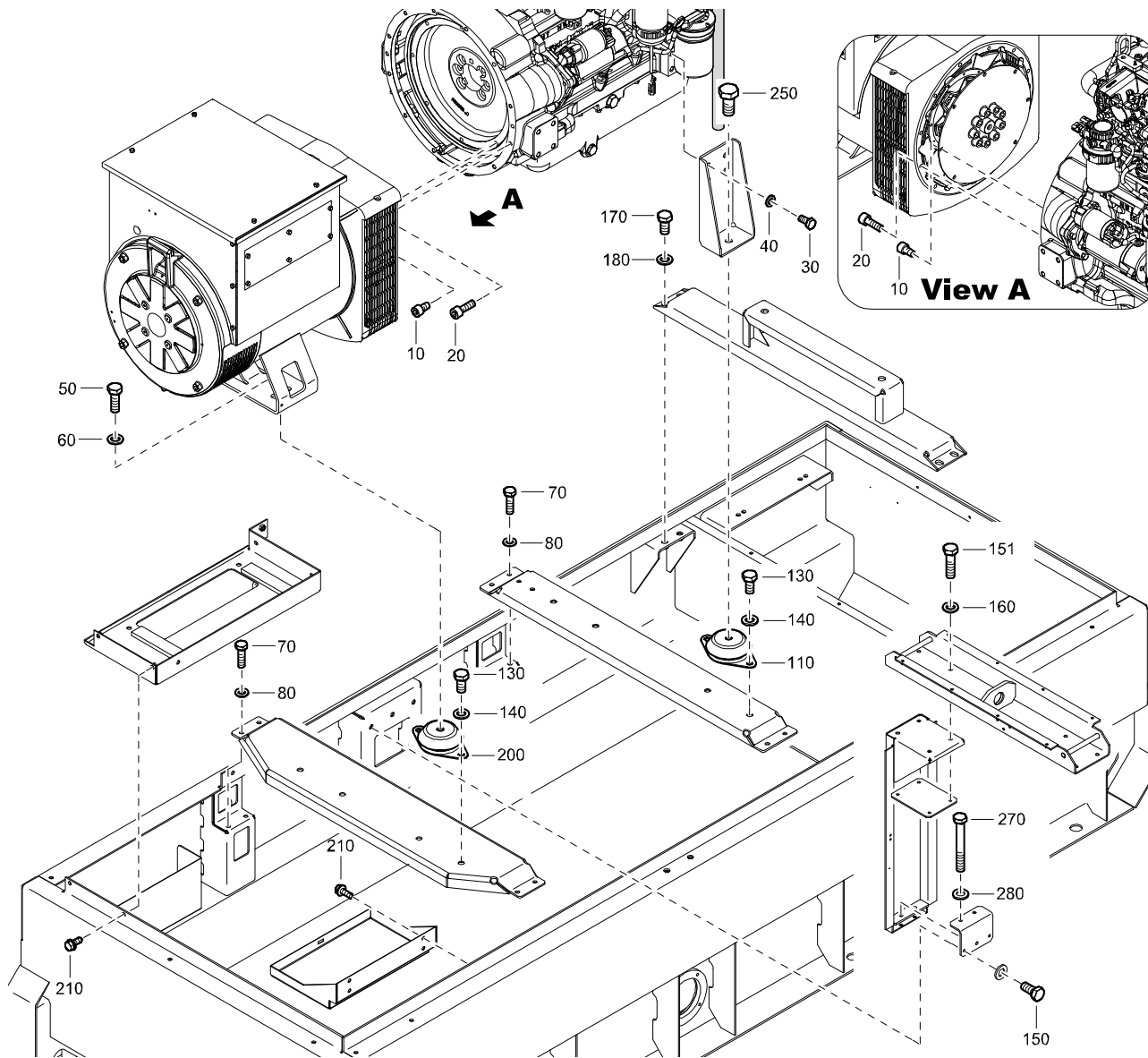
| REF | PART NUMBER  | DESIGNATION | QTY |
|-----|--------------|-------------|-----|
| 10  | 1310 6066 24 | ALTERNATOR  | 1   |
| 20  | 1089 9378 26 | SWITCH      | 1   |
| 30  | 1310 4642 50 | WIRE SET    | 1   |
| 40  | 1310 5003 00 | SUPPORT     | 1   |
| 50  | 1310 8088 00 | PANEL       | 1   |
| 60  | 1310 8089 00 | COVER       | 1   |

**FRAME AND MOUNTS - QAS 70-90 - STANDARD**



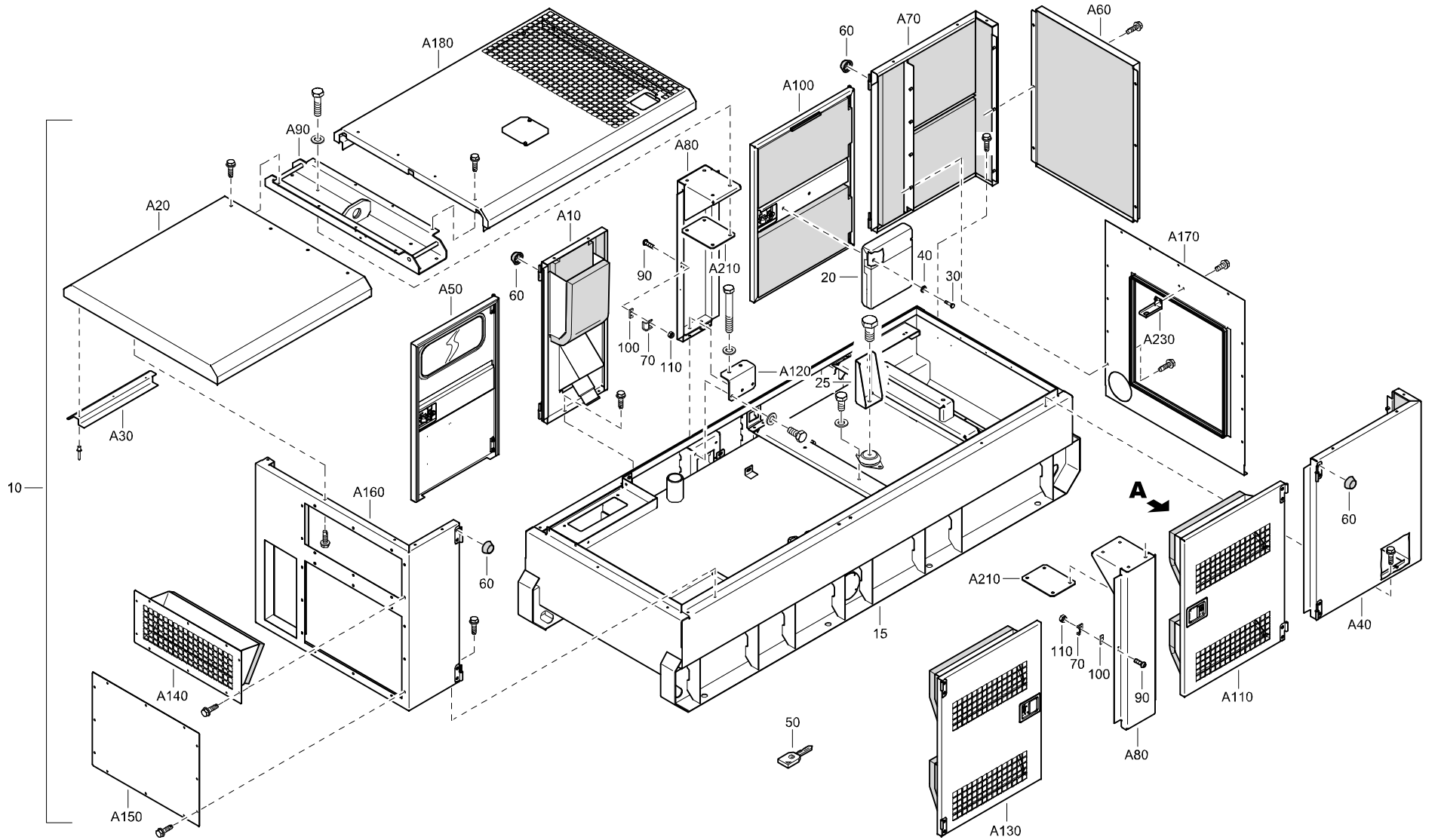
| REF | PART NUMBER  | DESIGNATION | QTY |
|-----|--------------|-------------|-----|
| 10  | 0211 5287 00 | SCREW       | 8   |
| 20  | 0211 1364 00 | SCREW       | 12  |
| 30  | 0147 1400 03 | SCREW       | 6   |
| 40  | 0301 2358 00 | WASHER      | 6   |
| 50  | 0147 1401 03 | SCREW       | 6   |
| 60  | 0301 2358 00 | WASHER      | 6   |
| 70  | 0147 1363 03 | SCREW       | 8   |
| 80  | 0301 2344 00 | WASHER      | 8   |
| 110 | 1613 6752 03 | RUBBER      | 2   |
| 130 | 0147 1400 03 | SCREW       | 8   |
| 140 | 0301 2358 00 | WASHER      | 8   |
| 150 | 0147 1398 03 | SCREW       | 6   |
| 151 | 0147 1404 03 | SCREW       | 8   |
| 160 | 0301 2358 00 | WASHER      | 4   |
| 170 | 0147 1400 03 | SCREW       | 6   |
| 180 | 0301 2358 00 | WASHER      | 6   |
| 200 | 1619 5044 00 | MOUNT       | 2   |
| 210 | 1619 2766 00 | SCREW       | 5   |
| 250 | 0147 1476 03 | SCREW       | 4   |
| 270 | 0147 1413 03 | SCREW       | 4   |
| 280 | 0301 2358 00 | WASHER      | 4   |

# FRAME AND MOUNTS - QAS 120 - STANDARD



| REF | PART NUMBER  | DESIGNATION | QTY |
|-----|--------------|-------------|-----|
| 10  | 0211 5287 00 | SCREW       | 8   |
| 20  | 0211 1364 00 | SCREW       | 12  |
| 30  | 0147 1400 03 | SCREW       | 6   |
| 40  | 0301 2358 00 | WASHER      | 6   |
| 50  | 0147 1401 03 | SCREW       | 6   |
| 60  | 0301 2358 00 | WASHER      | 6   |
| 70  | 0147 1363 03 | SCREW       | 8   |
| 80  | 0301 2344 00 | WASHER      | 8   |
| 110 | 1613 6752 03 | RUBBER      | 2   |
| 130 | 0147 1400 03 | SCREW       | 8   |
| 140 | 0301 2358 00 | WASHER      | 8   |
| 150 | 0147 1398 03 | SCREW       | 6   |
| 151 | 0147 1404 03 | SCREW       | 8   |
| 160 | 0301 2358 00 | WASHER      | 4   |
| 170 | 0147 1400 03 | SCREW       | 6   |
| 180 | 0301 2358 00 | WASHER      | 6   |
| 200 | 1619 5044 00 | MOUNT       | 2   |
| 210 | 1619 2766 00 | SCREW       | 5   |
| 250 | 0147 1476 03 | SCREW       | 4   |
| 270 | 0147 1413 03 | SCREW       | 4   |
| 280 | 0301 2358 00 | WASHER      | 4   |

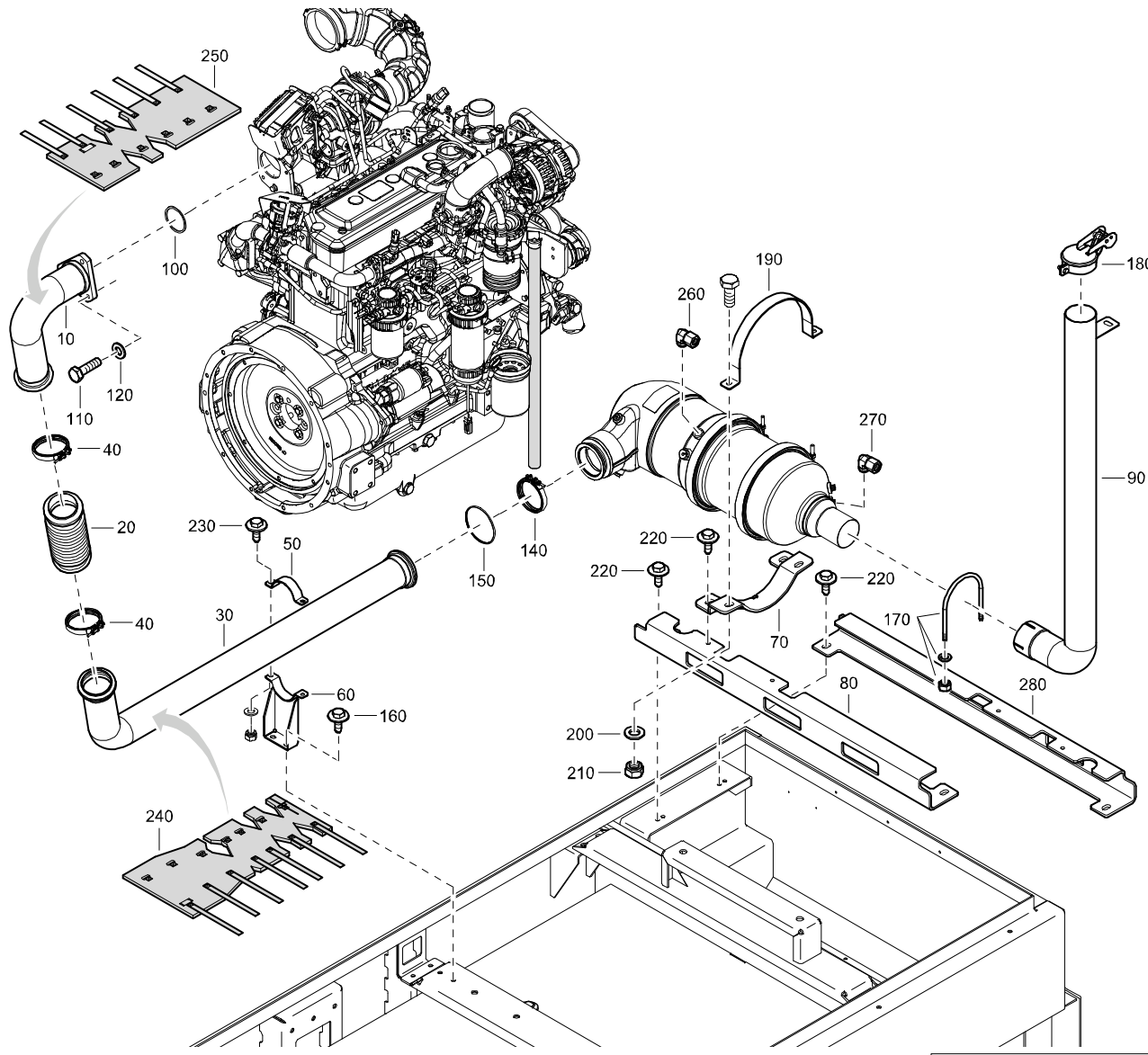
**BODYWORK - STANDARD**



## BODYWORK - STANDARD

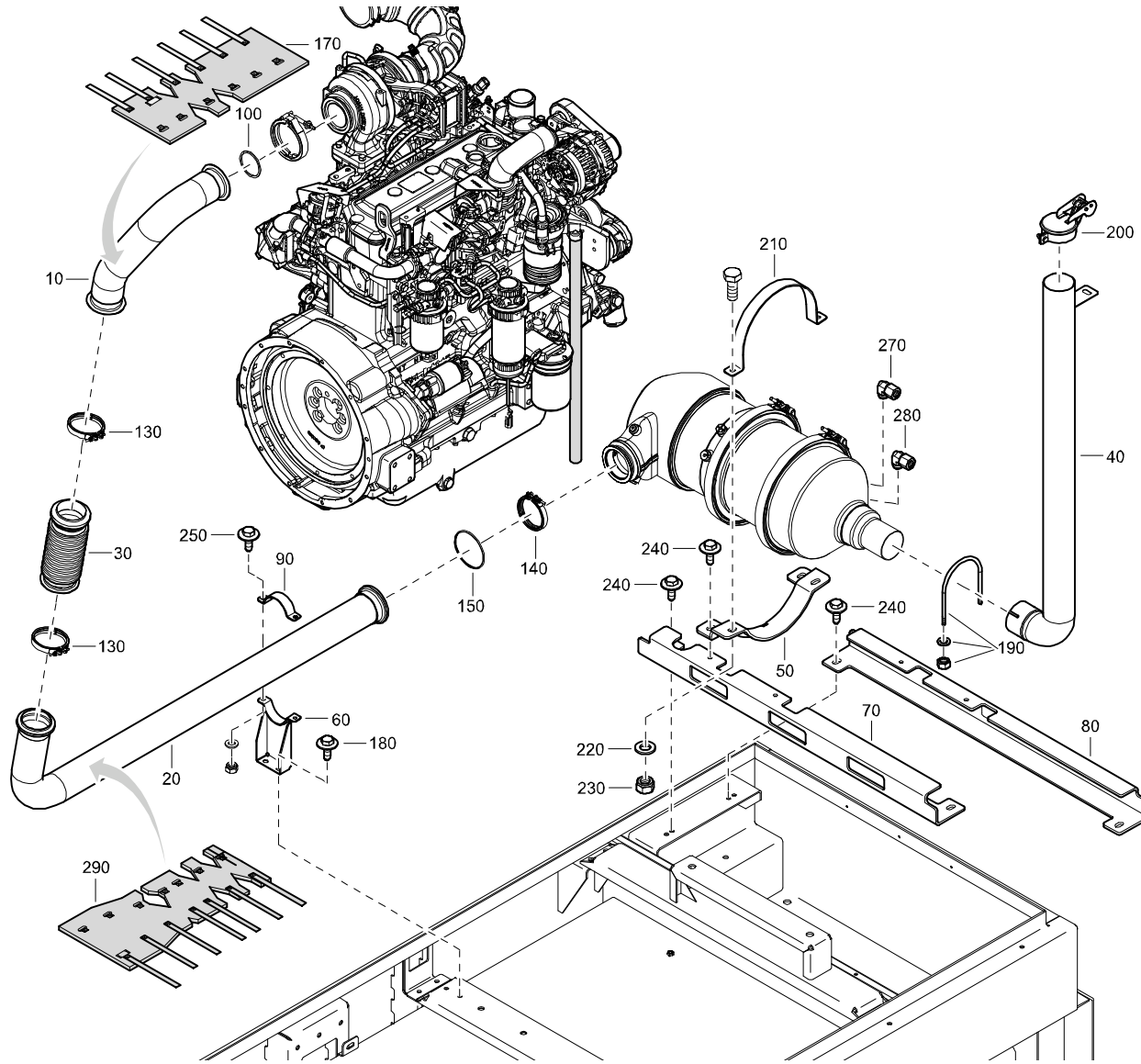
| REF   | PART NUMBER  | DESIGNATION               | QTY | REF | PART NUMBER  | DESIGNATION      | QTY | REF | PART NUMBER | DESIGNATION | QTY |
|-------|--------------|---------------------------|-----|-----|--------------|------------------|-----|-----|-------------|-------------|-----|
| 10    | 1310 0714 00 | CANOPY SET                | 1   | 60  | 1613 3672 00 | CAP-BOLT PROTECT | 8   |     |             |             |     |
| •A10  | 1310 0800 80 | PANEL                     | 1   | 70  | 1604 5031 00 | BRACKET          | 3   |     |             |             |     |
| •A20  | 1310 4371 80 | PANEL                     | 1   | 90  | 0215 0003 89 | SCREW            | 8   |     |             |             |     |
|       |              | (For details see page 60) |     | 100 | 1310 4019 00 | SPACER           | 4   |     |             |             |     |
| •A30  | 1310 4373 01 | PLATE                     | 1   | 110 | 0291 1108 00 | LOCKNUT          | 8   |     |             |             |     |
| •A40  | 1310 4373 80 | PANEL ASSY                | 1   |     |              |                  |     |     |             |             |     |
|       |              | (For details see page 61) |     |     |              |                  |     |     |             |             |     |
| •A50  | 1310 4377 80 | DOOR                      | 1   |     |              |                  |     |     |             |             |     |
|       |              | (For details see page 62) |     |     |              |                  |     |     |             |             |     |
| •A60  | 1310 4378 80 | PANEL                     | 1   |     |              |                  |     |     |             |             |     |
|       |              | (For details see page 65) |     |     |              |                  |     |     |             |             |     |
| •A70  | 1310 8692 80 | PANEL ASSY                | 1   |     |              |                  |     |     |             |             |     |
|       |              | (For details see page 70) |     |     |              |                  |     |     |             |             |     |
| •A80  | 1310 4408 00 | SIDE SUPPORT              | 2   |     |              |                  |     |     |             |             |     |
| •A90  | 1310 8694 00 | BEAM                      | 1   |     |              |                  |     |     |             |             |     |
| •A100 | 1310 4416 80 | DOOR                      | 1   |     |              |                  |     |     |             |             |     |
|       |              | (For details see page 63) |     |     |              |                  |     |     |             |             |     |
| •A110 | 1310 4417 80 | DOOR                      | 1   |     |              |                  |     |     |             |             |     |
|       |              | (For details see page 64) |     |     |              |                  |     |     |             |             |     |
| •A120 | 1310 4478 00 | BRACKET                   | 2   |     |              |                  |     |     |             |             |     |
| •A130 | 1310 5004 80 | DOOR                      | 1   |     |              |                  |     |     |             |             |     |
|       |              | (For details see page 66) |     |     |              |                  |     |     |             |             |     |
| •A140 | 1310 5006 80 | PANEL                     | 1   |     |              |                  |     |     |             |             |     |
|       |              | (For details see page 67) |     |     |              |                  |     |     |             |             |     |
| •A150 | 1310 5007 80 | PANEL                     | 1   |     |              |                  |     |     |             |             |     |
|       |              | (For details see page 68) |     |     |              |                  |     |     |             |             |     |
| •A160 | 1310 5008 80 | PANEL ASSY                | 1   |     |              |                  |     |     |             |             |     |
|       |              | (For details see page 69) |     |     |              |                  |     |     |             |             |     |
| •A170 | 1310 6971 80 | PANEL                     | 1   |     |              |                  |     |     |             |             |     |
|       |              | (For details see page 71) |     |     |              |                  |     |     |             |             |     |
| •A180 | 1310 6976 80 | PANEL ASSY                | 1   |     |              |                  |     |     |             |             |     |
|       |              | (For details see page 72) |     |     |              |                  |     |     |             |             |     |
| •A210 | 1310 4480 00 | PLATE                     | 2   |     |              |                  |     |     |             |             |     |
| •A230 | 1310 6980 00 | BRACKET                   | 1   |     |              |                  |     |     |             |             |     |
| 15    | 1310 8542 80 | FRAME ASSY                | 1   |     |              |                  |     |     |             |             |     |
|       |              | (For details see page 51) |     |     |              |                  |     |     |             |             |     |
| 20    | 1310 0356 39 | HOLDER                    | 1   |     |              |                  |     |     |             |             |     |
| 25    | 1310 4414 00 | MOUNT-ENGINE              | 2   |     |              |                  |     |     |             |             |     |
| 30    | 0144 3206 03 | SCREW                     | 2   |     |              |                  |     |     |             |             |     |
| 40    | 0301 2327 00 | WASHER                    | 2   |     |              |                  |     |     |             |             |     |
| 50    | 1615 7271 00 | KEY                       | 2   |     |              |                  |     |     |             |             |     |

**EXHAUST - QAS 70-90 - STANDARD**



| REF | PART NUMBER  | DESIGNATION   | QTY |
|-----|--------------|---------------|-----|
| 10  | 1310 5013 00 | PIPE          | 1   |
| 20  | 1310 0728 66 | PIPE          | 1   |
| 30  | 1310 5014 00 | PIPE          | 1   |
| 40  | 1310 0728 70 | CLAMP         | 2   |
| 50  | 1310 6982 00 | CLAMP         | 1   |
| 60  | 1310 6981 00 | BRACKET       | 1   |
| 70  | 1310 6974 01 | BRACKET       | 2   |
| 80  | 1310 6973 01 | SUPPORT       | 1   |
| 90  | 1310 5015 02 | EXHAUST STACK | 1   |
| 100 | 1310 0728 67 | GASKET        | 1   |
| 110 | 0147 1363 15 | SCREW         | 3   |
| 120 | 0301 2344 00 | WASHER        | 3   |
| 140 | 1310 0728 69 | CLAMP         | 1   |
| 150 | 1310 0728 68 | SEAL RING     | 1   |
| 160 | 1615 5664 00 | BOLT          | 1   |
| 170 | 1310 0355 61 | CLAMP-SADDLE  | 1   |
| 180 | 1615 7214 00 | CAP-RAIN      | 1   |
| 190 | 1310 0732 02 | STRAP         | 2   |
| 200 | 0301 2358 00 | WASHER        | 4   |
| 210 | 0291 1185 01 | NUT           | 4   |
| 220 | 1615 5664 00 | BOLT          | 8   |
| 230 | 1615 5664 00 | BOLT          | 1   |
| 240 | 1310 0734 64 | BLANKET       | 1   |
| 250 | 1310 0734 65 | BLANKET       | 1   |
| 260 | 1310 0723 41 | ELBOW         | 1   |
| 270 | 1310 0723 40 | ELBOW         | 1   |
| 280 | 1310 6973 02 | SUPPORT       | 0   |

# EXHAUST - QAS 120 - STANDARD



| REF | PART NUMBER  | DESIGNATION | QTY |
|-----|--------------|-------------|-----|
| 10  | 1310 5010 00 | EXHAUST     | 1   |
| 20  | 1310 5014 00 | PIPE        | 1   |
| 30  | 1310 0728 66 | PIPE        | 1   |
| 40  | 1310 5015 01 | EXHAUST     | 1   |
| 50  | 1310 6975 01 | SUPPORT     | 2   |
| 60  | 1310 6981 00 | BRACKET     | 1   |
| 70  | 1310 6973 03 | BRACKET     | 1   |
| 80  | 1310 6973 04 | BRACKET     | 1   |
| 90  | 1310 6982 00 | CLAMP       | 1   |
| 100 | 1310 0728 67 | GASKET      | 1   |
| 130 | 1310 0728 70 | CLAMP       | 3   |
| 140 | 1310 0728 69 | CLAMP       | 1   |
| 150 | 1310 0728 68 | SEAL RING   | 1   |
| 170 | 1310 0734 66 | BLANKET     | 1   |
| 180 | 1615 5664 00 | BOLT        | 1   |
| 190 | 1310 0355 61 | CLAMP       | 1   |
| 200 | 1615 7214 00 | CAP-RAIN    | 1   |
| 210 | 1310 0730 56 | STRAP       | 2   |
| 220 | 0301 2358 00 | WASHER      | 4   |
| 230 | 0291 1185 01 | NUT         | 4   |
| 240 | 1615 5664 00 | BOLT        | 8   |
| 250 | 1615 5664 00 | BOLT        | 1   |
| 270 | 1310 0723 41 | ELBOW       | 2   |
| 280 | 1310 0723 40 | ELBOW       | 1   |
| 290 | 1310 0734 65 | BLANKET     | 1   |

# MARKINGS - STANDARD

**WARNING OR SHUTDOWN DISPLAY**

|                          |    |                        |     |
|--------------------------|----|------------------------|-----|
| LOW OIL PRESSURE         |    | GENERATOR OVERVOLTAGE  | Hz> |
| HIGH COOLENT TEMPERATURE |    | GENERATOR UNDERVOLTAGE | Hz< |
| CHARGING ALTERNATOR      |    | SERVICE TIMER 1        | Y1  |
| LOW FUEL LEVEL           |    | SERVICE TIMER 2        | Y2  |
| LOW COOLENT LEVEL        |    | EMERGENCY STOP         |     |
| GENERATOR OVERVOLTAGE    | V> | ALARM                  |     |
| GENERATOR UNDERVOLTAGE   | V< | START FAILURE          |     |
|                          |    | STOP FAILURE           |     |

1310 4100 00 rev.1

**WARNING**

**SEVER HAZARD!**  
Machine can start automatically. Disconnect battery prior to servicing. Failure to comply can result in death or serious injury.

1310 0383 72

**Atlas Copco** GENUINE PARTS

|              |                                  |
|--------------|----------------------------------|
| SERVICE PAKS |                                  |
| 1310 3124 70 | normal (500 hr)                  |
| 1310 3124 71 | yearly (1000hr)                  |
| 1310 3124 72 | yearly (2000hr)                  |
| ENGINE OIL   |                                  |
| 1615 5953 00 | 1.3 - Gallon (5 Liter) container |
| 1615 5954 00 | 5.2 - Gallon (20 Liter) pail     |

1310 0383 07

**CAUTION**

**BURN HAZARD!**  
Keep clear. Hot exhaust may burn. Failure to comply may result in moderate or minor injury.

1310 0383 07

30

ULTRA LOW SULFUR FUEL ONLY

20

LOW ASH ENGINE OIL REQUIRED. SEE INSTRUCTION MANUAL

A130

NEUTRAL GROUNDED

A30

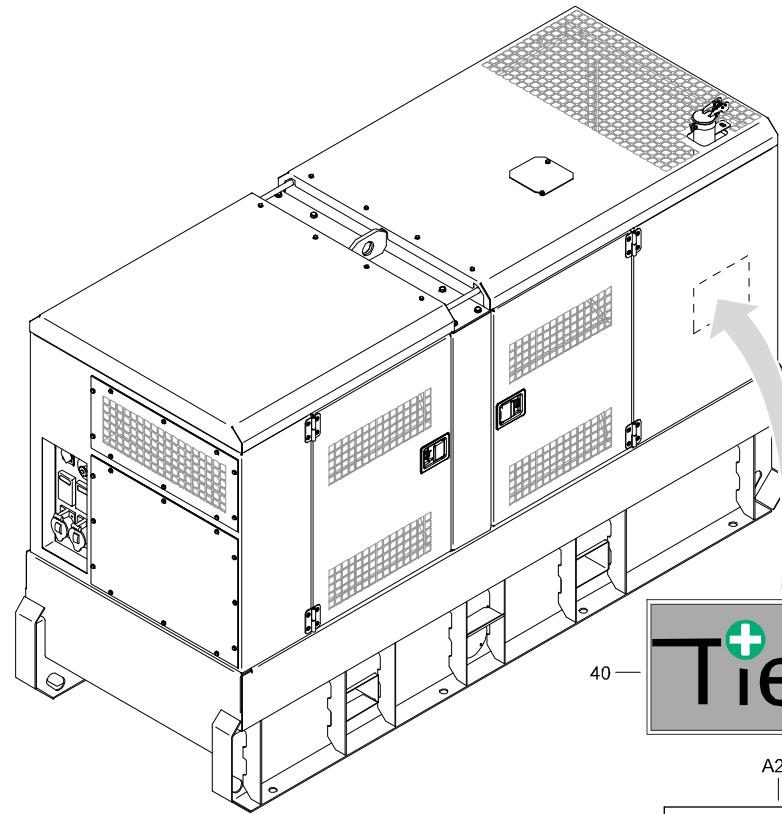
A110

15W 40 OIL

A120

| Relay | Function                |
|-------|-------------------------|
| K 11  | High Voltage start life |
| K 12  | Low Voltage start life  |
| K 13  | Socket enable contactor |

1310 3124 05



A60

**WARNING**

**CALIFORNIA PROPOSITION 65 WARNING**  
Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

1310 0383 07

A100

**CAUTION**

Coolant must meet ASTM D6210 OR ASTM D6211. Use of incorrect coolant will result in damage to the radiator and engine. Refer to the Instruction Manual

1310 0383 05



A20

Qc1002

Identification of symbols

1. Stop Generator
2. Start Generator
3. Remote start
4. To scroll up through menu
5. To scroll down through menu
6. To enter selection
7. To go back to main menu
8. Warning Indication
9. Power ON

1310 4068 00

A90

**WARNING**

**FIRE HAZARD!**  
Shut down generator before changing voltage selector switch. Failure to comply could result in death or serious injury.

1310 0383 37

A40

208-240V 3 PHASE

480V 3 PHASE

120-240V 1P/1L L1-L2

A10

**ATTENTION**

VOLTAGE SELECTOR POSITION

208-240V 3 PHASE

480V 3 PHASE

120-240V 1P/1L L1-L2

1310 0383 00

A70

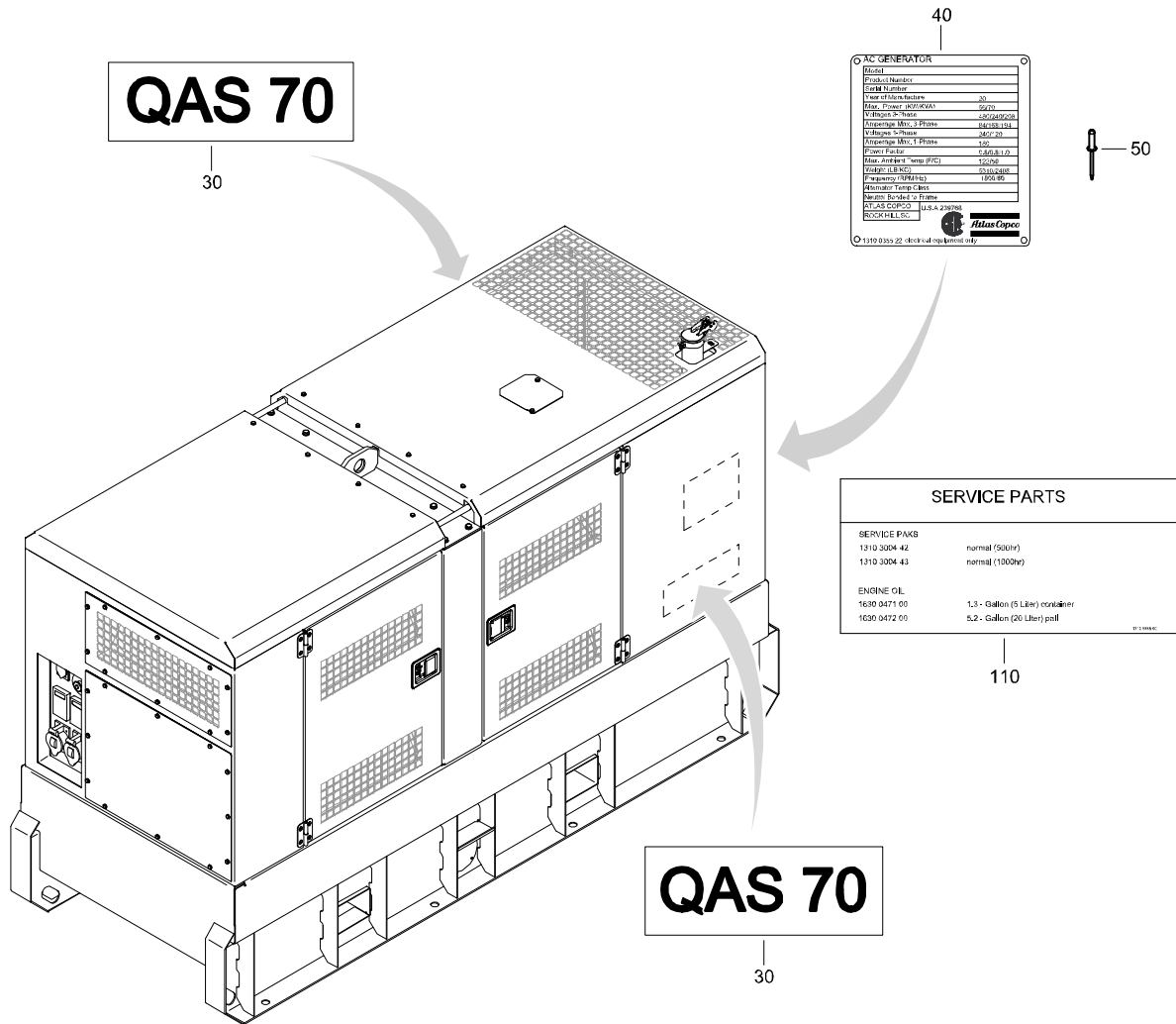
1310 0383 00



## MARKINGS - STANDARD

| REF   | PART NUMBER  | DESIGNATION | QTY | REF | PART NUMBER | DESIGNATION | QTY | REF | PART NUMBER | DESIGNATION | QTY |
|-------|--------------|-------------|-----|-----|-------------|-------------|-----|-----|-------------|-------------|-----|
| 10    | 1310 4557 00 | LABEL SHEET | 1   |     |             |             |     |     |             |             |     |
| •A10  | 1310 4561 00 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| •A20  | 1310 4558 00 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| •A30  | 1310 4559 00 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| •A40  | 1310 4560 00 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| •A50  | 1310 0353 72 | LABEL       | 2   |     |             |             |     |     |             |             |     |
| •A60  | 1310 3112 36 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| •A70  | 1310 4946 00 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| •A80  | 1310 4100 00 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| •A90  | 1310 0356 37 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| •A100 | 1310 0356 95 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| •A110 | 1310 0356 38 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| •A120 | 1310 3124 68 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| •A130 | 1310 3124 67 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| •A140 | 1310 0313 24 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| 20    | 1310 0723 22 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| 30    | 8915 0021 80 | LABEL       | 1   |     |             |             |     |     |             |             |     |
| 40    | 1310 6002 25 | LABEL       | 2   |     |             |             |     |     |             |             |     |

**PRINTED MATERIAL - QAS 70 - STANDARD**



| REF | PART NUMBER  | DESIGNATION | QTY |
|-----|--------------|-------------|-----|
| 30  | 1310 4703 00 | LABEL       | 2   |
| 40  | 1310 0355 22 | DATA PLATE  | 1   |
| 50  | 1310 0361 69 | RIVET       | 4   |
| 110 | 1310 8889 00 | LABEL       | 1   |

40

| AC GENERATOR               |             |
|----------------------------|-------------|
| Model                      |             |
| Product Number             |             |
| Code Number                |             |
| Year of Manufacture        | 30          |
| Max. Power (KW/KVA)        | 250/300     |
| V/Phase P-Phase            | 250/250/250 |
| V/Phase W-V-Phase          | 440/440/440 |
| V/Phase S-Phase            | 440/440     |
| Frequency (Hz)             | 60          |
| Power Factor               | 0.8         |
| Max. Ambient Temp (F/C)    | 150/60      |
| Factory SERVO              | 2510-0488   |
| Frequency (RPM/Hz)         | 1800/60     |
| Standard Term. Class       |             |
| Serial Number of Frame     |             |
| ATLAS COPCO U.S.A. 250/300 |             |
| ROCKWELL CO.               |             |

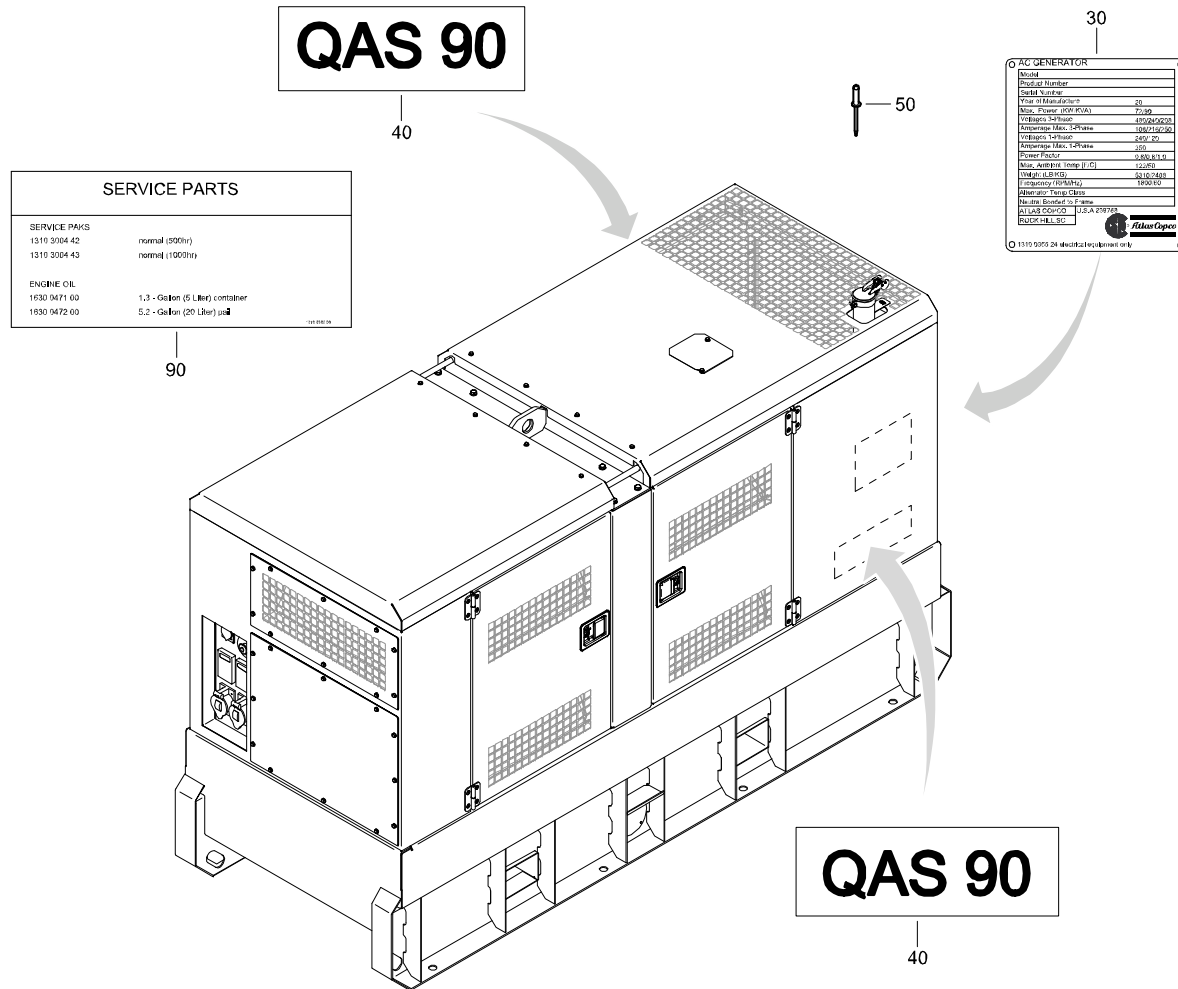
1310 0355 22 electrical equipment only

110

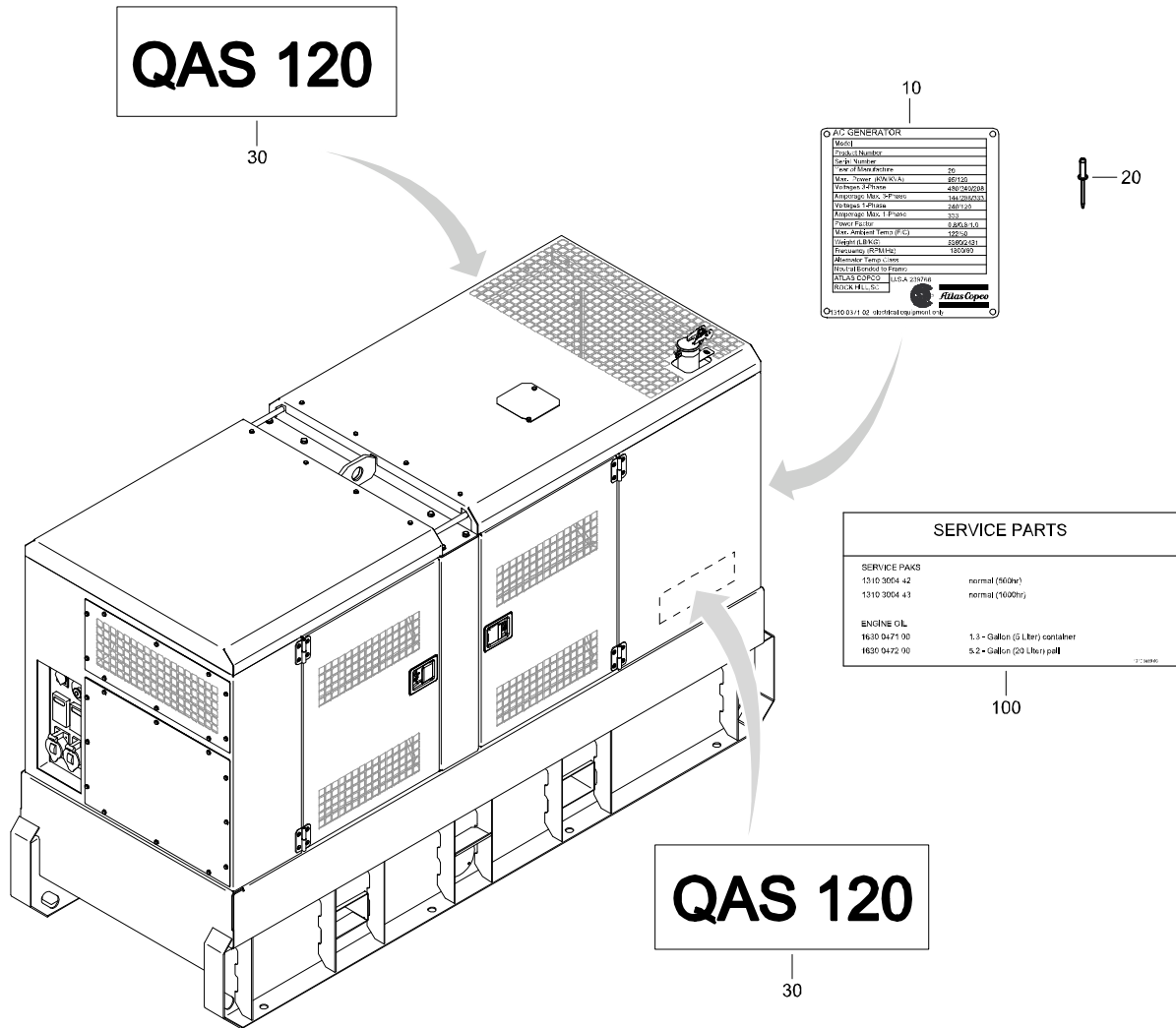
| SERVICE PARTS |                                  |
|---------------|----------------------------------|
| SERVICE PAKS  |                                  |
| 1310 3004 42  | normal (500hr)                   |
| 1310 3004 43  | normal (1100hr)                  |
| ENGINE OIL    |                                  |
| 1630 0471 01  | 1.5 - Gallon (5 Liter) container |
| 1630 0472 01  | 5.2 - Gallon (20 Liter) pail     |

PRINTED MATERIAL - QAS 90 - STANDARD

| REF | PART NUMBER  | DESIGNATION | QTY |
|-----|--------------|-------------|-----|
| 30  | 1310 0355 24 | DATA PLATE  | 1   |
| 40  | 1310 4171 00 | LABEL       | 2   |
| 50  | 1310 0361 69 | RIVET       | 4   |
| 90  | 1310 8889 00 | LABEL       | 1   |



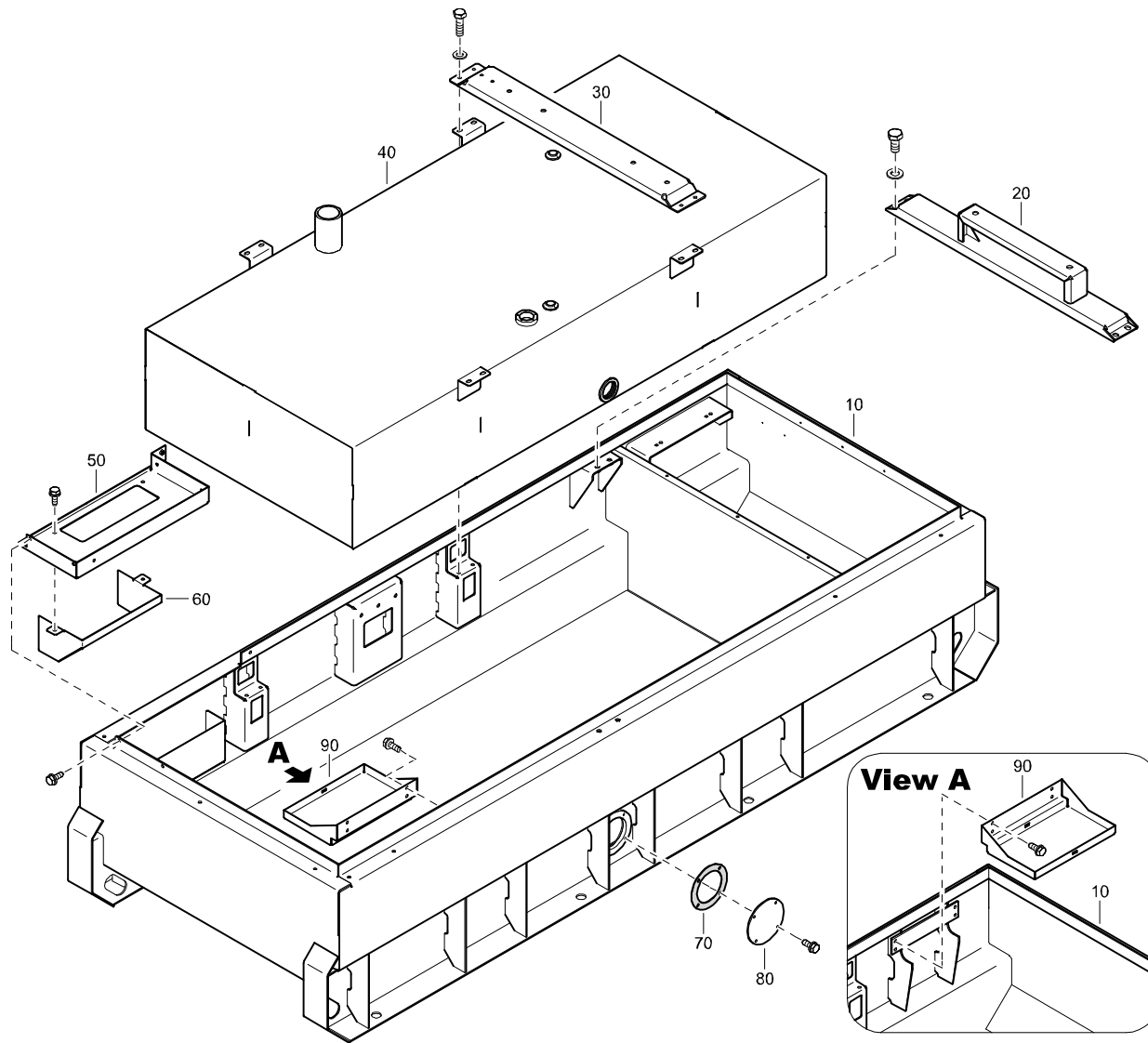
**PRINTED MATERIAL - QAS 120 - STANDARD**



| REF | PART NUMBER  | DESIGNATION | QTY |
|-----|--------------|-------------|-----|
| 10  | 1310 0371 02 | DATA PLATE  | 1   |
| 20  | 1310 0361 69 | RIVET       | 4   |
| 30  | 1310 4170 00 | LABEL       | 2   |
| 100 | 1310 8889 00 | LABEL       | 1   |

# FRAME ASSEMBLY - STANDARD

| REF | PART NUMBER  | DESIGNATION    | QTY |
|-----|--------------|----------------|-----|
| -   | 1310 8542 80 | FRAME ASSEMBLY |     |
|     |              | (From page 42) |     |
| •10 | 1310 8542 00 | FRAME          | 1   |
| •20 | 1310 6979 00 | BEAM           | 1   |
| •30 | 1310 4050 00 | SUPPORT        | 1   |
| •40 | 1310 8551 00 | TANK-FUEL      | 1   |
| •50 | 1310 8543 00 | BRACKET        | 1   |
| •60 | 1310 8544 00 | BRACKET        | 1   |
| •70 | 1310 4637 00 | GASKET         | 1   |
| •80 | 1310 4857 00 | COVER          | 1   |
| •90 | 1310 8701 00 | SUPPORT        | 0   |

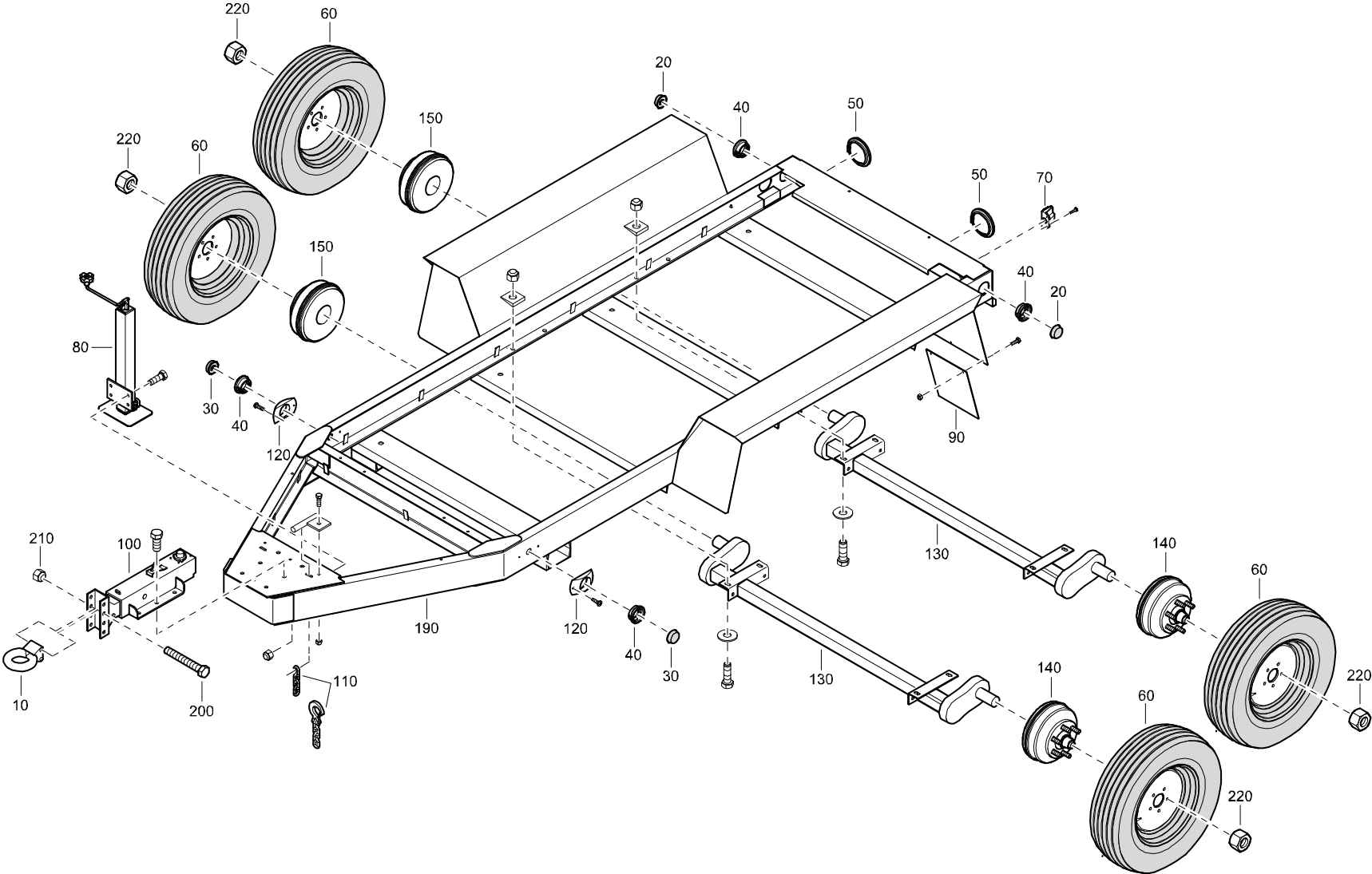




**TRAILER ASSEMBLY - ELETRIC BRAKE- STANDARD**

| REF | PART NUMBER  | DESIGNATION         | QTY | REF | PART NUMBER | DESIGNATION | QTY | REF | PART NUMBER | DESIGNATION | QTY |
|-----|--------------|---------------------|-----|-----|-------------|-------------|-----|-----|-------------|-------------|-----|
| 10  | 1310 0346 73 | 3RD TOWING EYE      | 1   |     |             |             |     |     |             |             |     |
| 20  | 1310 0347 42 | RED REFLECTOR       | 2   |     |             |             |     |     |             |             |     |
| 30  | 1310 0347 43 | YELLOW REFLECTOR    | 2   |     |             |             |     |     |             |             |     |
| 40  | 1310 0346 89 | LIGHT GROMMET       | 4   |     |             |             |     |     |             |             |     |
| 50  | 1310 0347 45 | STOP TURN TAIL LAMP | 2   |     |             |             |     |     |             |             |     |
| 60  | 1310 0348 56 | TIRE & WHEEL ASSY   | 4   |     |             |             |     |     |             |             |     |
| 70  | 1310 0347 33 | LICENCE PLATE LAMP  | 1   |     |             |             |     |     |             |             |     |
| 80  | 1310 0347 11 | JACK                | 1   |     |             |             |     |     |             |             |     |
| 90  | 1310 0347 65 | MUD FLAP            | 1   |     |             |             |     |     |             |             |     |
| 100 | 1310 0348 30 | BREAKAWAY SWITCH    | 1   |     |             |             |     |     |             |             |     |
| 110 | 1310 0351 44 | BATTERY BOX         | 1   |     |             |             |     |     |             |             |     |
| 120 | 1310 0351 45 | SEALED BATTERY      | 1   |     |             |             |     |     |             |             |     |
| 130 | 1310 0346 45 | SAFETY CHAIN        | 2   |     |             |             |     |     |             |             |     |
| 140 | 1310 0362 73 | LIGHT MOUNT         | 2   |     |             |             |     |     |             |             |     |
| 150 | 1310 0362 40 | AXLE ASSY EB        | 2   |     |             |             |     |     |             |             |     |
| 160 | 1310 0362 34 | BRAKE ASSY          | 2   |     |             |             |     |     |             |             |     |
| 170 | 1310 0362 33 | BRAKE ASSY          | 2   |     |             |             |     |     |             |             |     |
| 210 | 1310 0732 66 | FRAME               | 1   |     |             |             |     |     |             |             |     |
| 220 | 1310 0733 18 | SCREW HEX           | 2   |     |             |             |     |     |             |             |     |
| 230 | 1310 0733 17 | NUT                 | 2   |     |             |             |     |     |             |             |     |
| 240 | 1310 0732 74 | LUG NUT             | 20  |     |             |             |     |     |             |             |     |

**TRAILER ASSEMBLY -HYDRAULIC BRAKE- STANDARD**

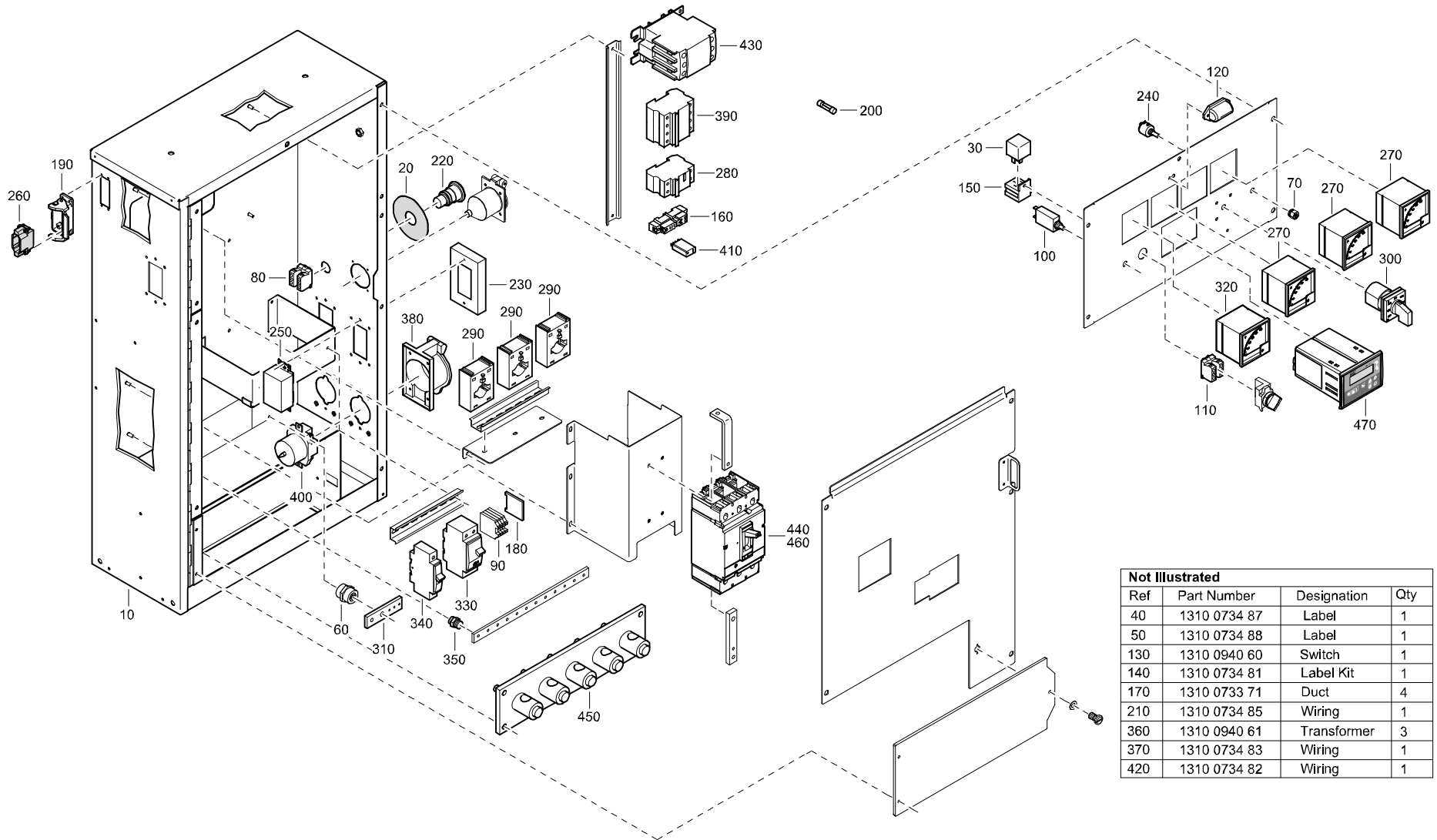




**TRAILER ASSEMBLY -HYDRAULIC BRAKE - STANDARD**

| REF | PART NUMBER  | DESIGNATION         | QTY | REF | PART NUMBER | DESIGNATION | QTY | REF | PART NUMBER | DESIGNATION | QTY |
|-----|--------------|---------------------|-----|-----|-------------|-------------|-----|-----|-------------|-------------|-----|
| 10  | 1310 0346 73 | 3RD TOWING EYE      | 1   |     |             |             |     |     |             |             |     |
| 20  | 1310 0347 42 | RED REFLECTOR       | 2   |     |             |             |     |     |             |             |     |
| 30  | 1310 0347 43 | YELLOW REFLECTOR    | 2   |     |             |             |     |     |             |             |     |
| 40  | 1310 0346 89 | LIGHT GROMMET       | 4   |     |             |             |     |     |             |             |     |
| 50  | 1310 0347 45 | STOP TURN TAIL LAMP | 2   |     |             |             |     |     |             |             |     |
| 60  | 1310 0348 56 | TIRE & WHEEL ASSY   | 4   |     |             |             |     |     |             |             |     |
| 70  | 1310 0347 33 | LICENCE PLATE LAMP  | 1   |     |             |             |     |     |             |             |     |
| 80  | 1310 0347 11 | JACK                | 1   |     |             |             |     |     |             |             |     |
| 90  | 1310 0345 82 | MUD FLAP            | 2   |     |             |             |     |     |             |             |     |
| 100 | 1310 0345 82 | HUDRAULIC ACTUATOR  | 1   |     |             |             |     |     |             |             |     |
| 110 | 1310 0346 45 | SAFETY CHAIN        | 2   |     |             |             |     |     |             |             |     |
| 120 | 1310 0362 73 | LIGHT MOUNT         | 2   |     |             |             |     |     |             |             |     |
| 130 | 1310 0362 39 | AXLE ASSY EB        | 2   |     |             |             |     |     |             |             |     |
| 140 | 1310 0362 36 | BRAKE               | 2   |     |             |             |     |     |             |             |     |
| 150 | 1310 0362 35 | BRAKE               | 2   |     |             |             |     |     |             |             |     |
| 190 | 1310 0732 62 | FRAME               | 1   |     |             |             |     |     |             |             |     |
| 200 | 1310 0733 17 | SCREW HEX           | 2   |     |             |             |     |     |             |             |     |
| 210 | 1310 0733 18 | NUT                 | 2   |     |             |             |     |     |             |             |     |
| 220 | 1310 0732 74 | LUG NUT             | 20  |     |             |             |     |     |             |             |     |

# CUBICLE ASSEMBLY - QAS 70 - STANDARD

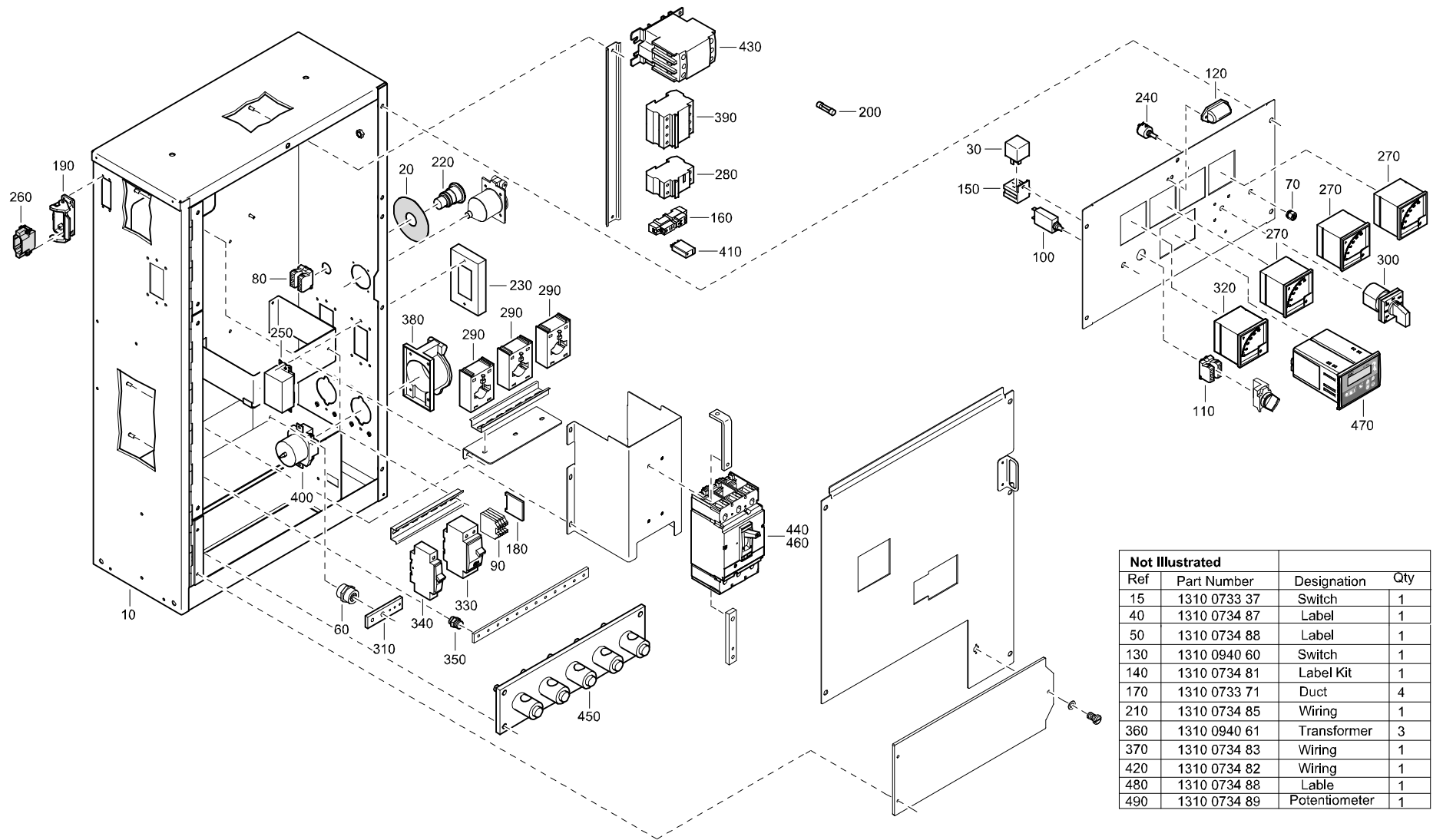


| Not Illustrated |              |             |     |
|-----------------|--------------|-------------|-----|
| Ref             | Part Number  | Designation | Qty |
| 40              | 1310 0734 87 | Label       | 1   |
| 50              | 1310 0734 88 | Label       | 1   |
| 130             | 1310 0940 60 | Switch      | 1   |
| 140             | 1310 0734 81 | Label Kit   | 1   |
| 170             | 1310 0733 71 | Duct        | 4   |
| 210             | 1310 0734 85 | Wiring      | 1   |
| 360             | 1310 0940 61 | Transformer | 3   |
| 370             | 1310 0734 83 | Wiring      | 1   |
| 420             | 1310 0734 82 | Wiring      | 1   |

**CUBICLE ASSEMBLY - QAS 70 - STANDARD**

| REF  | PART NUMBER  | DESIGNATION               | QTY            | REF  | PART NUMBER  | DESIGNATION       | QTY | REF | PART NUMBER | DESIGNATION | QTY |
|------|--------------|---------------------------|----------------|------|--------------|-------------------|-----|-----|-------------|-------------|-----|
| -    | 1310 8014 81 | CUBICLE ASSY              | (From page 35) | •400 | 1310 0733 38 | RECEPTACLE        | 2   |     |             |             |     |
| •10  | 1310 8014 00 | CUBICLE                   | 1              | •410 | 1310 0764 44 | OVERCURRENT RELAY | 3   |     |             |             |     |
| •20  | 1310 0734 91 | DECAL                     | 1              | •420 | 1310 0734 82 | WIRING            | 1   |     |             |             |     |
| •30  | 1310 0733 67 | RELAY                     | 1              | •430 | 1310 0734 76 | CONTACTOR         | 1   |     |             |             |     |
| •40  | 1310 0734 87 | LABEL                     | 1              | •440 | 1310 0940 62 | SHUNT TRIP        | 1   |     |             |             |     |
| •50  | 1310 0734 88 | LABEL                     | 1              | •450 | 1615 8508 00 | TERMINAL BOARD    | 1   |     |             |             |     |
| •60  | 1310 0734 72 | ISOLATOR                  | 4              | •460 | 1310 0940 63 | BREAKER           | 1   |     |             |             |     |
| •70  | 1310 0733 61 | NUT                       | 1              | •470 | 1604 9418 03 | CONTROLLER        | 1   |     |             |             |     |
| •80  | 1310 0733 60 | SWITCH                    | 2              |      |              |                   |     |     |             |             |     |
| •90  | 1310 0733 54 | TERMINAL                  | 4              |      |              |                   |     |     |             |             |     |
| •100 | 1310 0733 66 | BREAKER                   | 1              |      |              |                   |     |     |             |             |     |
| •110 | 1310 0733 55 | TERMINAL                  | 1              |      |              |                   |     |     |             |             |     |
| •120 | 1310 0733 65 | LIGHT                     | 1              |      |              |                   |     |     |             |             |     |
| •130 | 1310 0940 60 | SWITCH                    | 1              |      |              |                   |     |     |             |             |     |
| •140 | 1310 0734 81 | LABEL KIT                 | 1              |      |              |                   |     |     |             |             |     |
| •150 | 1310 0733 63 | SOCKET                    | 1              |      |              |                   |     |     |             |             |     |
| •160 | 1310 0734 78 | OVERCURRENT RELAY BASE    | 1              |      |              |                   |     |     |             |             |     |
| •170 | 1310 0733 71 | DUCT                      | 6              |      |              |                   |     |     |             |             |     |
| •180 | 1310 0733 59 | TERMINAL                  | 1              |      |              |                   |     |     |             |             |     |
| •190 | 1310 0733 58 | CONNECTOR HOUSING         | 1              |      |              |                   |     |     |             |             |     |
| •200 | 1310 0733 44 | FUSE                      | 4              |      |              |                   |     |     |             |             |     |
| •210 | 1310 0734 85 | WIRING                    | 1              |      |              |                   |     |     |             |             |     |
| •220 | 1310 0733 69 | SWITCH                    | 1              |      |              |                   |     |     |             |             |     |
| •230 | 1310 0733 41 | COVER                     | 3              |      |              |                   |     |     |             |             |     |
| •240 | 1310 0734 89 | POTENTIOMETER             | 1              |      |              |                   |     |     |             |             |     |
| •250 | 1310 0733 43 | RECEPTACLE                | 3              |      |              |                   |     |     |             |             |     |
| •260 | 1310 0733 53 | CONNECTOR                 | 1              |      |              |                   |     |     |             |             |     |
| •270 | 1310 0734 70 | METER                     | 3              |      |              |                   |     |     |             |             |     |
| •280 | 1310 0734 75 | FUSE HOLDER               | 1              |      |              |                   |     |     |             |             |     |
| •290 | 1310 0734 69 | TRANSFORMER               | 3              |      |              |                   |     |     |             |             |     |
| •300 | 1310 0733 49 | SWITCH                    | 1              |      |              |                   |     |     |             |             |     |
| •310 | 1310 0734 73 | BUSSBAR                   | 1              |      |              |                   |     |     |             |             |     |
| •320 | 1310 0733 50 | METER                     | 1              |      |              |                   |     |     |             |             |     |
| •330 | 1310 0733 39 | BREAKER                   | 2              |      |              |                   |     |     |             |             |     |
| •340 | 1310 0733 45 | BREAKER                   | 2              |      |              |                   |     |     |             |             |     |
| •350 | 1310 0734 71 | COPPER GROUND BAR         | 1              |      |              |                   |     |     |             |             |     |
| •360 | 1310 0940 61 | TRANSFORMER               | 3              |      |              |                   |     |     |             |             |     |
| •370 | 1310 0734 83 | WIRING SINGLE BREAKER POT | 1              |      |              |                   |     |     |             |             |     |
| •380 | 1310 0733 40 | COVER                     | 2              |      |              |                   |     |     |             |             |     |
| •390 | 1310 0733 48 | FUSEHOLDER                | 1              |      |              |                   |     |     |             |             |     |

# CUBICLE ASSEMBLY - QAS 90 - 120 - STANDARD



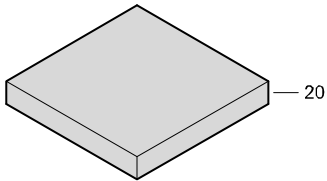
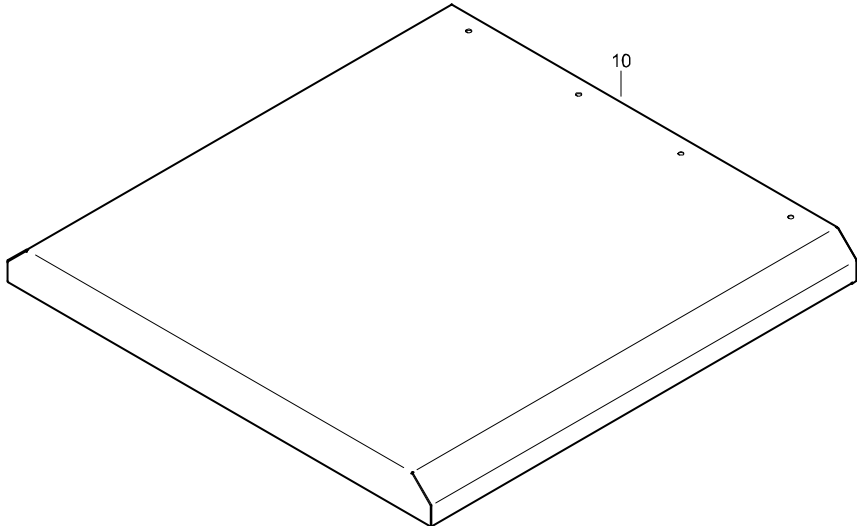
| Not Illustrated |              |               |     |
|-----------------|--------------|---------------|-----|
| Ref             | Part Number  | Designation   | Qty |
| 15              | 1310 0733 37 | Switch        | 1   |
| 40              | 1310 0734 87 | Label         | 1   |
| 50              | 1310 0734 88 | Label         | 1   |
| 130             | 1310 0940 60 | Switch        | 1   |
| 140             | 1310 0734 81 | Label Kit     | 1   |
| 170             | 1310 0733 71 | Duct          | 4   |
| 210             | 1310 0734 85 | Wiring        | 1   |
| 360             | 1310 0940 61 | Transformer   | 3   |
| 370             | 1310 0734 83 | Wiring        | 1   |
| 420             | 1310 0734 82 | Wiring        | 1   |
| 480             | 1310 0734 88 | Label         | 1   |
| 490             | 1310 0734 89 | Potentiometer | 1   |

**CUBICLE ASSEMBLY - QAS 90 - 120 - STANDARD**

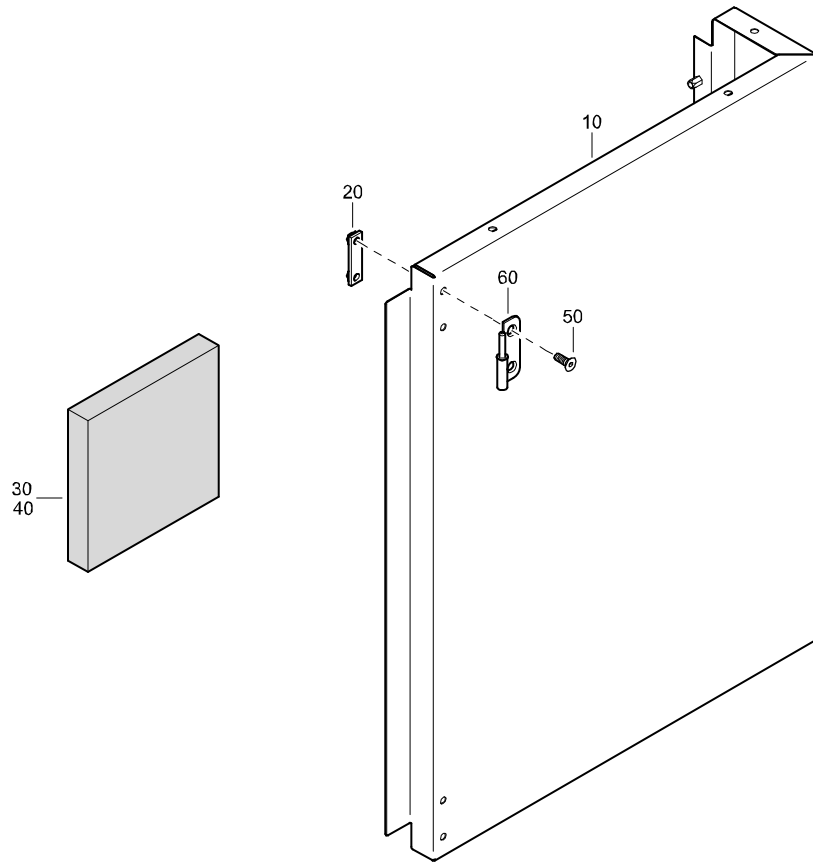
| REF  | PART NUMBER  | DESIGNATION            | QTY | REF  | PART NUMBER  | DESIGNATION   | QTY | REF | PART NUMBER | DESIGNATION | QTY |
|------|--------------|------------------------|-----|------|--------------|---------------|-----|-----|-------------|-------------|-----|
| -    | 1310 8015 81 | CUBICLE ASSEMBLY       |     | •390 | 1310 0734 81 | LABEL KIT     | 1   |     |             |             |     |
|      |              | (From page 36)         |     | •400 | 1310 0733 45 | BREAKER       | 2   |     |             |             |     |
| •10  | 1310 8015 00 | CUBICLE                | 1   | •410 | 1310 0733 39 | BREAKER       | 2   |     |             |             |     |
| •15  | 1310 0733 37 | SWITCH                 | 1   | •420 | 1310 0734 82 | WIRING        | 1   |     |             |             |     |
| •20  | 1310 0733 38 | RECEPTACLE             | 2   | •430 | 1310 0734 83 | WIRING        | 1   |     |             |             |     |
| •30  | 1310 0733 40 | COVER                  | 2   | •440 | 1310 0734 84 | WIRING        |     |     |             |             |     |
| •40  | 1310 0733 41 | COVER                  | 2   | •450 | 1310 0734 85 | WIRING        | 1   |     |             |             |     |
| •50  | 1310 0733 43 | RECEPTACLE             | 2   | •460 | 1310 0734 86 | WIRING        |     |     |             |             |     |
| •60  | 1310 0733 44 | FUSE                   | 4   | •470 | 1310 0734 87 | LABEL         | 1   |     |             |             |     |
| •70  | 1310 0733 48 | FUSEHOLDER             | 1   | •480 | 1310 0734 88 | LABEL         | 1   |     |             |             |     |
| •80  | 1310 0733 49 | SWITCH                 | 1   | •490 | 1310 0734 89 | POTENTIOMETER | 1   |     |             |             |     |
| •90  | 1310 0733 50 | METER                  | 1   |      |              |               |     |     |             |             |     |
| •100 | 1310 0733 53 | CONNECTOR              | 1   |      |              |               |     |     |             |             |     |
| •110 | 1310 0733 54 | TERMINAL               | 4   |      |              |               |     |     |             |             |     |
| •120 | 1310 0733 55 | TERMINAL               | 1   |      |              |               |     |     |             |             |     |
| •130 | 1310 0733 58 | CONNECTOR HOUSING      | 1   |      |              |               |     |     |             |             |     |
| •140 | 1310 0733 59 | TERMINAL               | 1   |      |              |               |     |     |             |             |     |
| •150 | 1310 0733 60 | SWITCH                 | 2   |      |              |               |     |     |             |             |     |
| •160 | 1310 0733 61 | NUT                    | 1   |      |              |               |     |     |             |             |     |
| •170 | 1310 0733 63 | SOCKET                 | 1   |      |              |               |     |     |             |             |     |
| •180 | 1310 0734 91 | DECAL                  | 1   |      |              |               |     |     |             |             |     |
| •190 | 1310 0733 65 | LIGHT                  | 1   |      |              |               |     |     |             |             |     |
| •200 | 1310 0733 66 | BREAKER                | 1   |      |              |               |     |     |             |             |     |
| •210 | 1310 0733 67 | RELAY                  | 1   |      |              |               |     |     |             |             |     |
| •220 | 1310 0733 69 | SWITCH                 | 1   |      |              |               |     |     |             |             |     |
| •230 | 1310 0733 71 | DUCT                   | 4   |      |              |               |     |     |             |             |     |
| •250 | 1310 0734 69 | TRANSFORMER            | 3   |      |              |               |     |     |             |             |     |
| •260 | 1310 0734 70 | METER                  | 3   |      |              |               |     |     |             |             |     |
| •270 | 1310 0734 71 | COPPER GROUND BAR      | 1   |      |              |               |     |     |             |             |     |
| •280 | 1310 0734 72 | ISOLATOR               | 4   |      |              |               |     |     |             |             |     |
| •290 | 1310 0734 73 | BUSSBAR                | 1   |      |              |               |     |     |             |             |     |
| •300 | 1310 0734 74 | PLUG                   | 1   |      |              |               |     |     |             |             |     |
| •310 | 1604 9418 03 | CONTROLLER             | 1   |      |              |               |     |     |             |             |     |
| •320 | 1310 0734 75 | FUSEHOLDER             | 1   |      |              |               |     |     |             |             |     |
| •330 | 1310 0734 76 | CONTACTOR              | 1   |      |              |               |     |     |             |             |     |
| •340 | 1310 0742 22 | OVERCURRENT RELAY      | 1   |      |              |               |     |     |             |             |     |
| •350 | 1310 0734 78 | OVERCURRENT RELAY BASE | 1   |      |              |               |     |     |             |             |     |
| •360 | 1310 0734 79 | BREAKER                | 1   |      |              |               |     |     |             |             |     |
| •370 | 1310 0734 80 | SHUNT TRIP             | 1   |      |              |               |     |     |             |             |     |
| •380 | 1615 8508 00 | TERMINAL BOARD         | 1   |      |              |               |     |     |             |             |     |

**REAR ROOF ASSEMBLY - STANDARD**

| REF | PART NUMBER  | DESIGNATION                                   | QTY |
|-----|--------------|---|-----|
| -   | 1310 4371 80 | PANEL-ROOF ASSY REAR<br><i>(From page 42)</i> |     |
| •10 | 1310 4371 00 | PANEL ROOF REAR                               | 1   |
| •20 | 1310 0370 10 | INSULATION ROOF                               | 2   |

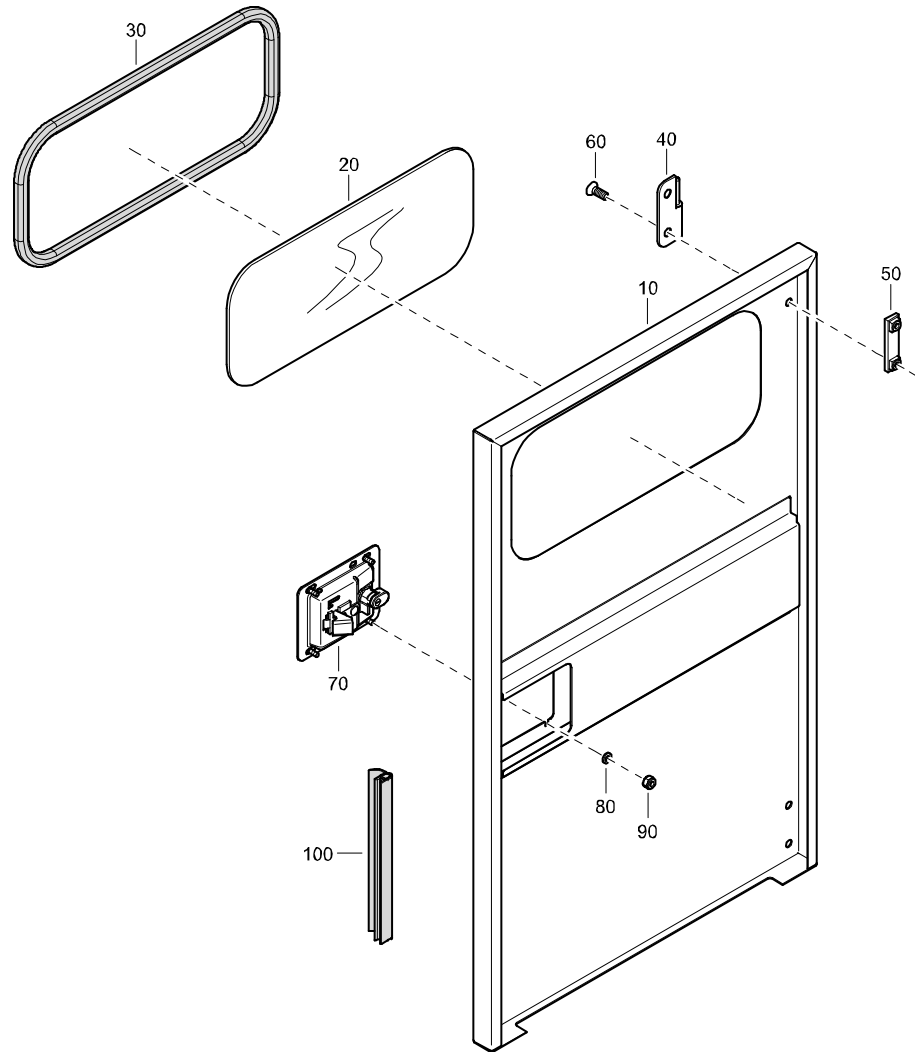


# SIDE PANEL ASSEMBLY - STANDARD



| REF | PART NUMBER  | DESIGNATION     | QTY            |
|-----|--------------|-----------------|----------------|
| -   | 1310 4373 80 | SIDE PANEL ASSY | (From page 42) |
| •10 | 1310 8692 00 | PANEL           | 1              |
| •20 | 1615 5684 00 | BRACKET         | 2              |
| •30 | 1310 8692 71 | INSULATION      | 2              |
| •40 | 1310 8692 72 | INSULATION      | 2              |
| •50 | 0216 1324 03 | SCREW           | 4              |
| •60 | 1604 3430 00 | HINGE           | 2              |

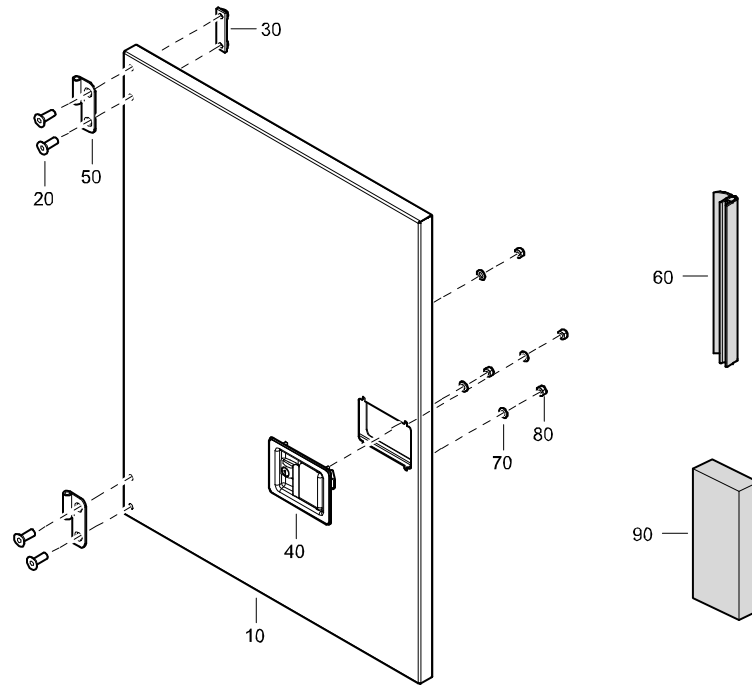
# CUBICLE DOOR ASSEMBLY - STANDARD



| REF  | PART NUMBER  | DESIGNATION                                       | QTY |
|------|--------------|---|-----|
| -    | 1310 4377 80 | CUBICLE DOOR ASSY. <a href="#">(From page 42)</a> |     |
| •10  | 1310 4377 00 | DOOR  | 1   |
| •20  | 1310 4048 00 | WINDOW  | 1   |
| •30  | 1310 4049 00 | SEAL  | AR  |
| •40  | 1615 5685 01 | HINGE   | 2   |
| •50  | 1615 5684 00 | BRACKET   | 2   |
| •60  | 0216 1324 03 | SCREW   | 4   |
| •70  | 1615 6967 03 | HANDLE  | 1   |
| •80  | 0301 2321 00 | WASHER  | 4   |
| •90  | 0291 1108 00 | LOCKNUT   | 4   |
| •100 | 1619 2665 00 | SEAL  | AR  |

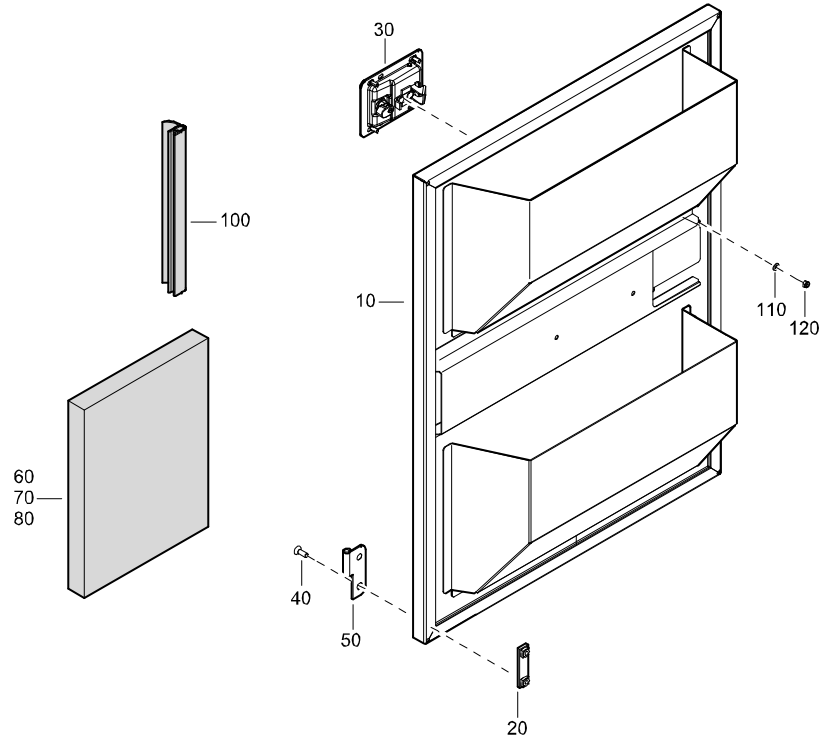


# DOOR ASSEMBLY - STANDARD



| REF | PART NUMBER  | DESIGNATION   | QTY            |
|-----|--------------|---------------|----------------|
| -   | 1310 4416 80 | DOOR ASSY     | (From page 42) |
| •10 | 1310 4416 00 | DOOR PANEL    | 1              |
| •20 | 0216 1324 03 | BOLT          | 4              |
| •30 | 1615 5684 00 | HINGE BRACKET | 2              |
| •40 | 1615 6967 03 | DOOR HANDLE   | 1              |
| •50 | 1604 3429 00 | HINGE- UPPER  | 2              |
| •60 | 1619 2665 00 | SEAL          | 1              |
| •70 | 0301 2321 00 | WASHER        | 4              |
| •80 | 0291 1108 00 | LOCKNUT       | 4              |
| •90 | 1310 4416 70 | INSULATION    | 2              |

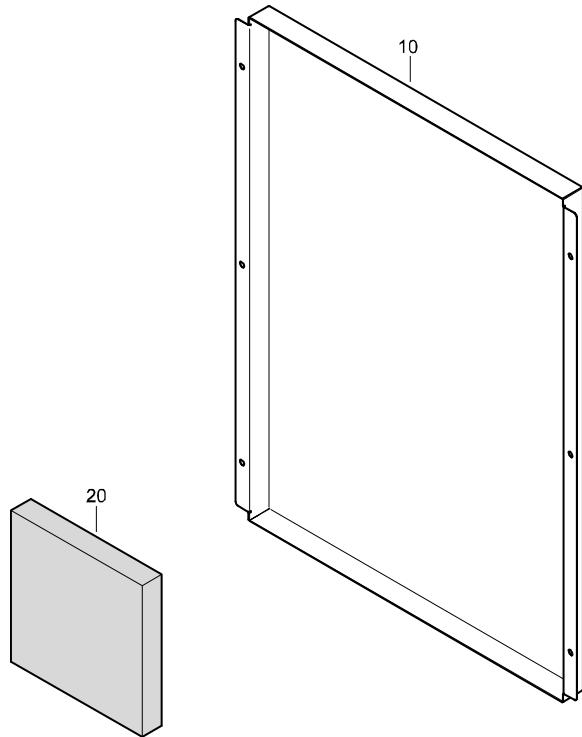
# DOOR ASSEMBLY - STANDARD



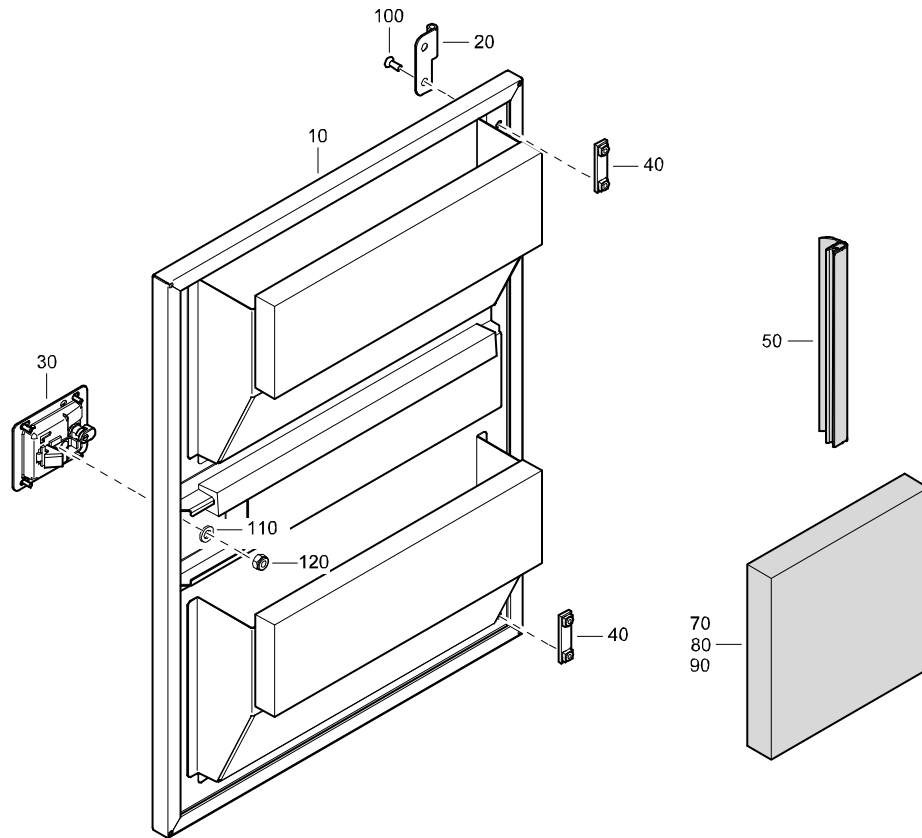
| REF  | PART NUMBER  | DESIGNATION              | QTY |
|------|--------------|--------------------------|-----|
| -    | 1310 4417 80 | DOOR ASSY (From page 42) |     |
| •10  | 1310 4417 00 | DOOR PANEL               | 1   |
| •20  | 1615 5684 00 | HINGE BRACKET            | 2   |
| •30  | 1615 6967 03 | DOOR HANDLE              | 1   |
| •40  | 0216 1324 03 | BOLT                     | 4   |
| •50  | 1604 3431 00 | HINGE - UPPER            | 2   |
| •60  | 1310 4417 72 | INSULATION               | 2   |
| •70  | 1310 5004 72 | INSULATION               | 2   |
| •80  | 1310 4417 70 | INSULATION               | 2   |
| •100 | 1619 2665 00 | SEAL                     | 1   |
| •110 | 0301 2321 00 | WASHER                   | 4   |
| •120 | 0291 1108 00 | LOCK NUT                 | 4   |

# FRONT PANEL ASSEMBLY - STANDARD

| REF | PART NUMBER  | DESIGNATION                                     | QTY |
|-----|--------------|---|-----|
| -   | 1310 4378 80 | FRONT PANEL ASSY <a href="#">(From page 42)</a> |     |
| •10 | 1310 4378 00 | PANEL   | 1   |
| •20 | 1310 0370 18 | INSULATION                                      | 1   |



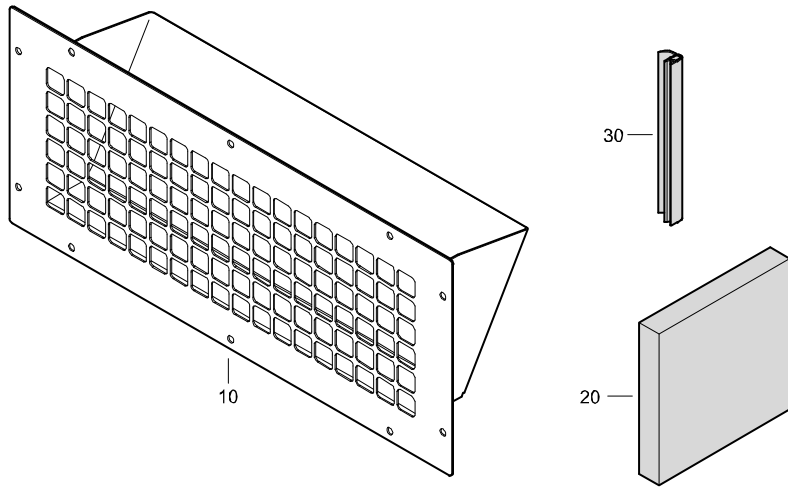
# DOOR ASSEMBLY - STANDARD



| REF  | PART NUMBER  | DESIGNATION   | QTY            |
|------|--------------|---------------|----------------|
| -    | 1310 5004 80 | DOOR ASSY     | (From page 42) |
| •10  | 1310 5004 00 | DOOR          | 1              |
| •20  | 1604 3429 00 | HINGE UPPER   | 2              |
| •30  | 1615 6967 03 | DOOR HANDLE   | 1              |
| •40  | 1615 5684 00 | HINGE BRACKET | 2              |
| •50  | 1619 2665 00 | SEAL          | 1              |
| •70  | 1310 5004 71 | INSULATION    | 2              |
| •80  | 1310 5004 72 | INSULATION    | 2              |
| •90  | 1310 5004 73 | INSULATION    | 2              |
| •100 | 0216 1324 03 | BOLT          | 4              |
| •110 | 0301 2321 00 | WASHER        | 4              |
| •120 | 0291 1108 00 | LOCKNUT       | 4              |

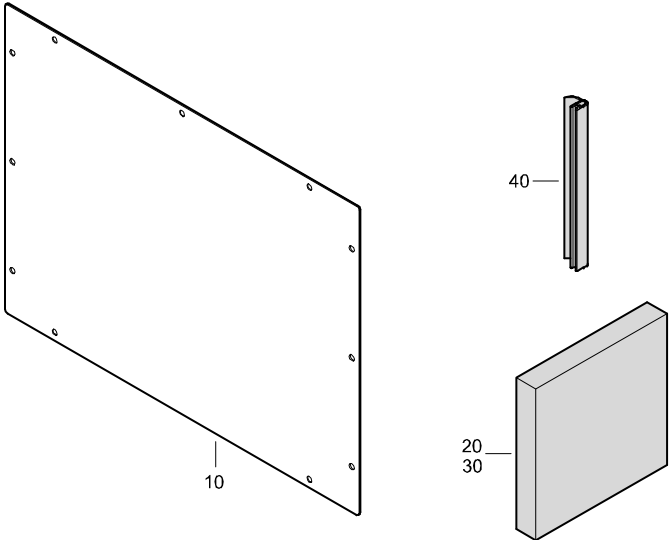
**PANEL ASSEMBLY - STANDARD**

| REF | PART NUMBER  | DESIGNATION | QTY            |
|-----|--------------|-------------|----------------|
| -   | 1310 5006 80 | PANEL ASSY  | (From page 42) |
| •10 | 1310 5006 00 | PANEL ASSY  | 1              |
| •20 | 1310 5006 70 | INSULATION  | 1              |
| •30 | -            | SEAL        | 1              |



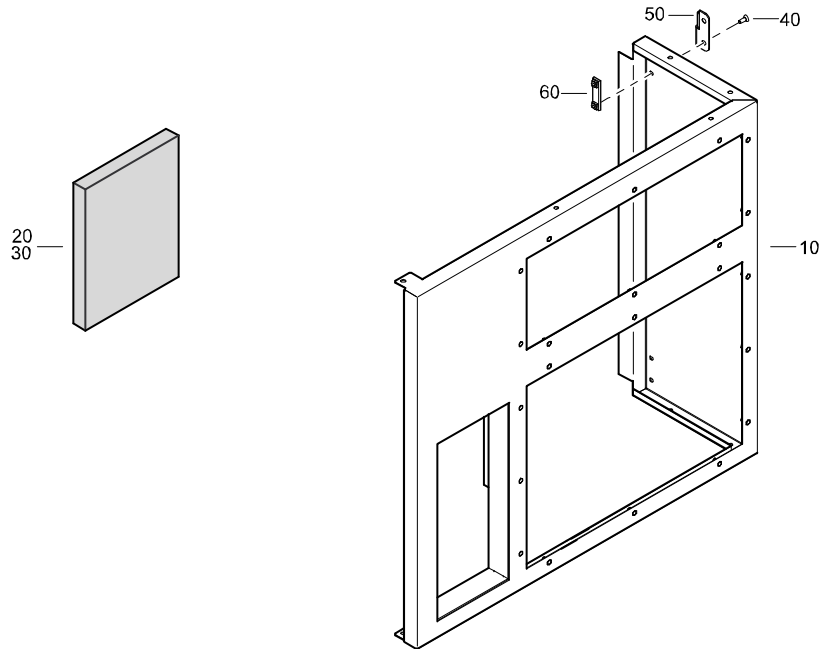
**PANEL ASSEMBLY - STANDARD**

| REF | PART NUMBER  | DESIGNATION   | QTY            |
|-----|--------------|---------------|----------------|
| -   | 1310 5007 80 | PANEL ASSY    | (From page 42) |
| •10 | 1310 5007 00 | SERVICE PLATE | 1              |
| •20 | 1310 5007 71 | INSULATION    | 1              |
| •30 | 1310 5007 70 | INSULATION    | 2              |
| •40 | 1310 5009 00 | SEAL          | 1              |

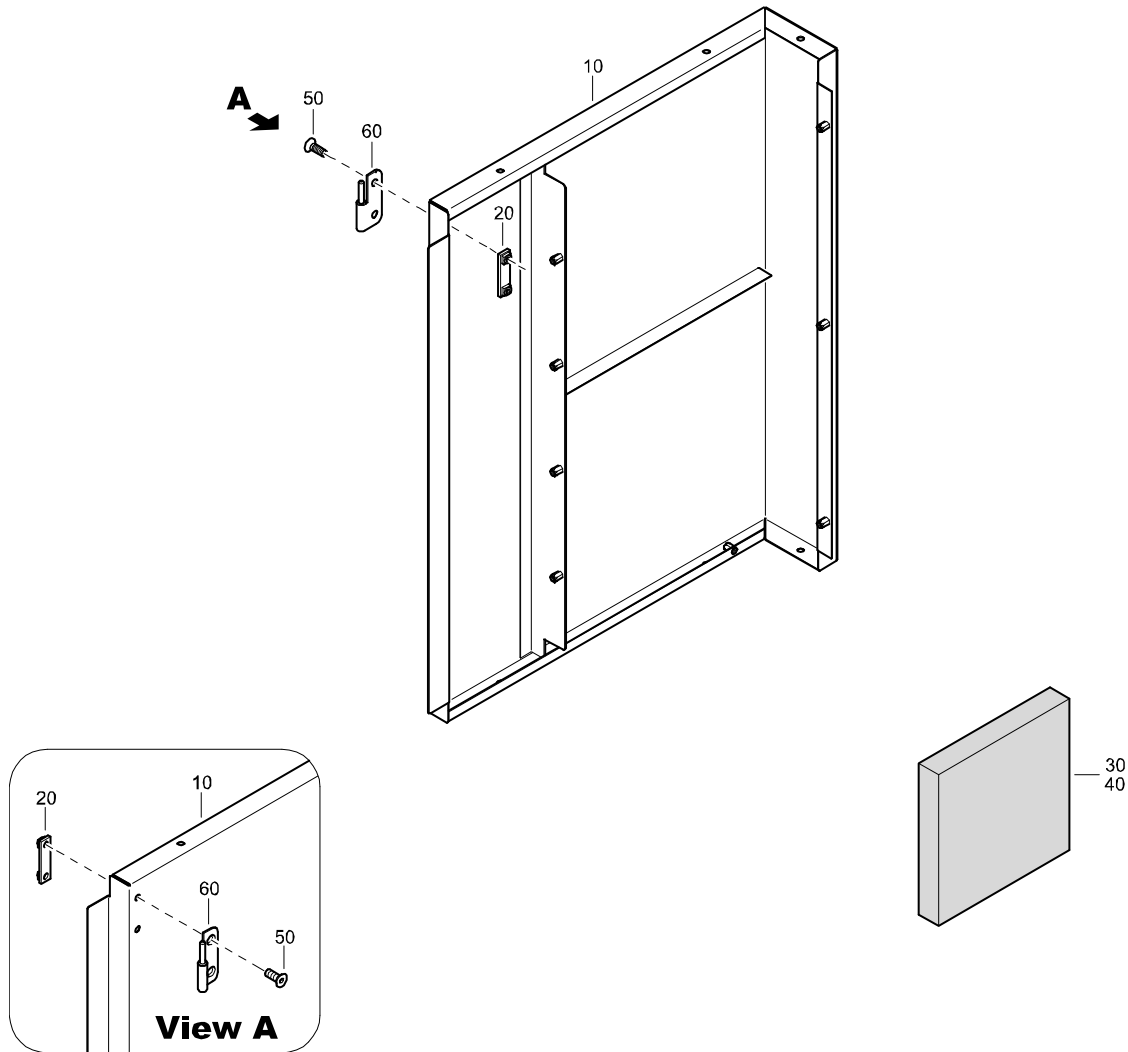


# PANEL ASSEMBLY - STANDARD

| REF | PART NUMBER  | DESIGNATION | QTY            |
|-----|--------------|-------------|----------------|
| -   | 1310 5008 80 | PANEL ASSY  | (From page 42) |
| •10 | 1310 5008 00 | PANEL ASSY  | 1              |
| •20 | 1310 5008 71 | INSULATION  | 1              |
| •30 | 1310 5008 70 | INSULATION  | 1              |
| •40 | 0216 1324 03 | BOLT        | 4              |
| •50 | 1604 3428 00 | HINGE       | 2              |
| •60 | 1615 5684 00 | HINGE       | 2              |



**PANEL ASSEMBLY - STANDARD**

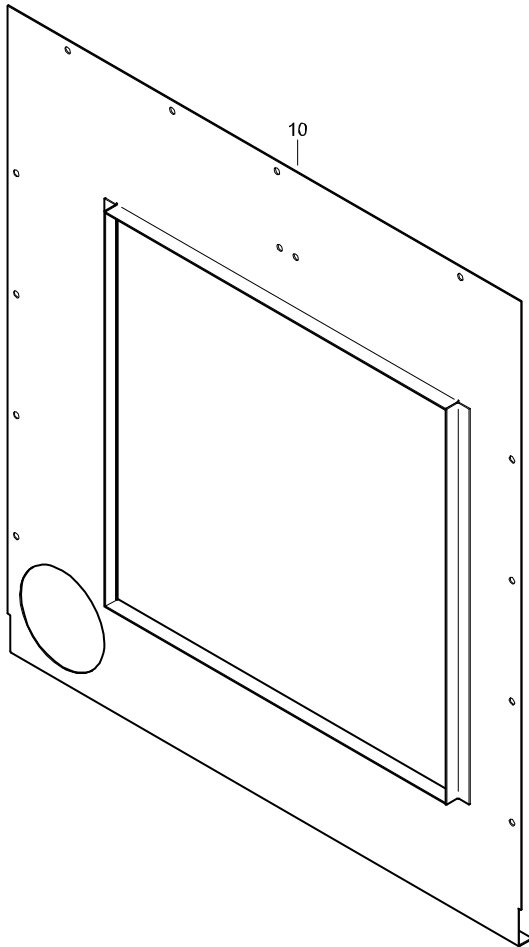


| REF | PART NUMBER  | DESIGNATION   | QTY            |
|-----|--------------|---------------|----------------|
| -   | 1310 8692 80 | PANEL ASSY    | (From page 42) |
| •10 | 1310 5008 00 | PANEL ASSY    | 1              |
| •20 | 1310 5008 71 | INSULATION    | 2              |
| •30 | 1310 5008 70 | INSULATION    | 2              |
| •40 | 0216 1324 03 | BOLT          | 2              |
| •50 | 1604 3428 00 | HINGE LOWER   | 4              |
| •60 | 1615 5684 00 | HINGE BRACKET | 2              |



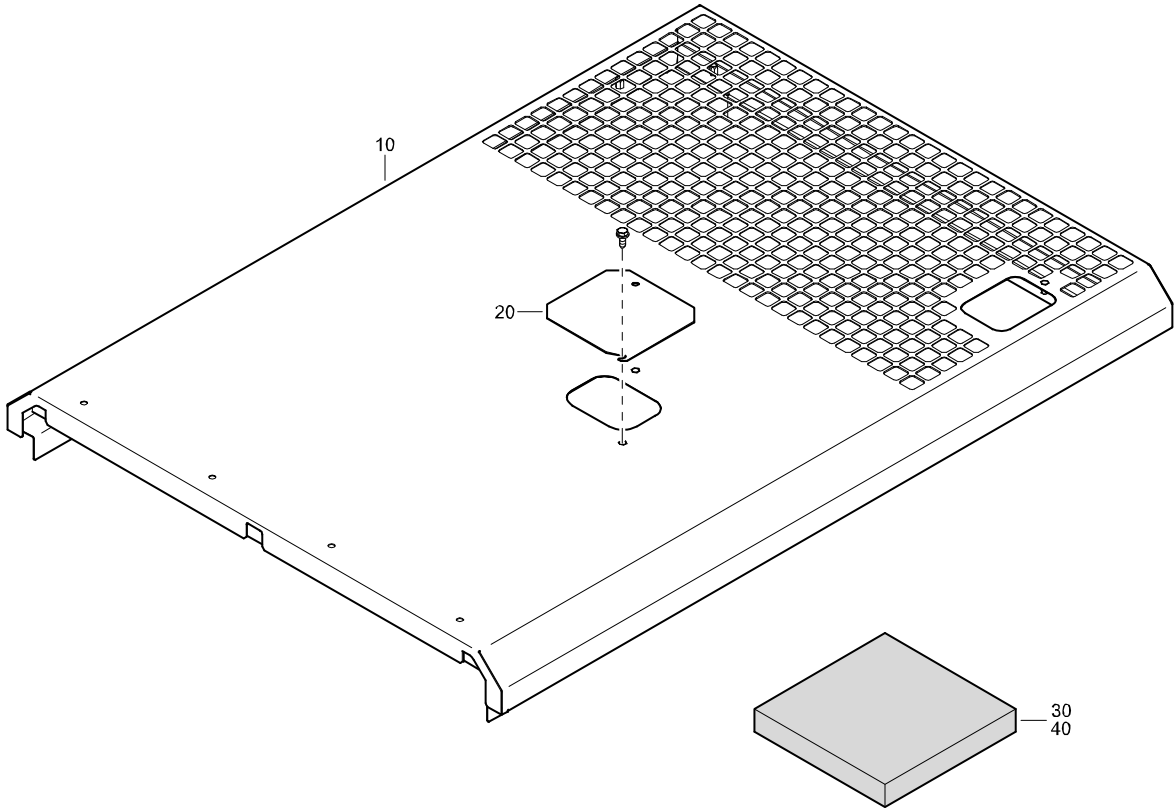
# PANEL - STANDARD

| REF | PART NUMBER  | DESIGNATION | QTY            |
|-----|--------------|-------------|----------------|
| -   | 1310 6971 80 | PANEL       | (From page 42) |
| •10 | 1310 6971 00 | PANEL       | 1              |



**PANEL ASSEMBLY - STANDARD**

| REF | PART NUMBER  | DESIGNATION                                   | QTY |
|-----|--------------|---|-----|
| -   | 1310 6976 80 | PANEL ASSEMBLY <a href="#">(From page 42)</a> |     |
| •10 | 1310 6976 00 | FRONT ROOF PANEL                              | 1   |
| •20 | 1310 4477 00 | COVER   | 1   |
| •30 | 1310 6976 72 | FOAM  | 1   |
| •40 | 1310 6976 71 | FOAM  | 1   |

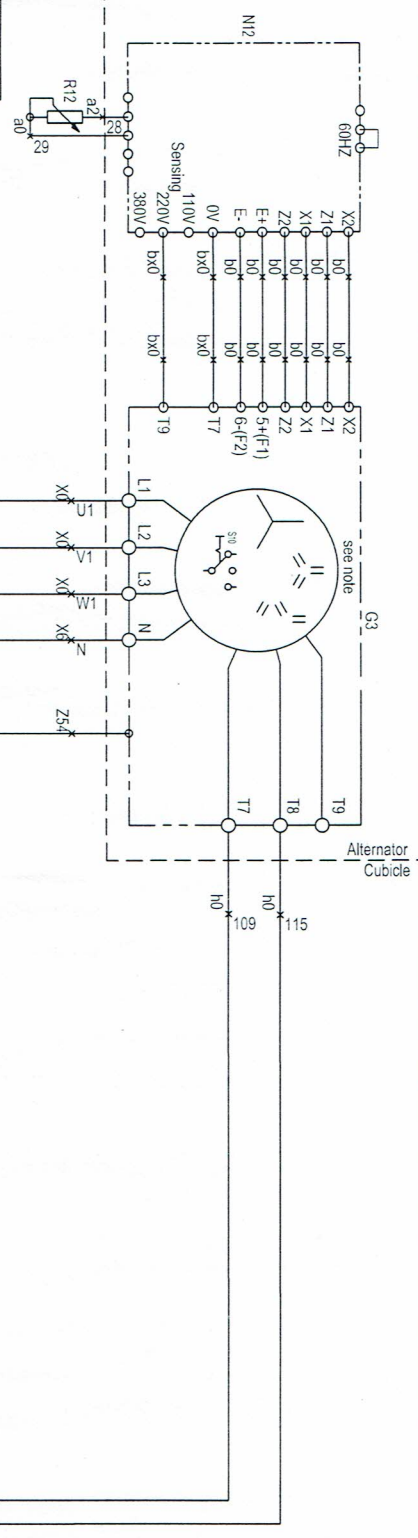








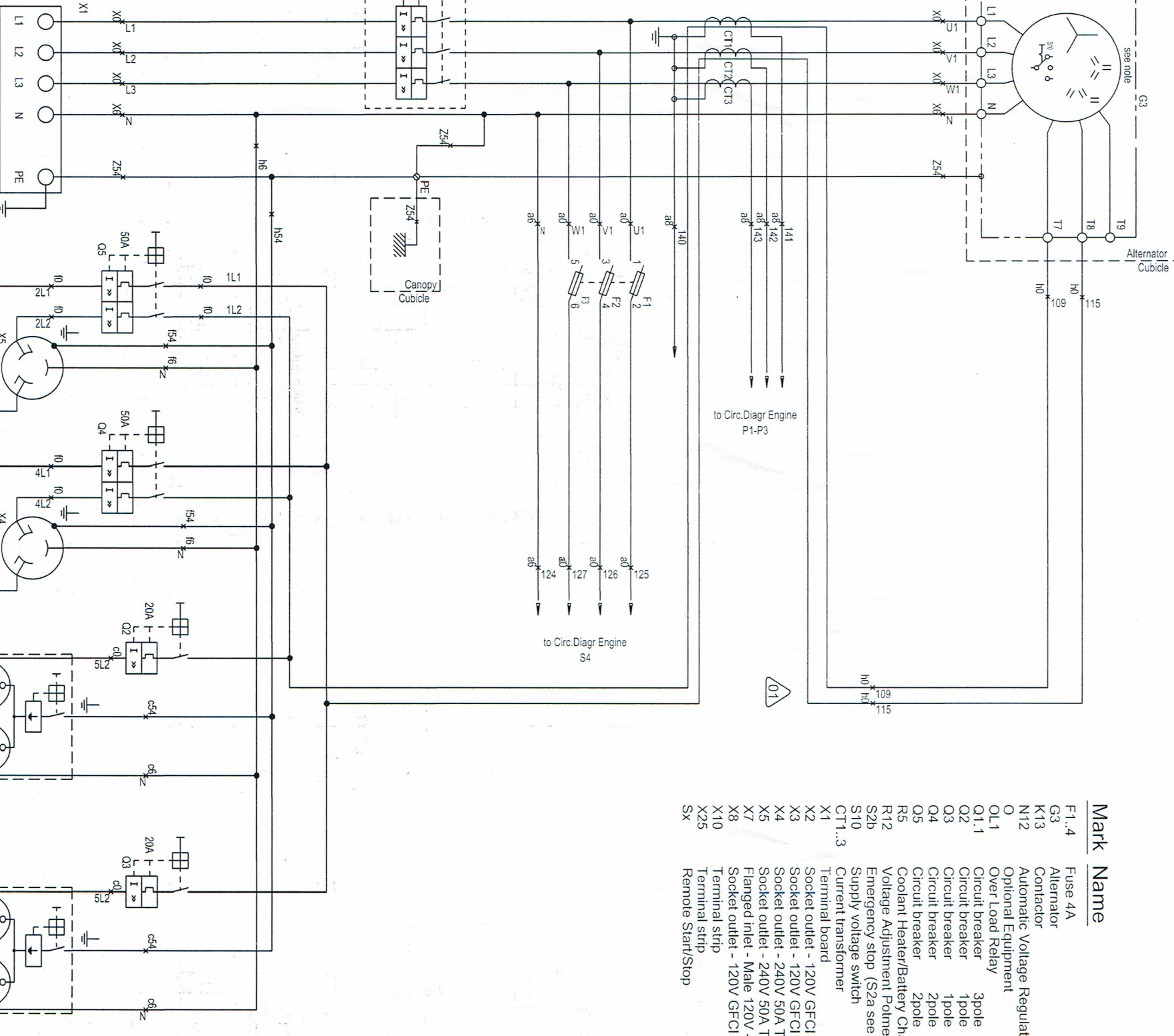
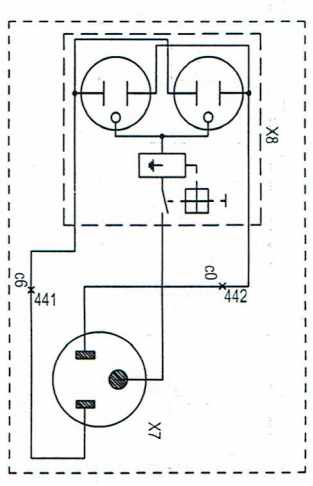




| S10 SWITCH PER DRAWING 1089 9082 00 | ALTERNATOR WINDING |
|-------------------------------------|--------------------|
| 1                                   | T1                 |
| 2                                   | T4                 |
| 3                                   | T7 & T109 & AVR    |
| 4                                   | T10 & T12          |
| 5                                   | T2                 |
| 6                                   | T5                 |
| 7                                   | T8 & T15 & AVR     |
| 8                                   | T11                |
| 9                                   | T3                 |
| 10                                  | T6                 |
| 11                                  | T9                 |

NOTE: CONNECTION BETWEEN SWITCH AND ALTERNATOR ARE MADE WITH ADD-ON WIRE SET. SEE UNIT PARTS MANUAL FOR WIRE SET PART NUMBERS.

SHORE POWER CONNECTION



| Mark   | Name                                    |
|--------|---|
| F1..4  | Fuse 4A                                 |
| G3     | Alternator                              |
| K13    | Contactor                               |
| N12    | Automatic Voltage Regulator             |
| O      | Optional Equipment                      |
| OL1    | Over Load Relay                         |
| Q1,1   | Circuit breaker 3pole                   |
| Q2     | Circuit breaker 1pole                   |
| Q3     | Circuit breaker 1pole                   |
| Q4     | Circuit breaker 2pole                   |
| Q5     | Circuit breaker 2pole                   |
| R5     | Coolant Heater/Battery Charger          |
| R12    | Voltage Adjustment Potmeter             |
| S2b    | Emergency stop (S2a see Engine Circ.)   |
| S10    | Supply voltage switch                   |
| CT1..3 | Current transformer                     |
| X1     | Terminal board                          |
| X2     | Socket outlet - 120V GFCI               |
| X3     | Socket outlet - 120V GFCI               |
| X4     | Socket outlet - 240V 50A TWISTLOCK      |
| X5     | Socket outlet - 240V 50A TWISTLOCK      |
| X7     | Flanged inlet - Male 120V - SHORE POWER |
| X8     | Socket outlet - 120V GFCI - SHORE POWER |
| X10    | Terminal strip                          |
| X25    | Terminal strip                          |
| Sx     | Remote Start/Stop                       |

| Wire size : | Colour code :     |
|-------------|-------------------|
| aa = 20 ga  | 0 = black         |
| a = 18 ga   | 1 = brown         |
| b = 16 ga   | 2 = red           |
| c = 14 ga   | 3 = orange        |
| d = 12 ga   | 4 = yellow        |
| e = 10 ga   | 5 = green         |
| f = 8 ga    | 6 = blue          |
| g = 6 ga    | 7 = purple        |
| h = 4 ga    | 8 = grey          |
| i = 2 ga    | 9 = white         |
| j = 1 ga    | 54 = green/yellow |
| k = 2/0 ga  |                   |
| l = 3/0 ga  |                   |
| m = 4/0 ga  |                   |

NOTE: All wire is 600V EPDM 125 deg. C (or equal) x = 600V EPDM 150 deg. C (or equal) y = 600V EPDM 150 deg. C (or equal) marked with "x" or "y" which identifies EPDM.

| BOX     | Q1.1 | CT1-3 | Wire size               |
|---------|------|-------|-------------------------|
| QAS 70  | 2    | 200A  | 400/5A<br>ix<br>Z       |
| QAS 90  | 2    | 400A  | 400/5A<br>lx<br>j<br>Z  |
| QAS 120 | 2    | 400A  | 400/5A<br>lx<br>j<br>Z  |
| QAS 150 | 2    | 400A  | 400/5A<br>lx<br>j<br>Z  |
| QAS 180 | 2    | 500A  | 1000/5A<br>lx<br>j<br>Z |
| QAS 230 | 3    | 600A  | 1000/5A<br>lx<br>j<br>Z |
| QAS 275 | 3    | 700A  | 1000/5A<br>lx<br>j<br>Z |
| QAS 330 | 3    | 1000A | 1000/5A<br>lx<br>j<br>Z |
| QAS 330 | 3    | 1000A | 1000/5A<br>lx<br>j<br>Z |

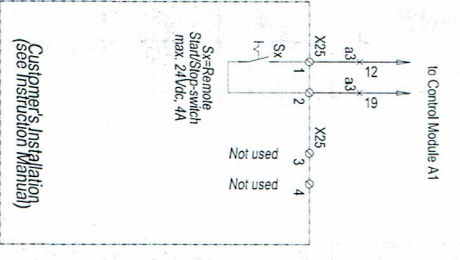
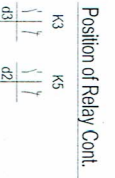
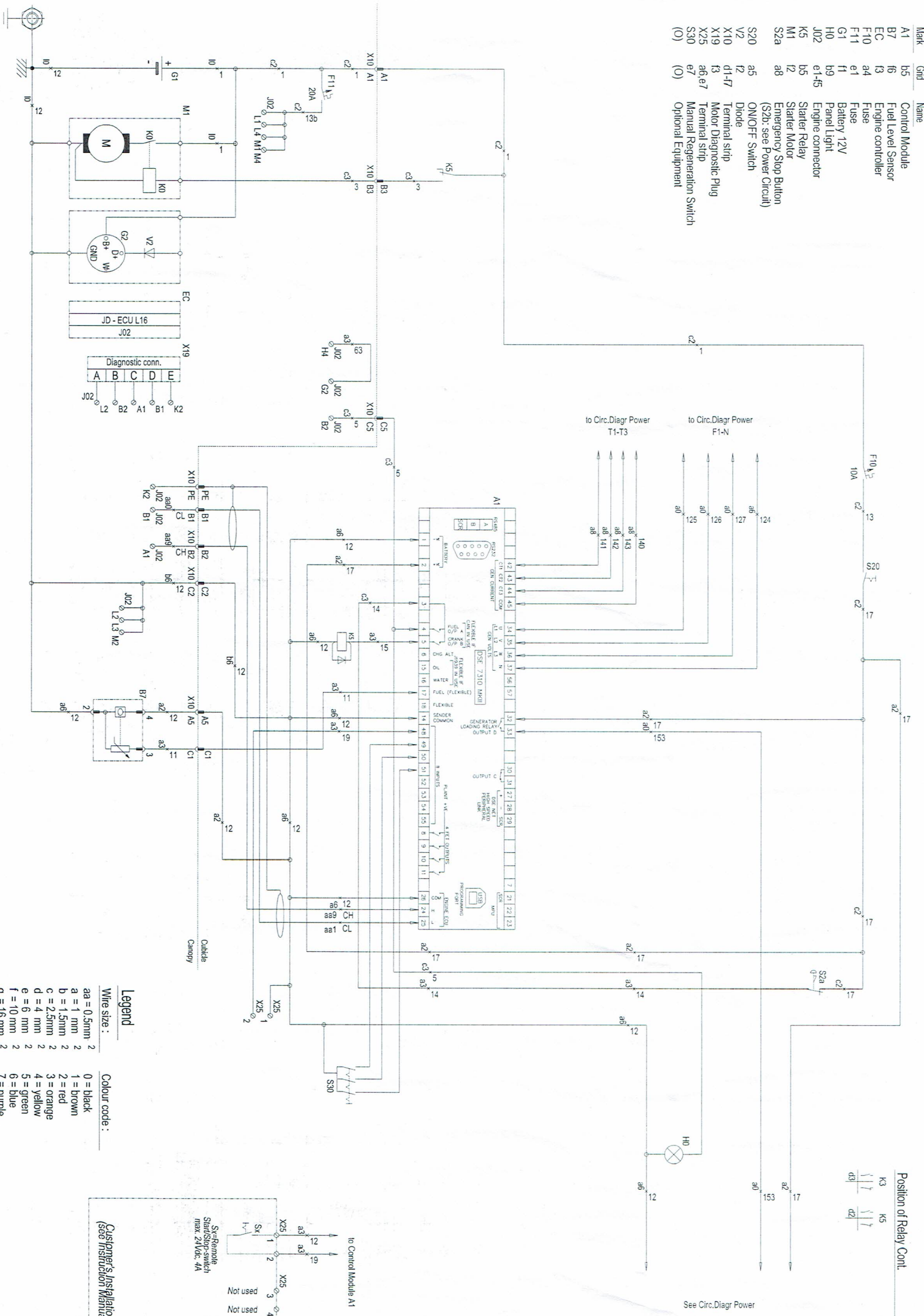
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|             |              |          |           |         |                 |
|-------------|--------------|----------|-----------|---------|-----------------|
| Scale       | NONE         | Material | BL        | Company | 1310 3171 34    |
| Drawn by    | BL           | Released | 1102 KI 2 | ACAD/HR | 3rd angle proj. |
| Checked by  |              | Approved |           |         | Owner's Mark    |
| Released    | 01/22/13     | Time     |           |         |                 |
| Designation | 1310 3200 55 | Sheet    | 1/1       | Ed      | 02              |

|    |   |                |            |    |
|----|---|----------------|------------|----|
| 02 | REV QAS70:WIRE SIZE OF X WAS (K), Z WAS (I)     | HHOP 160661 00 | 06/16/2016 | VS |
| 01 | UPDATE 109 & 115 TO BE ROUTED THROUGH CT1 & CT2 | HOP 150623 00  | 05/06/2015 | BL |
| ED | DESCRIPTION                                     | DN             | DATE       | BY |



| Mark | Grid  | Name   |
|------|-------|--|
| A1   | b5    | Control Module                                 |
| B7   | f6    | Fuel Level Sensor                              |
| EC   | f3    | Engine controller                              |
| F10  | a4    | Fuse   |
| F11  | e1    | Fuse   |
| G1   | b9    | Battery 12V                                    |
| H0   | f1    | Panel Light                                    |
| J02  | e1-45 | Engine connector                               |
| K5   | b5    | Starter Relay                                  |
| M1   | l2    | Starter Motor                                  |
| S2a  | a8    | Emergency Stop Button (S2b: see Power Circuit) |
| S20  | a5    | ON/OFF Switch                                  |
| V2   | l2    | Diode  |
| X10  | d1-17 | Terminal strip                                 |
| X19  | f3    | Motor Diagnostic Plug                          |
| X25  | a6,e7 | Terminal strip                                 |
| S30  | e7    | Manual Regeneration Switch                     |
| (O)  | (O)   | Optional Equipment                             |



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QAS 70-90-120-150-180-250-275-330-350  
DSE 7310 MKII DV SB

| ED | DESCRIPTION | DN | DATE | BY |
|----|-------------|----|------|----|
|    |             |    |      |    |

|            |       |          |       |          |              |
|------------|-------|----------|-------|----------|--------------|
| Scale      | NONE  | Frame    | Blank | Company  | 1310 3200 54 |
| Drawn by   | DD    | Material | None  | Replaces | 1310 3201 02 |
| Checked by | DD    | Approved | None  | Date     | 08/29/2016   |
| Drawn from | Blank | Drawn by | DD    | Drawn by | 1310 3201 02 |
| Drawn by   | DD    | Drawn by | DD    | Drawn by | 1310 3201 02 |
| Drawn by   | DD    | Drawn by | DD    | Drawn by | 1310 3201 02 |



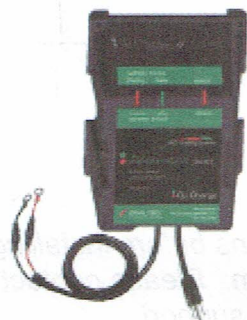
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# PRO Charging Systems

## Installation and Operating Instructions (for chargers shown below)

### Recreation SERIES



Model RS1  
6 Amp Output  
One 6 Amp Bank



Model RS2  
12 Amp Output  
Two 6 Amp Banks



Model RS3  
18 Amp Output  
Three 6 Amp Banks

For additional information please call our  
Technical Support Group 800.742.2740



**DUAL PRO**™  
Pro Quality Pro Performance

102812

PRO CHARGING SYSTEMS, LLC  
1551 Heil Quaker Boulevard, LaVergne, TN 37086-3539

## INSTALLATION AND OPERATING INSTRUCTIONS FOR THE FOLLOWING BATTERY CHARGING SYSTEMS:

| Model #           | Description       | Total Output | Independently charge 12V batteries in the following systems: |
|-------------------|-------------------|--------------|--|
| Recreation Series |                   |              |  |
| RS1               | One 6 Amp Bank    | 6 Amps       | 12V  |
| RS2               | Two 6 Amp Banks   | 12 Amps      | 12V, 24V   |
| RS3               | Three 6 Amp Banks | 18 Amps      | 12V, 24V or 36V  |

### **IMPORTANT NOTICE**

*Please save and read all safety, operating and installation instructions before installing or applying AC power to your PCS on-board battery charging system. Please contact PCS with any product, installation, or service questions at technical support (800.742.2740).*

### **INTRODUCTION**

Pro Charging Systems (PCS) has been manufacturing waterproof, on-board battery charging systems since 1989. Our charging systems are designed and built tough to withstand intense vibration, extreme temperature variations and submersion without damaging the unit. Our systems use temperature compensation in order to fully charge a battery in hot or cold environments and are controlled by microprocessors in order to assure precise control over each totally independent charging bank. All of our chargers have true reverse polarity protection and incorporated a float maintenance mode upon completion of each charge cycle.

| <b>TABLE OF CONTENTS</b>           |           |
|------------------------------------|-----------|
| Important Safety Instructions..... | Pages 2-3 |
| Product Summary.....               | Pages 4-5 |
| Installation Instructions.....     | Pages 5-6 |
| Trouble Shooting.....              | Page 7    |
| Warranty Information.....          | Page 8    |

### **IMPORTANT SAFETY INSTRUCTIONS**

Use of attachments not recommended or sold by PCS may result in a risk of fire, electrical shock, or injury to persons.

To reduce risk of damage to the electrical plug and power cord, always pull by the plug rather than by the power cord when disconnecting charger.



When using an extension cord, make sure:

1. That pins on the extension cord plug are the same number, size and shape as those of the charger's plug;
2. That extension cord meets UL (Underwriters Laboratories, Inc.) acceptance and is in proper operating condition;
3. That wire size is large enough for the ac ampere rating of charger.

Do not operate charger with a damaged cord or plug—replace the cord or plug immediately.

Do not operate charger if it has received a sharp blow, been dropped or otherwise damaged in any way; contact our technical support group for assistance (800.742.2740).

Do not disassemble charger; contact technical support when service or repair is required. Incorrect reassembly may result in risk of electrical shock or fire.

To reduce risk of electrical shock, unplug charger from outlet before attempting any maintenance or cleaning.

### **WARNING: RISK OF EXPLOSIVE GASES**

1. **WORKING IN THE VICINITY OF A LEAD-ACID BATTERY IS DANGEROUS.** Batteries generate explosive gases during normal battery operation. For this reason, it is of utmost importance that each time before using your charger, you read this manual and follow the instructions exactly.
2. To reduce risk of battery explosion, follow these instructions and those published by the battery manufacturer and by the manufacturer of any equipment you intend to use in the vicinity of battery. Review all cautionary markings on any product being utilized in or around the charging device.

### **PERSONAL PRECAUTIONS**

Someone should be within range of your voice or close enough to come to your aid when you work near a lead-acid battery.

Have plenty of fresh water and soap nearby in case battery acid contacts skin, clothing, eyes, or other surfaces.

Wear complete eye protection and clothing protection. Avoid touching eyes while working near battery.

If battery acid contacts skin or clothing, wash immediately with soap and water. If acid enters eye, immediately flood eye with running cold water for at least 10 minutes and seek medical attention.

**NEVER** smoke or allow a spark or flame in the vicinity of a battery or engine.

Be extra cautious to reduce risk of dropping a metal tool onto battery. This might cause a spark or short-circuit a battery, possibly resulting in an explosion.

Remove personal metal items such as rings, bracelets, necklaces, and watches when working with a lead-acid battery. A lead-acid battery can produce a short-circuit current high enough to weld a ring, or the like, to metal, causing a severe burn.

Use charger for charging a LEAD-ACID (lead acid, sealed lead acid, gel cell, and AGM) battery only. It is not intended to supply power to a low voltage electrical system other than in a starter-motor application. Do not use battery charger for charging dry-cell batteries that are commonly used with home appliances. These dry cell batteries may explode, causing personal injury and damage to property.

NEVER charge a frozen battery.

## **PREPARING TO CHARGE**

If it is necessary to remove the battery or batteries to charge, always remove grounded terminal from battery first. Make sure all accessories are off, so as not to cause battery arcing.

Be sure the area around any battery is well ventilated while batteries are being charged. On occasion, "gas fumes" may be present during charging and can be forcefully blown away by using a piece of cardboard or other nonmetallic material as a fan. Proper ventilation is always recommended in the charging area.

Clean all of the battery terminals. Be careful to keep corrosion from coming into contact with eyes.

Add distilled water in each cell (wet cell batteries) until battery acid reaches level specified by battery manufacturer. This helps purge excessive gas from cells. Do not overfill. For a battery without cell caps, carefully follow manufacturer's recharging instructions.

Study all battery manufacturers' specific precautions such as removing or not removing cell caps while charging and recommended rates of charge.

Extension cords should be industrial grade/heavy duty UL approved and grounded. Check extension cord before use for damage, bent prongs and cuts. Replace if damaged.

Always make your extension cord connection on the charger side first. After connecting the extension cord to the charger, proceed to plug the extension cord into a 120VAC GFCI protected (Ground Fault Circuit Interrupt) A/C outlet. The unit will operate with a VAC input range of 90VAC-264VAC.

Always remove the extension cord from the A/C outlet first when charging is completed followed by unplugging the charger.

## **PRODUCT SUMMARY**

### **General Operation:**

Use the following guidelines in this manual to install your fully automatic PCS battery charging system.

Assure that the area around your charger and batteries is properly ventilated. Connect your extension cord with no A/C power present to the battery charger and proceed to plug your extension cord in at a nearby A/C outlet.

Once you plug in your PCS battery charging system, your batteries will be simultaneously and independently charged to 100%. Unlike systems that utilize one large charger to attempt to charge multiple batteries, your system utilizes a totally independent battery charger for each battery. Each charging bank will remain in a "float" stage once the battery is charged and then monitor and/or maintain the battery indefinitely.

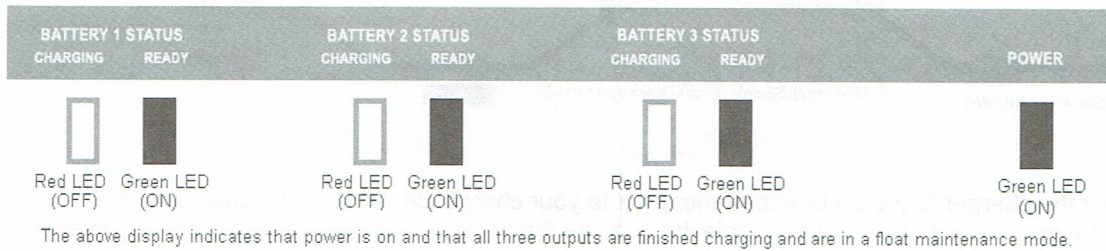
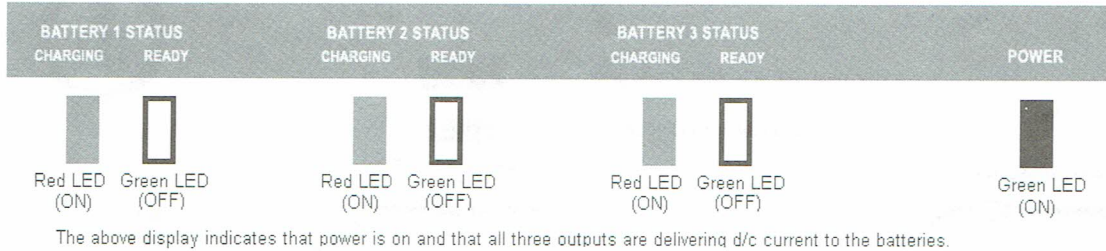
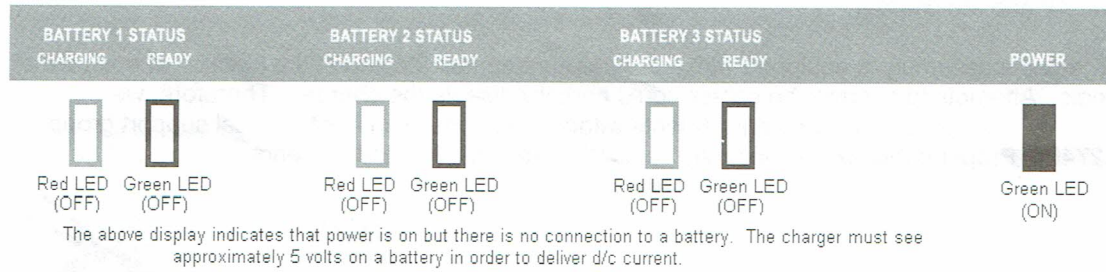
We recommend that you leave your system plugged in. This will reduce sulfation on the lead plates of the batteries and allow your PCS charging system to keep your batteries fully maintained and ready to perform at their best.

### **Independent Charging Bank Indications**

When your battery charging system is activated, each bank provides charging information utilizing 1 red Light Emitting Diode (LED) indicator and one green Light Emitting Diode (LED) indicator. The Red (CHARGING) LED indicates d/c current is flowing to the battery and the Green (READY) LED indicates that the charger has finished it's bulk and absorption stage and has entered the float maintenance mode. There is also a Green (POWER) LED that illuminates to indicate that power is supplied to the charger when it is plugged in properly to a functioning A/C outlet.



Below is an example of the display on a Three output Recreation Series Charger (RS3):



## **INSTALLATION INSTRUCTIONS**

All PCS battery charging systems are designed to be permanently installed in a well-ventilated area and have no mounting restrictions.

Do not make any electrical connections to the power supply (AC) or to a battery (DC) until the installation process has been completed.

If mounting the charger in a boat, please choose a flat surface as high above the water level as possible. If a compartment wall is chosen, make certain its strength is adequate to support the weight of the charger.

Use the mounting flanges of the charger to mark locations for starter holes. Drill a 1/16 inch hole at each marked location. Then, utilize all stainless steel screws that have been provided and install the charger securely, being cautious not to over tighten the screws. Silicon sealer should be used to secure and waterproof the screw holes.

### **IMPORTANT NOTICE**

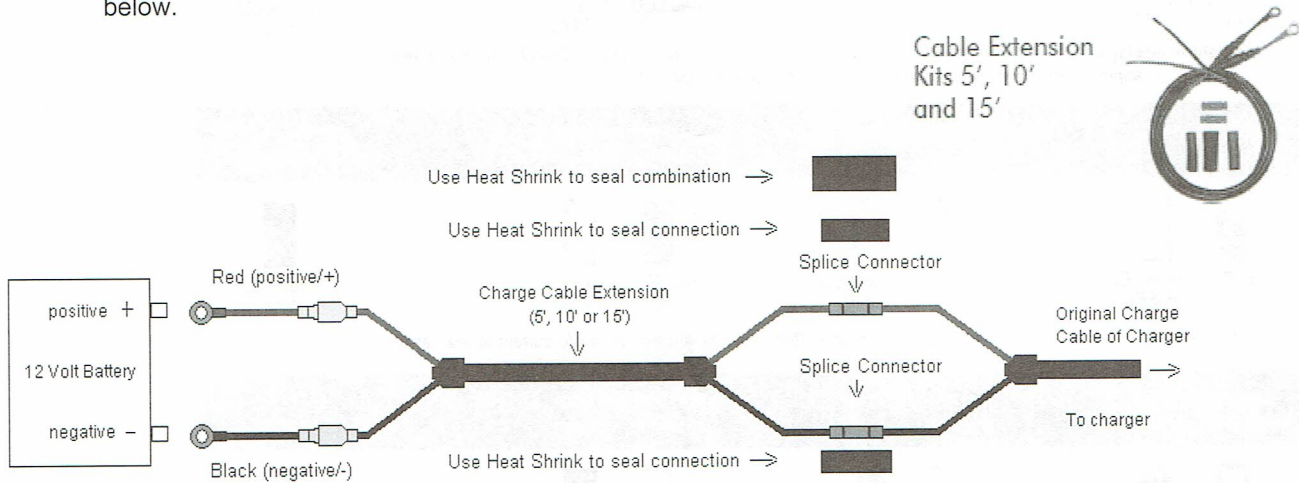
The mounting brackets of the system may contain keyholes that are designed so that screws can be started before putting the charger into place. If applicable, the keyhole locations vary depending on which model you own.

Before making any connections, prepare batteries as follows:

- (a) With caps securely in place, thoroughly clean the case and posts with a solution of baking soda and water. Be careful not to allow any baking soda to get inside the case.

- (b) All posts, terminals, and connectors should be cleaned to a shiny bright finish, using a wire brush or sand paper. This should be done periodically to assure maximum conductivity between the battery and the charger.

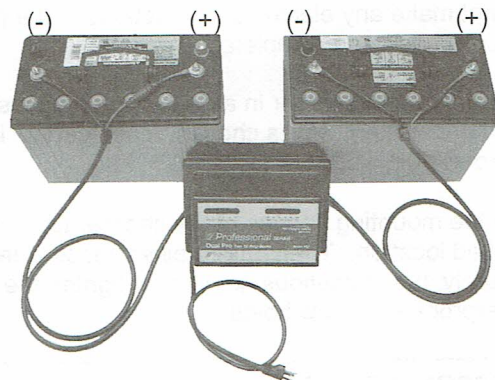
Each charge cable assembly is equipped with a temperature sensor located at the junction of each set of ring terminals. Attempts to shorten the cables could partially disable the charger. Therefore, we recommend that you do not make any adjustments without first consulting our technical support group (800.742.2740). Proper cable extensions may be purchased in 5', 10', and 15' lengths. See picture below.



To connect the charger to the battery (batteries), route your charge cables from the charger to the batteries, being cautious to avoid sharp objects, and use the supplied wire ties to hold them securely and neatly in place.

Securely attach each charge cable independently to one 12V battery by connecting the red (positive/+) lead ring terminal to the positive (+) battery post and the black (negative/-) lead ring terminal to the negative (-) battery post. See picture below:

*The charger pictured is a **Professional Series Dual Pro**, which has two independent 15 amp outputs.*



Connect a heavy duty UL approved extension cord to the power cord of your charger and then plug the extension cord into a nearby 120VAC GFI protected (Ground Fault Circuit Interrupt) outlet. You should now observe a red LED indication on each bank of the charger representing each individual battery being charged. The voltage of each battery will reflect the number of LED indicators illuminated.

When charging is complete, remove the extension cord from the 120VAC outlet first and then unplug the charger.



## **TROUBLE SHOOTING**

**PROBLEM: No LED indicators illuminate on the charger.**

Solution Sequence: Check the AC power supply from its source through all connecting points up to the charger by using a meter or test light to confirm that current is being delivered to the charger.

**PROBLEM: The Green (POWER) LED is illuminated, but the Red (CHARGING) LED and the Green (READY) LED are off.**

Solution Sequence: This indicates that the charger does not recognize that it is connected properly to a battery that has at least 5Volts. With the AC power supply cord unplugged, check the ring terminals for correct polarity (Red to positive or +) and (Black to negative or -). Also check for corrosion free secure connections to the batteries. Check in-line fuses in charge cable for any signs of opening or corroded connections. Call the technical support group for further assistance (800.742.2420).

**PROBLEM: The RED (CHARGING) LED remains illuminated for more than 16 hours and the Green (READY) LED does not come on.**

Solution Sequence: This indicates that the battery is not reaching a sufficient voltage to indicate that the battery is fully charged. Disconnect AC power to the charging system. On multi bank chargers, remove the charge cable assembly of the affected bank from the battery and attach it to another battery in the boat. Take the original charge cable assembly from this battery and attach it to the battery from which you removed the first cable. Plug the charger in and observe the LED indications. If the rapid LED sequence (red to green repeatedly) occurs on a different bank of the charger, this confirms the existence of a battery problem.

On single bank systems, simply try the charger on another battery. If the charger now operates normally (steady red LEDs or changes to green and holds), this indicates a possible problem with the original battery.

If the same bank continues to malfunction, please call our technical support group (800.742.2740).

**PROBLEM: The green (READY) LED was illuminated before disconnecting the power from the charger, but upon reconnection, the red (CHARGING) LED appears and remains on.**

Solution Sequence: This is normal operating procedure for the system and simply indicates that a re-analysis of the battery status has been initiated and after a series of steps, the green LED will illuminate.

## LIMITED WARRANTY

Pro Charging Systems, LLC (PCS) makes this Limited Warranty only to the original retail purchaser.

PCS warrants this battery charger for two years from the date of retail purchase against defective materials and/or workmanship. If such defects should occur, this unit will either be repaired or replaced at the discretion of the manufacturer. It is the responsibility of the original purchaser to return the charger along with proof of purchase, transportation, and/or any mailing or handling charges prepaid to the manufacturer or its authorized representative.

This limited warranty is void if the product is misused, improperly maintained, handled carelessly or incorrectly operated. Additionally, this warranty is void if the charger is disassembled, the charger's charge cables are cut, the power cord is cut off, the charger is altered without authorization from PCS, the serial number is removed, or repair is attempted by anyone other than an authorized representative.

PCS makes no other warranty other than this limited warranty and expressly excludes any implied warranty, including warranty for any incidental or consequential damages.

This is the only expressed limited two year warranty authorized by PCS and does not authorize anyone to assume or make any other obligation towards the product other than this two year Limited Warranty. Some states do not allow limitation of incidental or consequential damages.

This warranty gives you specific legal rights and you may also have other rights which vary from state to state.

Please call Pro Charging Systems, LLC (800.742.2740) for full warranty information and/or service.

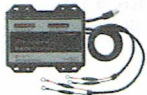
Below are some of our other options in chargers and battery accessories. Call our technical support group for more detailed information or visit our web site [www.dualpro.com](http://www.dualpro.com).

### Professional SERIES

Uni Pro  
One 15 Amp  
Bank



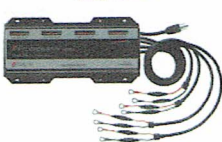
Dual Pro  
Two 15 Amp  
Banks



Tri Pro  
Three 15 Amp  
Banks



Quad Pro  
Four 15 Amp  
Banks



### Sportsman SERIES

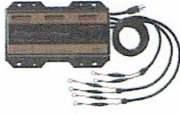
Uni Pro  
One 10 Amp  
Bank



Dual Pro  
Two 10 Amp  
Banks



Tri Pro  
Three 10 Amp  
Banks



Quad Pro  
Four 10 Amp  
Banks



### Eagle Performance SERIES

Available in 12 to 48 Volts  
and 9 to 25 Amps



### Charge On The Run SERIES

12 Volt, Available in 1, 2 or 3  
Banks



### Go Charge

Maintainer/Charger  
Available in 1.25 Amp and  
2 Amp Units



For more information and products:

[www.dualpro.com](http://www.dualpro.com)

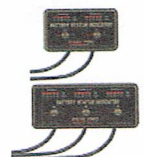
Technical Support: 800.742.2740

### Accessories

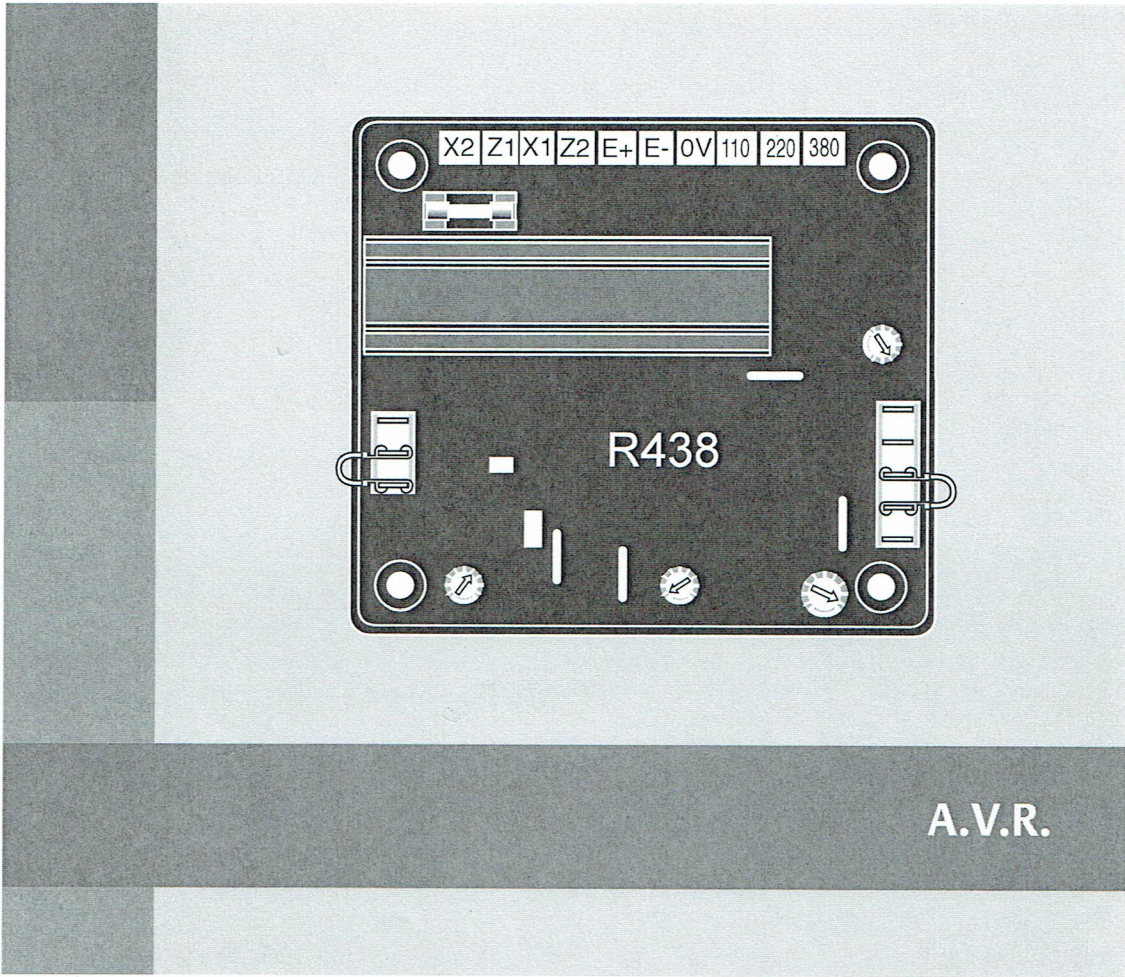
Cable Extension  
Kits 5', 10'  
and 15'



Remote Battery Status  
Indicators 2 and 3 Banks







A.V.R.

## R438

Installation and maintenance

Leroy-Somer

  
EMERSON

|                           |                              |                       |
|---------------------------|------------------------------|-----------------------|
| Electric Power Generation | Installation and maintenance | 3971 en - 2016.07 / i |
| <b>R438<br/>A.V.R.</b>    |                              |                       |

This manual concerns the alternator A.V.R. which you have just purchased. We wish to draw your attention to the contents of this maintenance manual.

## SAFETY MEASURES

Before using your machine for the first time, it is important to read the whole of this installation and maintenance manual.

All necessary operations and interventions on this machine must be performed by a qualified technician.

Our technical support service will be pleased to provide any additional information you may require.

The various operations described in this manual are accompanied by recommendations or symbols to alert the user to potential risks of accidents. It is vital that you understand and take notice of the following warning symbols.

### WARNING

Warning symbol for an operation capable of damaging or destroying the machine or surrounding equipment.



Warning symbol for general danger to personnel.



Warning symbol for electrical danger to personnel.



All servicing or repair operations performed on the AVR should be undertaken by personnel trained in the commissioning, servicing and maintenance of electrical and mechanical components.



When the generator is driven at a frequency less than 28 Hz for more than 30 seconds with an analogic regulator, the AC power must be disconnected.

### WARNING

This A.V.R. can be incorporated in a machine marked C.E.  
This manual is be given to the end user.

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**Disposal and recycling instructions**

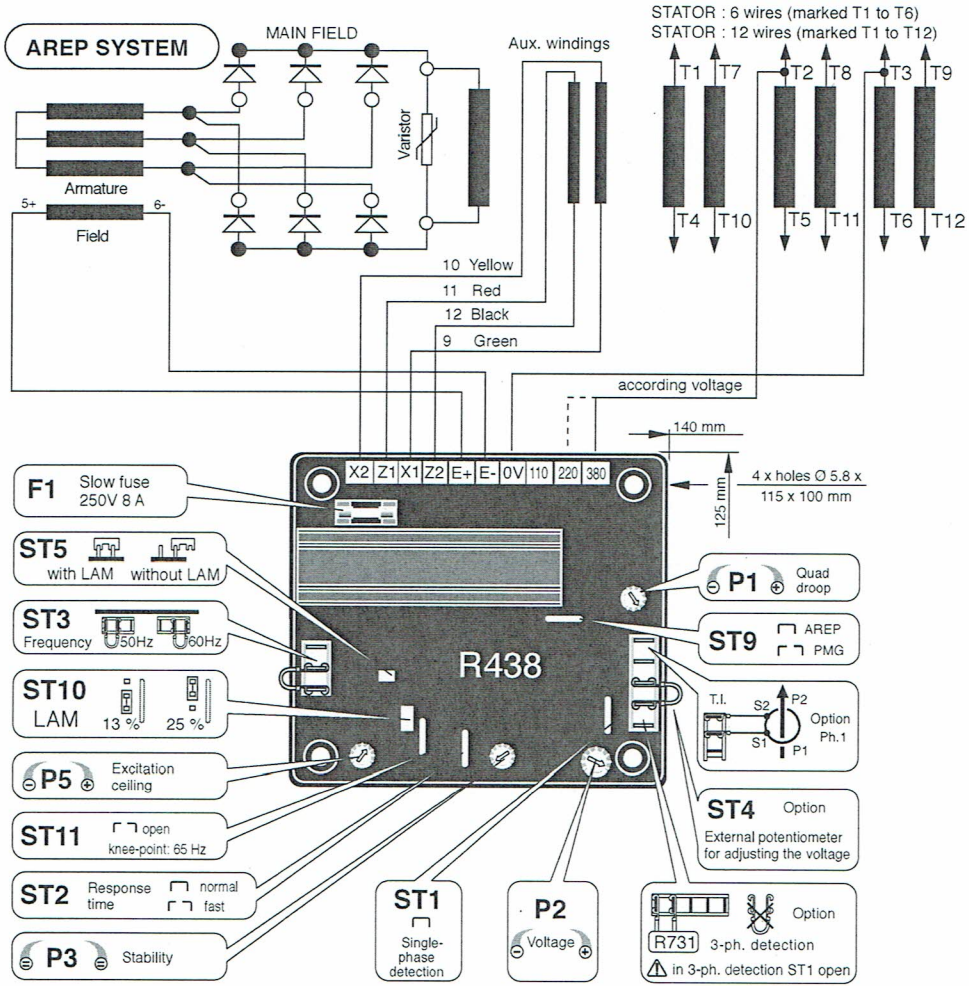


**1 - SUPPLY**

**1.1 - AREP excitation system**

For both AREP & PMG excitation systems, the alternator voltage regulator is the R438. With AREP excitation, the R438 electronic AVR is powered by two auxiliary windings which are independent of the voltage match circuit. The first winding has a voltage in proportion

to that of the alternator (characteristic Shunt), the second has a voltage in proportion to the stator current (compound characteristic: Booster effect). The power supply voltage is rectified and filtered before being used by the AVR monitoring transistor. This principle ensures that regulation is not affected by distortions generated by the load.



|                           |                              |                       |
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### 1.2 - PMG excitation system

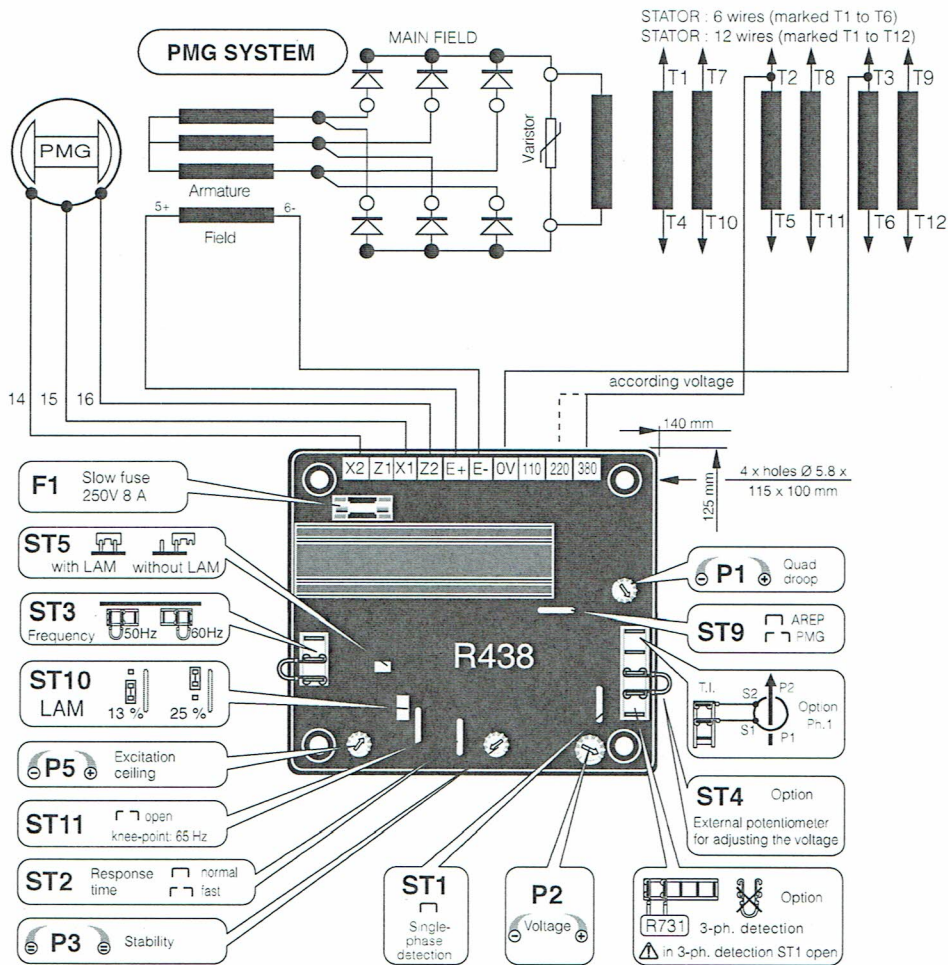
This excitation system consists of a «PMG» (permanent magnet generator). This is fitted at the rear of the machine and connected to the R438 AVR.

The PMG supplies the AVR with constant voltage which is independent of the main

alternator winding. As a result the machine has a short-circuit current capacity and good immunity to distortions generated by the load.

The AVR monitors and corrects the alternator output voltage by adjusting the excitation current.

- 50/60 Hz selection via the ST3 jumper.



### 1.3 - SHUNT or separate excitation system

A.V.R. can be operated with SHUNT supply (with a transformer / secondary 50V or a 48V battery).



|                           |                              |                       |
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## 2 - R438 A.V.R.

### 2.1 - Characteristics

- Storage : -55°C ; +85°C
- Operation : -40°C ; +70°C
- Standard power supply: AREP or PMG.
- Rated overload current: 8 A - 10 s
- Electronic protection (overload, short-circuit on opening of voltage sensing circuit): excitation overload current for 10 seconds then return to approximately 1A. The alternator must be stopped (or the power switched off) in order to reset the protection.
- Fuse : F1 on X1, X2. 8A ; slow - 250V
- Voltage sensing : 5 VA isolated via transformer ;
  - 0-110 V terminals = 95 to 140 V,
  - 0-220 V terminals = 170 to 260 V,
  - 0-380 V terminals = 340 to 520 V.
- Voltage regulation  $\pm 0.5\%$ .
- Normal or rapid response time via **ST2** jumper (see below).
- Voltage adjustment via potentiometer **P2**. other voltages via adapter transformer
- Current sensing (parallel operation): C.T. 2.5 VA cl1, secondary 1 A (optional).
- Quadrature droop adjustment via potentiometer **P1**.
- Max. excitation current adjustment via **P5** (see below).

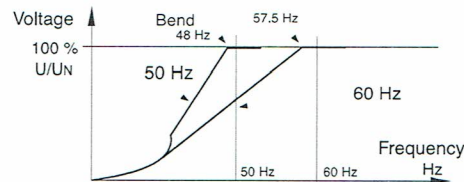
#### 2.1.1 - Configuration jumpers function

| Pot. | Delivery config.       |             | Position    | Function                                   |
|------|------------------------|-------------|-------------|--|
|      | Open                   | Closed      |             |  |
| ST1  | 3-ph.                  | Mono        |             | Open for module installation tri detection |
| ST2  | Fast                   | Normal      |             | Response time                              |
| ST3  |                        |             | 50 ou 60 Hz | Frequency selection                        |
| ST4  | External potentiometer | Without     |             | Potentiometer                              |
| ST5  | Without                | With        |             | LAM  |
| ST9  | Others (PMG...)        | AREP        |             | Supply                                     |
| ST10 |                        |             | 13% or 25%  | LAM voltage drop amplitude                 |
| ST11 | 65 Hz                  | 48 or 58 Hz |             | U/f function bend position                 |

#### 2.1.2 - Setting potentiometers function

| Delivery position | Pot. | Function                                  |
|-------------------|------|---|
| 0                 | P1   | Quadrature droop ; // operation with C.T. |
| 400V              | P2   | Voltage                                   |
| Centre            | P3   | Stability                                 |
| Maxi              | P5   | Excitation current ceiling                |

### 2.2 - Frequency compared with voltage (without LAM)



### 2.3 - LAM (Load Acceptance Module) characteristics

#### 2.3.1 - Voltage drop

The LAM system is integrated in the R438 AVR as standard.

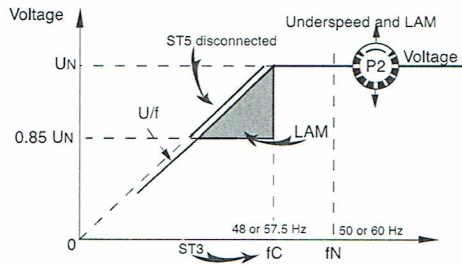
Role of the «LAM» (Load Adjustment Module) :

On application of a load, the rotation speed of the generator set decreases. When it passes below the preset frequency threshold, the LAM causes the voltage to drop by approximately 13% or 25% and consequently the amount of active load applied is reduced by approximately 25% to 50%, until the speed reaches its rated value again.

Hence the LAM can be used either to reduce the speed variation (frequency) and its duration for a given applied load, or to increase the applied load possible for one speed variation (turbo-charged engine).

To avoid voltage oscillations, the trip threshold for the LAM function should be set approximately 2 Hz below the lowest frequency in steady state.

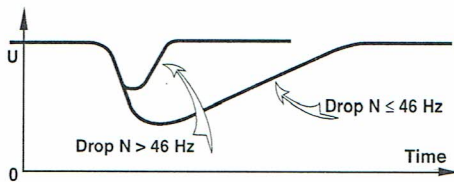
- LAM : action eliminated by cutting the ST5 jumper.



### 2.3.2 - Gradual voltage return function

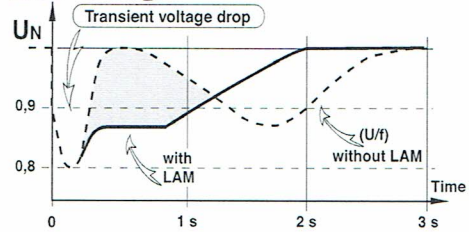
During load impacts, the function helps the genset to return to its rated speed faster thanks to a gradual increase in voltage according to the principle:

- If the speed drops between 46 and 50 Hz, the rated voltage follows a fast gradient as it is restored.
- If the speed drops below 46 Hz, since the engine needs more help, the voltage follows a slow gradient as it returns to the reference value.

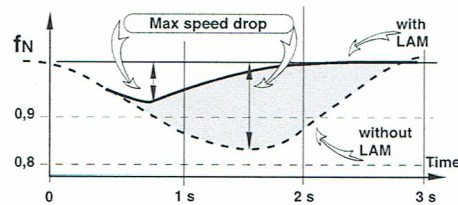


## 2.4 - Typical effects of the LAM with a diesel engine with or without a LAM (U/F only)

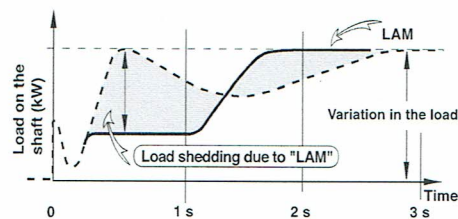
### 2.4.1 - Voltage



### 2.4.2 - Frequency



### 2.4.3 - Power



|                           |                              |                       |
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## 2.5 - R438 A.V.R. options

- **Current transformer** for parallel operation of ...../1A. 5 VA CL 1.

- **Remote voltage adjustment potentiometer:** 470  $\Omega$ , 0.5 W min: adjustment range  $\pm 5\%$  (range limited by internal voltage potentiometer P2). Remove ST4 to connect the potentiometer. (A 1 k $\Omega$  potentiometer can also be used to extend the adjustment range).



For wiring up the external potentiometer; the "earth" wires must be isolated as well as the potentiometer terminals (wires at the same voltage as the power).

- **R731 external module:** sensing of 3-phase voltage 200 to 500 V, compatible with parallel operation. Disconnect ST1 to connect the module; set the voltage via the module potentiometer.

- **R734 module:** detection of 3-phase current and voltage for parallel operation on unbalanced installations (imbalance > 15%).

- **R726 module:** 3 functions (mounted externally). P.F. regulation (2F) and voltage sensing circuit before paralleling (3 F).

- **Voltage control:** with an isolated D.C. current source applied to the terminals used for the external potentiometer:

- Internal impedance 1.5 k $\Omega$ .
- A variation of  $\pm 0.5$  V corresponds to a voltage adjustment of  $\pm 10\%$ .



|                           |                              |                       |
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### 3 - INSTALLATION - COMMISSIONING

#### 3.1 - Electrical checks on the AVR

- Check that all connections have been made properly as shown in the attached wiring diagram.
- Check that the ST3 frequency selection jumper is on the correct frequency setting.
- Check whether the ST4 jumper or the remote adjustment potentiometer have been connected.
- Optional operating modes.
  - ST1 jumper : open to connect the R731 or R734 3-phase sensing module.
  - ST2 jumper : open if rapid response time used
  - ST5 jumper : open to suppress the LAM function.

#### 3.2 - Settings



The machine is tested and set at the factory. When first used with no load, make sure that the drive speed is correct and stable (see the nameplate). After operational testing, replace all access panels or covers.

The only possible adjustments to the machine should be made on the AVR.

##### 3.2.1 - R438 settings (AREP or PMG system)

### WARNING

Before any intervention on the A.V.R., make sure that the ST9 jumper is closed with AREP excitation and disconnected with PMG or SHUNT or separate excitation.

- a) Initial potentiometer settings (see table below)
- Remote voltage adjustment potentiometer : centre (ST4 jumper removed).

| Action  | Factory setting                      | Pot. |
|---|--------------------------------------|------|
| <b>Voltage</b><br>minimum fully anti-clockwise  | 400V - 50 Hz<br>(Input<br>0 - 380 V) |      |
| <b>Stability</b>  | Not set<br>(centre position)         |      |
| <b>Voltage quadrature droop</b><br>(// operation with C.T.)<br>- 0 quadrature loop fully anti-clockwise.  | Not set<br>(fully anti-clockwise)    |      |
| <b>Excitation ceiling</b><br>Limit of excitation and short-circuit current, minimum fully anti-clockwise. | 10 A<br>maximum                      |      |

#### Stability adjustments in standalone operation

- b) Install a D.C. analogue voltmeter (needle dial) cal. 50V on terminals E+, E- and an A.C. voltmeter cal 300 - 500 or 1000V on the alternator output terminals.
- c) Make sure that the ST3 jumper is positioned on the desired frequency (50 or 60 Hz).
- d) Voltage potentiometer P2 at minimum, fully anti-clockwise.
- e) Stability potentiometer P3 to around 1/3 of the anti-clockwise limit.
- f) Start the engine and set its speed to a frequency of 48 Hz for 50 Hz, or 58 for 60 Hz.
- g) Set the output voltage to the desired value using P2.
  - Rated voltage UN for solo operation (eg. 400 V)
  - Or UN + 2 to 4% for parallel operation with C.T. (eg. 410 V)
If the voltage oscillates, use P3 to make adjustments (try both directions) observing the voltage between E+ and E- (approx. 10V D.C.).

|                              |                              |                       |
|------------------------------|------------------------------|-----------------------|
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The best response times are obtained at the limit of the instability. If no stable position can be obtained, try disconnecting or replacing the ST2 jumper (normal/fast).

h) Check LAM operation : **ST5** closed.

i) Vary the frequency (speed) around 48 or 58 Hz according to the operating frequency, and check the change in voltage from that observed previously (~ 15%).

j) Readjust the speed of the unit to its rated no-load value.  
Adjustments in parallel operation

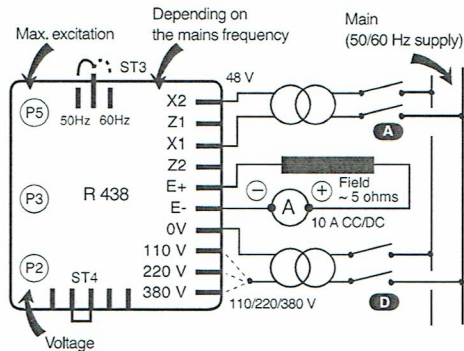
**Before any intervention on the alternator, make sure that the speed droop is identical for all engines.**

k) Preset for parallel operation (with C.T. connected to S1, S2)  
- Potentiometer P1 (quadrature droop) in centre position.  
Apply the rated load (P.F. = 0.8 inductive).  
The voltage should drop by 2 to 3%. If it increases, check that V and W and also S1 and S2 have not been reversed.

l) The no-load voltages should be identical for all the alternators intended to run in parallel.  
- Couple the machines in parallel.  
- By adjusting the **speed**, try to obtain **0 KW** power exchange.  
- By altering the voltage setting P2 on one of the machines, try to cancel (or minimise) the **current** circulating between the machines.  
- From now on, do not touch the voltage settings.

m) Apply the available load (the setting is only correct if a **reactive** load is available)  
- By altering the **speed**, match the **kW** (or divide the rated power of the units proportionally)  
- By altering the quadrature droop potentiometer **P1**, match or divide the **currents**.

### 3.2.2 - Max. excitation setting (excitation ceiling)



Static adjustment of the current limit, potentiometer P5 (factory setting: 7.5 A, fuse rating: 8 A - 10 seconds).

The maximum factory setting corresponds to that of the excitation current required to obtain a 3-phase short-circuit current of approximately 3 IN at 50 Hz for industrial power, unless otherwise specified(\*).

A static method can be used to reduce this value or adapt the Isc to the actual operating power (derated machine), which is safer for the alternator and the installation. Disconnect power supply wires X1, X2 and Z1, Z2 and the voltage reference (0-110V-220V-380V) on the alternator.

Connect the mains power supply using a transformer (200-240V) as indicated (X1, X2 : 48V). Install a 10A D.C. ammeter in series with the exciter field. Turn P5 fully anti-clockwise and activate the power supply. If there is no output current from the AVR, turn potentiometer P2 (voltage) clockwise until the ammeter indicates a stable current. Switch the power supply off, then on again, turn P5 clockwise until the required max. current is obtained (no more than 8 A).



**Checking the internal protection :**

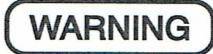
Open switch (D) : the excitation current should increase to its preset ceiling, remain at that level for  $\geq 10$  seconds and then drop to  $< 1A$ .

To reset, switch off the power supply by opening switch (A).

Note: After setting the excitation ceiling as described, adjust the voltage again (see section 2.1.1)

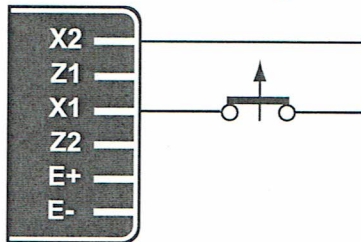
(\*) In some countries it is a legal requirement to have a short-circuit current of  $3 I_N$ , so as to offer selective protection.

**3.2.3 - Special type of use**



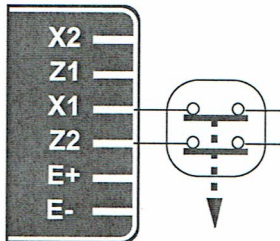
Excitation circuit E+, E- must not be left open when the machine is running : AVR damage will occur.

**3.2.3.1 - R438 field weakening (SHUNT)**



The exciter is switched off by disconnecting the AVR power supply (1 wire - X1 or X2). Contact rating 16 A - 250V A.C.

**3.2.3.2 - R438 field weakening (AREP/ PMG)**



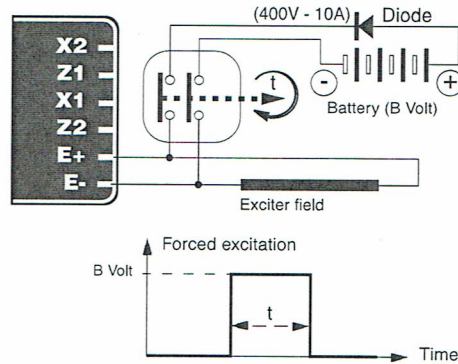
The exciter is switched off by disconnecting the AVR power supply (1 wire on each auxiliary winding) - contact rating 16 A - 250V A.C.

Connection is identical for resetting the AVR internal protection.



In case of using the de-excitation, provide a forced excitation.

**3.2.3.3 - R438 field forcing**



| Applications                      | B volts | Time t   |
|-----------------------------------|---------|----------|
| Guaranteed voltage build-up       | 12 (1A) | 1 - 2 s  |
| Parallel operation, de-energized  | 12 (1A) | 1 - 2 s  |
| Parallel operation, at standstill | 12 (1A) | 5 - 10 s |
| Frequency starting                | 12 (1A) | 5 - 10 s |
| Sustained voltage on overload     | 12 (1A) | 5 - 10 s |

|                              |                              |                       |
|------------------------------|------------------------------|-----------------------|
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| <b>R438</b><br><b>A.V.R.</b> |                              |                       |

### 3.3 - Electrical faults

| Fault  | Action   | Effect   | Check/Cause   |
|--|--|--|---|
| No voltage at no load on start-up  | Connect a new battery of 4 to 12 volts to terminals E- and E+, respecting the polarity, for 2 to 3 seconds | The alternator builds up and its voltage is still correct when the battery is removed.               | - Lack of residual magnetism  |
|  |  | The alternator builds up but its voltage does not reach the rated value when the battery is removed. | - Check the connection of the voltage reference to the AVR<br>- Faulty diodes<br>- Armature short-circuit   |
|  |  | The alternator builds up but its voltage disappears when the battery is removed                      | - Faulty AVR<br>- Field windings disconnected<br>- Main field winding open circuit - check the resistance   |
| Voltage too low  | Check the drive speed  | Correct speed  | Check the AVR connections (AVR may be faulty)<br>- Field windings short-circuited<br>- Rotating diodes burnt out<br>- Main field winding short-circuited - Check the resistance |
|  |  | Speed too low  | Increase the drive speed (Do not touch the AVR voltage pot. (P2) before running at the correct speed.)  |
| Voltage too high   | Adjust AVR voltage potentiometer   | Adjustment ineffective   | Faulty AVR  |
| Voltage oscillations   | Adjust AVR stability potentiometer   | If no effect : try normal / fast recovery modes (ST2)  | - Check the speed : possibility of cyclic irregularity<br>- Loose connections<br>- Faulty AVR<br>- Speed too low when on load (or U/F bend set too high)                        |
| Voltage correct at no load and too low when on load (*)  | Run at no load and check the voltage between E+ and E- on the AVR  | Voltage between E+ and E-SHUNT < 20 V<br>AREP / PMG < 10V  | - Check the speed (or U/F bend set too high)  |
|  |  | Voltage between E+ and E-SHUNT > 30V<br>AREP / PMG > 15V   | - Faulty rotating diodes<br>- Short-circuit in the main field. Check the resistance<br>- Faulty exciter armature.   |
| <b>(*) Caution :</b> For single-phase operation, check that the sensing wires coming from the AVR are correctly connected to the operating terminals |  |  |   |
| Voltage disappears during operation (**)   | Check the AVR, the surge suppressor, the rotating diodes, and replace any defective components             | The voltage does not return to the rated value.  | - Exciter winding open circuit<br>- Faulty exciter armature<br>- Faulty AVR<br>- Main field open circuit or short-circuited   |
| <b>(**) Caution :</b> Internal protection may be activated (overload, open circuit, short-circuit)   |  |  |   |



**Warning : after operational testing, replace all access panels or covers.**

|                              |                              |                       |
|------------------------------|------------------------------|-----------------------|
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## 4 - SPARE PARTS

### 4.1 - Designation

| Description | Type | Code           |
|-------------|------|----------------|
| A.V.R.      | R438 | AEM 110 RE 017 |

### 4.2 - Technical support service

Our technical support service will be happy to provide any information you require.

When ordering spare parts, you should indicate the complete machine type, its serial number and the information indicated on the nameplate.

Part numbers should be identified from the exploded views and their description in the parts list.

Our extensive network of «service stations» can dispatch the necessary parts without delay.

To ensure correct operation and the safety of our machines, we recommend the use of original manufacture spare parts.

In the event of failure to comply with this advice, the manufacturer cannot be held responsible for any damage.

|                              |                              |                       |
|------------------------------|------------------------------|-----------------------|
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| <b>R438</b><br><b>A.V.R.</b> |                              |                       |

### Disposal and recycling instructions

We are committed to limit the environmental impact of our activity. We continuously survey our production processes, material sourcing and products design to improve recyclability and diminish our footprint.

These instructions are for information purposes only. It is the user responsibility to comply with local legislation regarding product disposal and recycling.

### Recyclable materials

Our alternators are mainly built out of iron, steel and copper materials, which can be reclaimed for recycling purposes.

These materials can be reclaimed through a combination of manual dismantling, mechanical separation and melting processes. Our technical support department can provide detailed directions on products dismantling upon request.

### Waste & hazardous materials

The following components and materials need a special treatment and need to be separated from the alternator before the recycling process:

- electronic materials found in the terminal box, including the Automatic Voltage Regulator (198), Current Transformers (176), interference suppression module (199) and other semi-conductors.
- diode Bridge (343) and Surge suppressor (347), found on the alternator rotor.
- major plastic components, such as the terminal box structure on some products. These components are usually marked with plastic type information.

All materials listed above need special treatment to separate waste from reclaimable material and should be handed to specialized disposal companies.

The oil and grease from the lubrication system should be considered as a hazardous waste and has to be handled according to local legislation.



# Service & Support

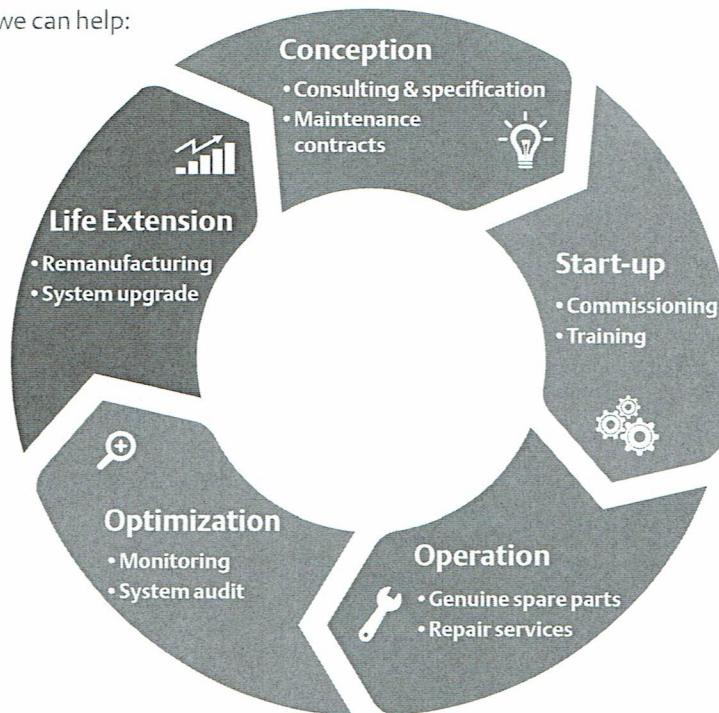
Our worldwide service network of over 80 facilities is at your service.

This local presence is our guarantee for fast and efficient repair, support and maintenance services.

Trust your alternator maintenance and support to electric power generation experts. Our field personnel are 100% qualified and fully trained to operate in all environments and on all machine types.

We know alternators operation inside out, providing the best value service to optimize your cost of ownership.

Where we can help:



Contact us:

**Americas:** +1 (507) 625 4011

**Europe & International:** +33 238 609 908

**Asia Pacific:** +65 6263 6334

**China:** +86 591 88373036

**India:** +91 806 726 4867

✉ [service.epg@leroy-somer.com](mailto:service.epg@leroy-somer.com)



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**EMERSON. CONSIDER IT SOLVED.™**

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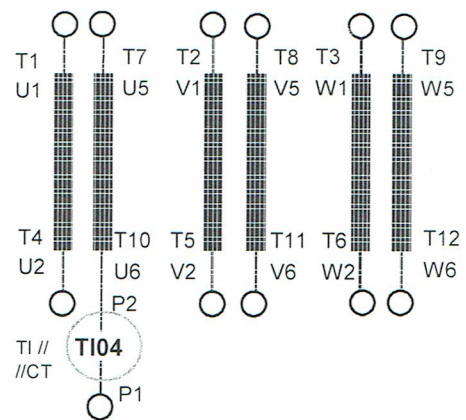
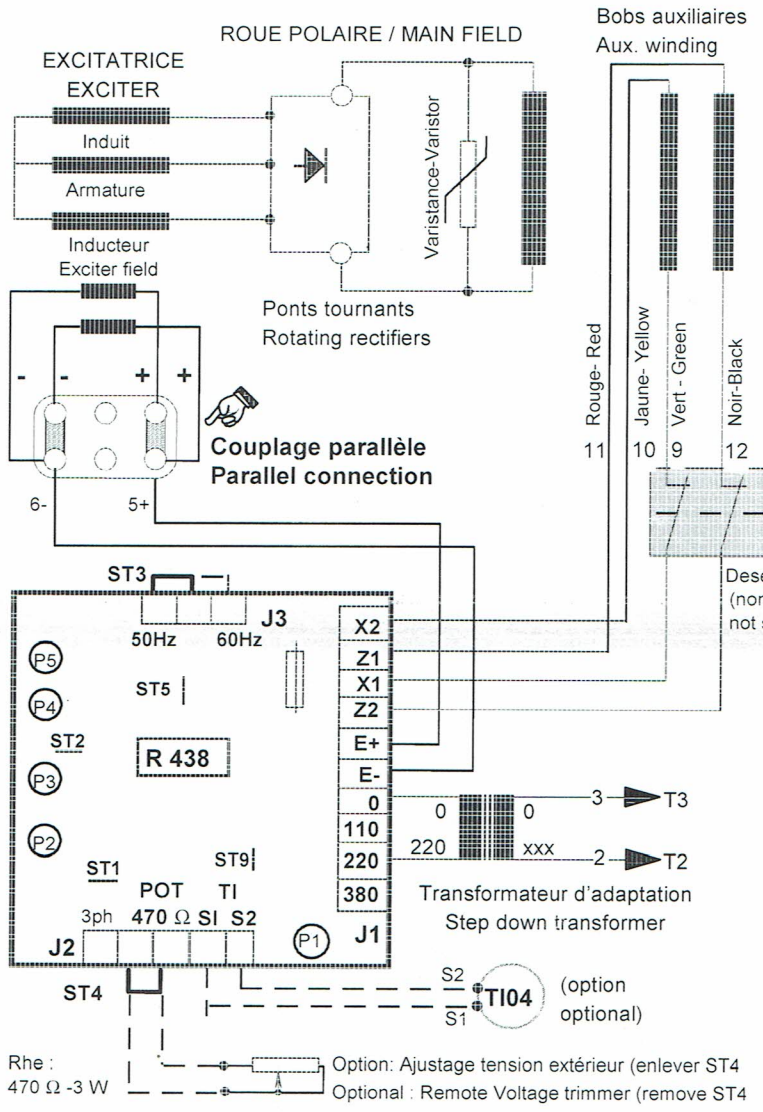
**Leroy-Somer**

  
**EMERSON**

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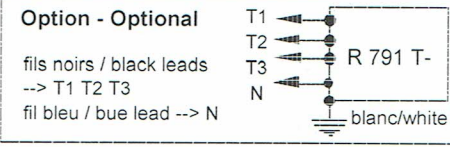
12 ou 6 Fils / 8 Bornes - 12 or 6 Leads / 8 Terminals  
 U > 500V - R 438 + Transformateur / Transformer



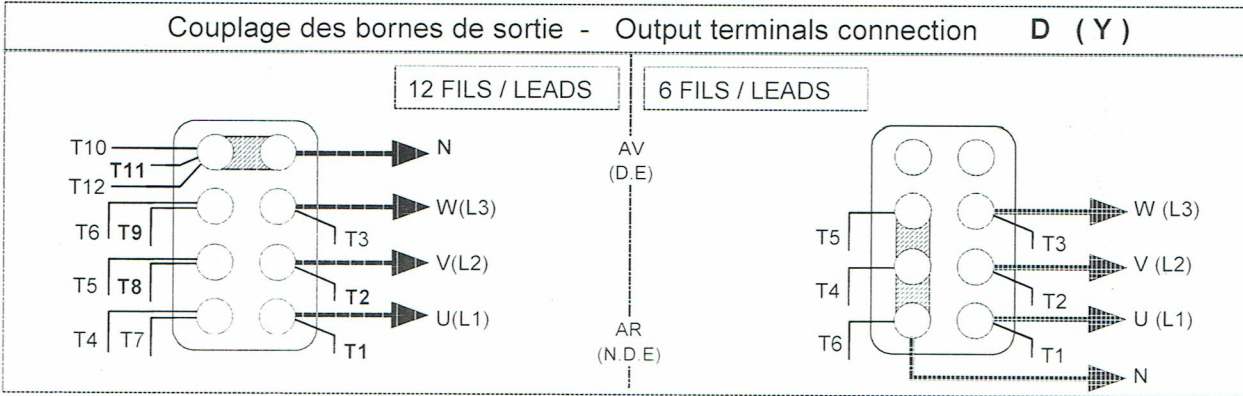
**STATOR :**  
 Marquage - Mark  
 T1 à T12 (12 Fils / Leads)  
 T1 à T6 (6 Fils / Leads)

| Transformateur d'adaptation<br>Step down transformer |                   |
|--|-------------------|
| Secondaire<br>0/220                                  | Primaire<br>0/xxx |
| 0  | 0                 |
|  | 500               |
|  | 600               |
| 220  | 660               |

XXX Selon tension alternateur  
 According to alternator voltage



Rhe : 470 Ω -3 W  
 Option: Ajustage tension extérieur (enlever ST4)  
 Optional: Remote Voltage trimmer (remove ST4)



|                |                                |             |          |                 |  |
|----------------|--------------------------------|-------------|----------|-----------------|--|
| SCH 000 OP 159 | N° de C.T.<br>E/97 12 512      | Dess RR     | Vérif EV | Date : 23/12/97 | Usine de Sillac. bd Marcellin Leroy<br>16015 ANGOULEME - CEDEX |
| D              |                                |             |          |                 |  |
| C              | général 6 /12 Fils 19/11/03 RR | 03 11 609   |          |                 | N°: 2717 . 12 . 97 LEX<br>B C<br>0                             |
| B              | inducteur sur PAB 03/03/99 RR  | E/99 03 654 |          |                 |  |
| A              | mise à jour 27/05/98 RR        | E/93 05 530 |          |                 |  |

SCHEMA DES CONNEXIONS ET  
 BRANCHEMENT DU REGULATEUR  
 WIRING AND A.V.R CONNECTION  
 DIAGRAM