
Part 1 General**1.1 RELATED SECTIONS**

- .1 Section 26 05 00 - Common Work Results for Electrical.
- .2 Section 26 23 00 – Low Voltage Switchgear.
- .3 Section 26 28 16.02 - Moulded-Case Circuit Breakers.
- .4 Section 26 36 23 - Automatic Transfer Switches.

1.2 REFERENCES

- .1 Canadian Standards Association (CSA International)
 - .1 CAN/CSA-C282-05, Emergency Electrical Power Supply for Buildings.
 - .2 CAN/CSA C22.2 No. 61010-1-2004 – Safety Requirements for Electrical Equipment for Measurement Control and Laboratory Use. Part 1: General Requirements. (Adopted IEC 1010-1:1990 with modifications), Includes Update No. 1 (2008)
- .2 American National Standards Institute (ANSI) National Electrical Manufacturers Association (NEMA).
 - .1 ANSI/NEMA MG1-04-Motors and Generators
- .3 International Organization for Standardization (ISO)
 - .1 ISO 3046-1-2002, Reciprocating internal combustion engines – Performance – Part 1: Declarations of power, fuel and lubricating oil consumptions, test methods
 - .2 ISO 3046-4-2009, Reciprocating internal combustion engines – Performance – Part 4: Speed governing

1.3 DESCRIPTION OF SYSTEM

- .1 Emergency Power Generation Diesel System shall consist of:
 - .1 Diesel engine,
 - .2 Alternator,
 - .3 Engine/alternator control equipment,
 - .4 Engine cooling system including unit-mounted radiator,
 - .5 Starting system, including battery charger and battery,
 - .6 Exhaust system (silencer and flex connections),
 - .7 Structural steel mounting base and vibration isolators,
 - .8 Remote emergency stop button.
- .2 The system shall be designed to operate as an unattended automatic unit for designated systems loads.

1.4 OPERATION AND MAINTENANCE DATA

- .1 The work of this section includes fabrication, assembly, factory testing, delivery, installation, field assembly, connections, supervision of related trades, on-site testing, commissioning and warranty of the system, and operating staff instructions.
- .2 Installation, assembly and field connections shall include all interconnecting power and control wiring to terminals within the system, battery system, and installation of vibration isolation to unit and floor slab.

1.5 SHOP DRAWINGS AND PRODUCTION INFORMATION

- .1 Submit detailed shop drawing and product information for the system in compliance with Section 01 00 10 – General Instructions.
- .2 Information shall include:
 - .1 Submit complete and detailed information on the step load capability of the emergency generator, alternator and engine combination being supplied. Refer to 2.2.5 for step-load transient response capabilities.
 - .2 Dimensioned outline drawings showing all connections and components on the unit, including vibration isolators, exhaust system, drip trays and total weight.
 - .3 Exhaust silencer drawings and selection criteria.
 - .4 Engine make and model with performance curves including brake horsepower versus rated speed curves.
 - .5 British (ISO) standard rating of engine.
 - .6 Governor make and model.
 - .7 Fuel consumption information.
 - .8 Heat rejection, combustion air, cooling air requirements.
 - .9 Starting battery, rack drawings and battery selection criteria.
 - .10 Battery charger drawings.
 - .11 Flow diagrams for diesel fuel, lubricating oil, cooling air and engine cooling system.
 - .12 Complete wiring diagrams for control and power wiring with identified terminal numbers for all interconnection between components, including all connections external to the system.
 - .13 Alternator make and model.
 - .14 Alternator damage curves.
 - .15 Alternator short-circuit decrement curves plotted against main breaker curve to show proper co-ordination over the full range of alternator output.
 - .16 Schematic block diagrams showing all components and identifying electrical and mechanical field connections including control and status wiring.
- .3 Calculations for full load output at 0.8 PF lagging with engine capacity calculated for site conditions based on CSA standard.
- .4 Provide separate calculations for prime power and standby rating.

- .5 Description of set operation including:
 - .1 Automatic starting and transfer to load and back to normal power, including time in seconds from the start of cranking until the unit reaches the rated voltage and frequency.
 - .2 Manual starting.
 - .3 Automatic shutdown.
- .6 Engine alternator control panel: dimensioned layout, details and wiring diagrams with the make and type of all devices.
- .7 Drawings and information on the complete vibration mounting assembly.
- .8 Exact static and dynamic loading weights with dimensions shall be provided for the diesel generator set assembly in the wet and dry conditions and including enclosure weights. These shall be submitted with the shop drawings.

1.6 OPERATION AND MAINTENANCE MANUAL

- .1 Provide data in a separately bound operation and maintenance manual for the complete system in accordance with Section 01 00 10 – General Instructions.
- .2 Operation and Maintenance Manual to include instructions for the particular unit supplied and not a general description of units manufactured by the supplier and:
 - .1 Operation and maintenance instructions for engine, alternator, control panel, battery charger, battery, fuel system, exhaust system and accessories to permit effective operation, maintenance and repair.
 - .2 Technical data:
 - .1 Illustrated parts lists with parts catalogue numbers.
 - .2 Schematic diagram of electrical controls.
 - .3 Flow diagrams for:
 - .1 fuel system,
 - .2 lubricating oil,
 - .3 cooling system, and
 - .4 certified copy of factory test results.
 - .4 Include a complete one-line power drawing with all components and operating descriptions.
 - .5 Include a schematic drawing of engine lubrication system, illustrated drawings, and complete electric schematics and wiring diagrams of all equipment and controls. Also include a list of all parts used in the diesel generator and control cubicles and a list of tools. The source of all parts shall be stated.
- .3 Include copies of completed data sheets and test results.

1.7 INSTRUCTION

- .1 The diesel generator set supplier shall provide a qualified service representative for a period of two days to instruct the Departmental Representative operating personnel in the correct operation and maintenance of the set. Include all costs in this contract.

1.8 FACTORY WITNESS TEST

- .1 Factory test the generator set, including engine, alternator, controls and accessories in the presence of the Departmental Representative.
- .2 Notify the Departmental Representative 15 days in advance of date of the factory test.
- .3 Test procedures:
 - .1 Prepare blank forms and check sheet with spaces to record data.
 - .2 Mark check sheet and record data on forms in duplicate as test proceeds.
 - .3 The Departmental Representative and manufacturer's representative signature on the completed forms to indicate concurrence in results of the test.
 - .4 Provide test equipment to demonstrate all generator systems characteristics described in this specification. Equipment to include but not limited to:
 - .1 Power analyzers, to record and print voltage, current and frequency during tests,
 - .2 Digital true rms ammeter / voltmeter,
 - .3 Tachometer,
 - .4 Vibration analyzer,
 - .5 Sound level analyzer, and
 - .6 Infrared digital thermometer (non contact).
- .4 Testing - General:

Before starting the load test, perform the following:

 - .1 Verify calibration of all instrumentation (meters and gauges) using proper calibration equipment for speed, temperature, pressure, frequency, voltage and current (AC and DC).
 - .2 Verify approved and calibrated load bank is provided.
 - .3 Demonstrate the protection and operation of the low lube oil-pressure switch and over-temperature switch in the following manner:
 - .1 The operation of low lubricating oil-pressure switch to be demonstrated by removing the pressure switch from the engine. Connecting to pressure source (pump) and pressure gauge via valve. Second valve connected for bleeding off pressure. Connect indication device (light, buzzer or meter) to switch contacts and record pressure set points. Record in factory test report.
 - .2 The operation of the over-temperature switch to be demonstrated by removing the switch and immersing it in a heated container of oil until the temperature switch operates its contacts. Switch operation to be monitored by a digital thermometer immersed in the oil. Oil must be mixed continuously during test. Record in Factory Test Report.
- .5 Load test:

With 100% rated load and at 40°C ambient temperature, operate set for 12 hours continuously taking readings at 30-minute intervals. Record the following:

 - .1 Time of reading,
 - .2 Running time,

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- .3 Ambient temperature (measured at engine air intake),
 - .4 Lube oil pressure,
 - .5 Lube oil temperatures (inlet and outlet),
 - .6 Engine coolant temperatures (inlet and outlet),
 - .7 Exhaust stack temperatures (before and after turbo),
 - .8 Alternator voltage, Phases 1, 2 and 3,
 - .9 Alternator current, Phases 1, 2 and 3,
 - .10 Power in kW,
 - .11 Frequency in Hz,
 - .12 Power factor,
 - .13 Battery charging current (Disconnect battery charger and record generator output current every minute for the first ten minutes after starting and every two minutes for the next 20 minutes.),
 - .14 Battery voltage,
 - .15 Alternator stator temperature,
 - .16 Number of starts, and
 - .17 Using the infrared thermometer, record the highest surface temperature of each of the following:
 - .1 Alternator,
 - .2 Engine,
 - .3 Exhaust pipe,
 - .4 Cooling pipes,
 - .5 Fuel pipes, and
 - .6 Fuel day tank.
- .6 Demonstrate overvoltage and under-frequency safety shutdowns by adjusting the voltage regulator and governor.
- .7 Demonstrate all safety functions and alarms to be in compliance with the listed performance herein.
- .8 After full load test use a power analyzer to record frequency and voltage variations on three phases during load switching procedures. From a cold start, no load to full load, the transient response shall not exceed voltage and frequency capabilities in 2.2.5. Each load change delayed until steady state conditions exist. Switching increments to include:
- .1 No load to 100% full rated load to no load.
 - .2 No load to 75% rated load to no load.
 - .3 No load to 50% rated load to no load.
 - .4 No load to 25% rated load to no load.
- .9 Demonstrate:
- .1 Automatic starting of set.
 - .2 Automatic shut down of engine.
 - .3 That the battery charger reverts to the high rate charge after cranking.
 - .4 Test and record:
 - .1 Time delay on start,

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- .2 Cranking time until engine starts, and
 - .3 Time required to achieve steady state condition.
 - .5 Demonstrate all devices and status indications including alarms and shutdowns:
 - .1 Overcranking,
 - .2 Low engine temp. alarm,
 - .3 High engine temp. alarm,
 - .4 High engine temp. shutdown,
 - .5 Low lube oil pressure alarm,
 - .6 Low lube oil pressure shutdown,
 - .7 Overspeed,
 - .8 Low fuel level,
 - .9 Emergency supply to load,
 - .10 Control switch not in auto,
 - .11 Low battery voltage,
 - .12 Lamp test,
 - .13 Common alarm in remote and local,
 - .14 Audible alarm silencing,
 - .15 Alternator overvoltage,
 - .16 Under frequency,
 - .17 Combustion air shutdown damper,
 - .18 Radiator low coolant level,
 - .19 Output breaker open alarm, and
 - .20 Output breaker trip.
 - .10 Carry out vibration testing - use qualified mechanical vibration analysis technician using instrumentation designed for the purpose.
 - .1 Measure and record machine vibration levels at a minimum of 12 positions, under the following conditions:
 - 100% Full Load – No Load
 - 75% Load – No Load
 - 50% Load – No Load
 - 25% Load – No Load
 - .2 Maximum allowable vibration 5 mils peak to peak amplitude for vibration frequency from 0 to 1800 CPM.
 - .11 Measure audible noise at 1 m around the generator.

1.9 WASTE MANAGEMENT AND DISPOSAL

- .1 Separate and recycle waste materials in accordance with Section 01 00 10 – General Instructions.
- .2 Remove from site and dispose of all packaging materials at appropriate recycling facilities.
- .3 Collect and separate for disposal all packaging material in appropriate on-site bins for recycling in accordance with Waste Management Plan.
- .4 Divert unused metal and wiring materials from landfill to metal recycling facility as approved by Departmental Representative.

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- .5 Fold up metal banding, flatten and place in designated area for recycling.

Part 2 Products

2.1 SYSTEM DESCRIPTION AND OPERATION

- .1 The emergency power system shall consist of a complete operating diesel electric generator unit with all necessary controls and auxiliary support equipment.
- .2 The complete system shall provide regulated 60 Hz AC power to building loads, lighting, cooling equipment and building ventilation, motor loads. It shall be capable of starting, attaining stable voltage and frequency and be connected to all of the loads within 15 seconds following a power failure.
- .3 All equipment shall have sprinkler-proof construction.

2.2 SYSTEM CHARACTERISTICS

- .1 Ratings:
- Prime Power Rating: 2000 kW/ 2500 kVA
- The unit shall have a nameplate or nameplates with both ratings.
- .2 Output Voltage:
- .1 Nominal: 600 V, 3ph, 3w.
- .2 Maximum Harmonic Content: 5% THD, 3% any single harmonic, at any load condition.
- .3 Step-load transient response capability - with the engine generator running at no load at 1800 rpm with rated output voltage.
- .4 Step-load capability as follows:
- .1 The complete unit shall be capable of meeting the following transient load conditions:
- .1 Voltage limit: maximum deviation 25% recovery to steady state band within five seconds.
- .2 Frequency limit: maximum deviation, 10% recovery to state band within five seconds.
- .3 A maximum step load will be 840 kW at 0.9 lagging power factor.
- .5 Voltage Regulation/Control:
- .1 Steady state
- .2 No load to full load: $\pm 0.5\%$
- .3 Stability at any fixed load: $\pm 0.5\%$ of RMS value
- .6 Frequency:
- .1 Regulation: isochronous
- .2 Nominal: 60 Hz at 1800 rpm
- .3 Maximum frequency change between no load and full load, not to exceed 0.5% of rated frequency.

- .4 Steady state deviation $\pm .25\%$.
- .7 Maximum audible noise: 50 dbA @ 11 m at 100% load.

2.3 DIESEL ENGINE

- .1 The diesel engine shall be of compression ignition type, four-cycle, turbocharged, and inter-cooled. Tier 2 EPA rated.
- .2 The engine shall start reliably without any delay or manual priming at an ambient temperature of 0°C , and shall be capable of delivering full output within 15 seconds from normal power failure.
- .3 It shall be possible to perform a top overhaul on the engine, including replacement of pistons and piston rings without removing the engine from its base or disturbing its alignment.
- .4 The continuous minimum net brake horsepower of the engine at the flywheel shall include losses to all engine driven accessories including the fan, silencer and exhaust stack back pressure, overload, site conditions, alternator power and efficiency.
 - .1 Site conditions are as follows:
 - Altitude: 100 meters above sea level.
 - Ambient temperature: 40°C .
 - Relative humidity: 60%
 - .2 For purposes of the BPH calculation, use actual alternator efficiency.
- .5 The brake horsepower rating and specific fuel consumption of the engine shall be stated and shall be certified by the manufacturer in accordance with ISO 3046 and shown in published data, as permissible for heavy-duty industrial applications.
- .6 Engine shall be rated as EPA Tier 2 rated.
- .7 Break Mean Effective Pressure (BMEP) shall be equal to or less than 2167 kPa.
- .8 Fuel-oil system:
 - .1 Provide all flexible braided stainless steel connections for fuel piping on the unit.
 - .2 High pressure fuel injection pipes shall be double skin shielded type.
 - .3 Engine shall operate on commercial grades of diesel fuel oil.
 - .4 Engine shall be equipped with engine driven fuel transfer pump.
 - .5 Fuel filters shall have fire-resistant metal bowl and replaceable elements that can be easily removed without disturbing other parts of the engine. Filters to be duplex arrangement.
 - .6 The fuel system shall include a particulate and coalescing type water separator fuel filter with visual inspections means. The filter system shall remove 98% of the water and filter 95% of the contaminants down to five microns in size. Fuel filter(s) shall be equipped with a drain valve of water drainage. The fuel system shall provide an automatic means for removal of air from the fuel system without disconnecting fuel lines.

.9 Air Intake

Provide one or more heavy-duty high-efficiency dry-type air filters of a type recommended by the engine manufacturer, mounted on the engine with dust-tight connections to the engine air intake manifold.

.10 Lube Oil System:

- .1 Oil pump, engine driven gear type, with strainer and adjustable pressure relief valve, full pressure lubrication.
- .2 The mounting of the engine on the base shall be such that the sump can be removed without requiring a depression in the floor. Sump drain pipe with gate valve and plug to extend 75 mm beyond bed plate.
- .3 Provide first on site replacement of lubricating oil shipped in containers to replace oil used at factory test.
- .4 Provide a one-piece oil-drip tray. The drip tray shall be the complete size of the diesel engine.
- .5 Engine oil temperature shall not exceed 88°C. If required, provide external oil cooler to maintain lube oil temperature within 88°C.

.11 Cooling System:

- .1 The system shall be capable of cooling the engine with an ambient temperature of 40°C with 100% full load.
- .2 The engine jacket water shall be cooled by means of a water to air radiator and engine-driven cooling fan. The radiator shall be vibration free, mounted on the electric set base furnished with:
 - .1 filler cap with pressure valve,
 - .2 self-air bleed off,
 - .3 core-encased in protective shell,
 - .4 duct adapter on outlet side of radiator,
 - .5 push type fan, belt driven from pulley on engine crankshaft with a minimum of two (2) "V" belts, each capable of driving the fan if one belt fails.
 - .6 belt adjusting mechanism (Charging alternator not to be used for belt adjustment),
 - .7 sealed fan hub bearings that do not require lubrication,
 - .8 safety guard for fan,
 - .9 fan shroud,
 - .10 first full of 50/50 mixture of glycol, and
 - .11 low-level alarm switch.

.12 Block Heater

- .1 A suitable electric engine block heater and means for connecting thereto shall be supplied. A thermostat shall be provided to operate the heater. The heater shall be adequate size to maintain the coolant in the cylinder jackets at a minimum temperature of 21° C with an ambient air temperature of -18° C. Block heater shall be connected from 347/600 V, three-phase emergency panel and wired through a breaker in the control panel (identify source of supply and provide power on light on control panel).

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- .13 Guards
- Provide adequate guards to protect the operating personnel from exposed moving parts. Provide blankets for exhaust manifolds and turbochargers. Guards to be located to permit normal maintenance inspections without their removal.

2.4 EXHAUST SYSTEM

- .1 The exhaust system must be designed to meet the Authority Having Jurisdiction requirements.
- .2 Provide a critical grade exhaust silencer with flanges drain plug and clean out, bottom inlet type.
- .3 Provide flexible stainless steel exhaust connections. Flexible connections shall have close pitch corrugations and flanged ends. The flexible hose connections shall be capable of taking up 38 mm movement of diesel engine, plus pipe expansion of horizontal run between diesel engine and anchor point on horizontal run. Flexible hose connections shall have sufficient length to handle the movement specified and to handle expansion between anchors in the piping plus not less than 25% safety factor, from 0o C, ambient temperature to corresponding exhaust gas temperature.
- .4 Provide insulated schedule 40 exhaust stack on the exterior of the enclosure running horizontally and directing the exhaust to the west. Provide bird screen at end of exhaust pipe.
- .5 Provide pyrometers for turbo-in and turbo-out.

2.5 ELECTRONIC GOVERNING SYSTEM

- .1 Electronic Governing System to operate with the alternator/voltage regulator and engine to be capable of achieving specified steady state and transient performance.
- .2 System to provide isochronous type operation.

2.6 STARTING SYSTEM

- .1 Positive shift, gear engaging starter. The motor voltage shall be as recommended by the engine manufacturer.
- .2 Cranking limiter to provide for one or more cranking cycle.
- .3 Batteries: Storage batteries shall be 24 Volts comprising 12 cells lead calcium in flame-retardant jars and covers. Cells to be complete with flame arrester type vent caps and lead-plated copper intercell connectors battery to have sufficient capacity to provide a total of 120 seconds cranking time at 0° C, consisting of 3–30-second cranking attempts with 15-second rest between each attempt and with a battery end voltage of not less than 80% voltage. Voltage measured at terminals at end of 60 seconds cranking, with cranking current flowing, to be not less than 1.75 V per cell. Size battery on the basis of the engine and battery manufacturer's published data. Batteries to be dry charged, specific gravity of electrolyte 1.220 when fully charged at 27° C.
- .4 Provide battery stand fabricated from angle iron coated with acid-resistant paint. Provide clear battery cover. Stand to be same width and length as battery. Height of stand 300mm.

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- .5 Provide necessary battery cables and connectors, select cable wire size on the basis of allowing not more than 5% voltage drop at time of peak load.

2.7 BATTERY CHARGER

- .1 Battery charger shall be a silicon controlled rectifier type (thyristor) for automatic float charge operating from 120 Volts, single phase, 60 Hz supply. Charger shall be automatic two-rate type with the following components and features.
 - .1 Float and equalizer voltage adjustments.
 - .2 Adjustable current limit control.
 - .3 Equalize circuit.
 - .4 Overload protected input switch.
 - .5 D.C. output breaker.
 - .6 D.C. ammeter.
 - .7 D.C. voltmeter.
 - .8 Short-circuit current limit protection.
 - .9 Reverse polarity protection.
 - .10 Temperature compensation.
 - .11 Dry contacts for remote supervision of alarm condition.
- .2 Output Voltage, 24 V DC, within +/- 0.5% steady state - with input voltage variation +/- 10% from 10% to 100% load.
- .3 Alarm/Status - Indicating annunciator with indicators for:
 - .1 AC power on - status only.
 - .2 AC power off - alarm.
 - .3 Float and equalize - status only.
 - .4 Reverse polarity - alarm.
 - .5 Voltage Limit - alarm.
 - .6 Current Limit - alarm.
- .4 Alarm contacts (2) for remote monitoring of battery system alarms.
- .5 The battery charger shall be capable of recharging the battery when completely discharged to 80% of capacity within four hours and to full capacity within 12 hours.
- .6 Battery charger shall be wall mounted in ventilated enclosure.

2.8 ALTERNATOR

- .1 Alternator: to ANSI/NEMA MG1 together with additional features as herein listed.
- .2 The balanced line-to-line Telephone Influence Factor (TIF) shall be max. 50 and meet NEMA and EEMAC Standards. Total harmonic content - 5% maximum. Voltage waveform deviation - 3% maximum.
- .3 Provide a single-bearing type alternator designed to be bolted directly to the engine flywheel. The generator shall be self-ventilated and of drip-proof construction.

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- .4 The alternator shall be three-phase brushless revolving field synchronous machine of salient pole construction with ammortisseur windings. Alternator insulation shall be class H or better. When operating continuously at full load the average winding temperature in °C measured by resistance shall not exceed 105° C at an ambient of 40° C.
 - .5 Connect each phase and the neutral point of generator windings to fully insulated terminals in the terminal box. The terminal box shall be extra large, suitable for terminating the output cables.
 - .6 An automatic static voltage regulating system shall be provided which will operate automatically in conjunction with the brushless exciter to maintain the generator output voltage within specified limits from no load to full load at 0.8 power factor. The air gap shall be separately excited by a permanent magnet rotating generator. The regulator adjustment shall be based on the average of the three-phase voltages.
 - .7 A control shall be provided to adjust the stabilizing or anti-hunt circuit which controls overshoot or undershoot of the alternator voltage on load changes.
 - .8 A current-forcing circuit shall be provided supply a minimum of 300% of nominal alternator output for at least 10 seconds to allow proper co-ordination of the system's protective devices. Supply decrement and damage curves plotted against breaker trip curves to show proper co-ordination over the full range of alternator output.
 - .9 A manual control shall be provided to allow for adjustment of the automatically regulated generator voltage by $\pm 10\%$. Control to be mounted inside control panel - screwdriver adjustable with locking nut.
 - .10 The static voltage regulating system shall be mounted in the control panel. The rectifier input shall be protected by a surge suppressor.
 - .11 Provide ground fault protection for the generator, including relay and current transformers.

2.9 MOUNTING

- .1 A complete mounting assembly shall be provided. The engine generator shall be mounted on a common fabricated steel base. This frame shall be mounted on adjustable spring isolators. The spring isolators shall be fastened to a steel baseplate. The baseplate shall be mounted on three thicknesses of ribbed neoprene. These pads shall be loaded at 200 - 350 MPa unless otherwise specified by the manufacturer. Isolation efficiency not to be less than 95%.
- .2 Levelling shims to be used only beneath generator feet.
- .3 The steel base shall be provided with hooks, hubs, etc., for the attachment of slings. These shall be suitable for moving the unit with the engine wet or dry.
- .4 Supply all foundation bolts suitable for securing the vibration mounts to the concrete foundation.

2.10 PAINTING

- .1 Paint the complete diesel generator set including, but not limited to, the alternator, engine, radiator and base with two (2) coats of oil and heat resistant paint. Colour to be the manufacturer's standard colours.

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- .2 Supply 0.5 L of touch-up enamel.

2.11 CONTROL PANEL

- .1 The control unit shall be wall-mounted and shall contain, but not be limited to, the following devices:
 - .1 Microprocessor engine control and monitoring unit.
 - .2 Auxiliary breakers.
 - .3 Alarm annunciator.
 - .4 Digital metering unit.
 - .5 Lamp-testing facility.
 - .6 Gauges and instruments.
- .2 Refer to Section 26 28 16.02 - Moulded Case Circuit Breakers and Section 26 23 00 - Low Voltage Switchgear.
- .3 Gauges and instruments:
 - .1 The following instruments shall be mounted on the generator controller.
 - .2 All gauges shall be electric, compatible with sensor units installed in engine. Each instrument assembly shall have minimum accuracy of 2%:
 - .1 Run-off auto switch,
 - .2 Emergency stop button,
 - .3 Tachometer,
 - .4 Lube oil pressure gauge,
 - .5 Lube oil inlet temp. gauge,
 - .6 Lube oil outlet temp. gauge,
 - .7 Engine coolant inlet temp.
 - .8 Engine coolant outlet temp.
 - .9 Exhaust pyrometer (to read each bank) before and after turbo,
 - .10 Running time meter (non-resettable),
 - .11 Combustion air intake temp.
 - .12 Battery voltage,
 - .13 Turbo boost pressure for all banks,
 - .14 Number of starts counter (non-resettable),
 - .15 Turbo oil pressure,
 - .16 Battery charging current (from engine mounted DC generator), and
 - .17 Alternator stator temp,
 - .18 Solid State Generator output metering package.
 - .1 Current
 - .2 Voltage
 - .3 kW/kVA
- .4 Microprocessor programmable generator controller shall provide automatic starting of the diesel upon closing of an auxiliary contact in the automatic transfer switches and required alarms and shutdowns.

- .5 Safety shutdown and alarms: The panel shall contain all components required to provide status indication, automatic shutdown and alarm. Alarm shall be maintained with manual reset and audible alarm with silence button and ring back.

Alarm annunciators for the indicated conditions (all indication lights shall be LCD and LED type):

Indication/Function	Shutdown	Alarm	Status
– Overcrank, after 3 cranking periods of 10 sec. duration on 10 sec off crank cycles	X	X	
– Low engine temperatures (i.e. too low for reliable start)		X	
– High engine temperature prealarm (105%)	X		
– High engine temperature (115%)	X	X	
– Low lube oil pressure prealarm (80%)		X	
– Low lube oil pressure (40%)	X	X	
– Overspeed (105%)	X	X	
– Low fuel level (contact from level measurement unit)		X	
– Emergency generator supplying load			0
– Control switch not in automatic position		X	
– Battery low voltage		X	
– Low coolant level		X	
– Alternator over-voltage (110%)	X	X	
– Under speed (95%)	X	X	
– Generator output breaker open		X	
– Generator output breaker trip	X	X	
– Alternator under voltage (90%)	X	X	
– Remote emergency stop activated	X	X	
– High alternator temperature	X	X	
– Output breaker trip		X	

- .6 Alarms which would create nuisance signals during start-up and shutdown shall be supervised by suitable time delay contacts.

- .7 Provide minimum of five (5) spare windows for addition alarm annunciation.

- .8 Each status indication and alarm shall have a separate indicating light. Provide a common audible signal. For each alarm or shutdown, provide auxiliary contacts connected together in parallel for supervised wiring from a remote location. The alarm, and where applicable, shutdown circuits shall be powered from the engine start battery.

- .9 Provide provisions to extend annunciation of following conditions to a remote annunciator panel or the building fire alarm system:

- .1 Diesel generator running,
- .2 Diesel generator in alarm condition,
- .3 Engine start switch not in auto,
- .4 High engine temperature – pre-alarm,

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- .5 Low lube oil pressure,
 - .6 Low fuel level, and
 - .7 Battery low voltage.
- .10 Provide a summary alarm contact for all system shutdown and alarm condition listed in 2.11.
 - .11 The electronic controller shall be supplemented as necessary, with an auxiliary alarm panel to incorporate those alarms which are unavailable on the controller.
 - .12 Normal shutdown: The shutdown of the engine shall be affected automatically by the starting panel upon opening of auxiliary contacts on all automatic transfer switches. A timer shall keep the engine running for 1 - 30 minutes (adjustable) after signal from the transfer switch indicating restoration of normal power. After normal shutdown of the engine is initiated, its auxiliaries and controls shall be in the position to allow immediate restarting so that if the utility source power fails during rundown period, a normal automatic start sequence can be initiated.
 - .13 Provide auxiliary contacts to operate the following systems when the diesel starts:
 - .1 Operate generator room dampers.
 - .14 All wiring shall be suitably numbered and all internal components shall be identified. All connections shall be wired to identified terminals on terminal strips.

Part 3 Execution

3.1 SHIPPING

- .1 Protect emergency power system equipment during shipping.

3.2 INSTALLATION

- .1 Do complete the installation in accordance with the manufacturer / supplier instructions.
- .2 The generator shall be installed in walk-in enclosure as specified in Section 26 32 20. Generator factory testing shall be completed with the unit in the enclosure.

3.3 START-UP PREPARATION

- .1 Before starting the unit, carry out a thorough mechanical and electrical inspection of the equipment. Do the following checks and adjustments:
 - .1 Disconnect the battery cables from the batteries to prevent accidental starting.
 - .2 Turn the engine several revolutions by means of hand-barring devices to ensure that all parts are free and there are no obstructions to its running.
 - .3 Check engine/generator alignment readings to ensure they match readings attained at the time of manufacture.
 - .4 Check all fluid levels and top up as necessary. Pre-lubricate the engine and turbochargers as recommended by the engine manufacturer. Install drip pan beneath engine.
 - .5 Check that the cooling system antifreeze is effective to at least minus 40°C.
 - .6 Check belts for correct tension and adjust as necessary.

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- .7 Check and grease all grease points.
 - .8 Check and tighten properly all nuts, bolts, etc.
 - .9 Ensure all safety guards are in place and properly secured.
 - .10 Check all linkages for damage and freedom of movement.
 - .11 Check the fuel supply system for leakage.
 - .12 Ensure the fuel supply and fuel injection systems are properly primed.
 - .13 Check and tighten properly all electrical connections.
 - .14 Check starting battery electrolyte level specific gravity and for proper installation.
 - .15 Check battery charger for proper operation and adjust as necessary.
 - .16 Carry out generator winding insulation resistance test. If the reading is unacceptable, carry out recognized drying procedure. Do not start the unit until a satisfactory reading has been achieved.
 - .17 Check the jacket coolant heater for proper operation.

3.4 START-UP AND PERFORMANCE CHECK

- .1 On completion of the start-up preparations, take the following action:
 - .1 Have at hand, during initial start-up, the means for choking off the air supply to the engine air induction manifold in the event of the engine run away or other emergency.
 - .2 Reconnect the starting battery cables to the starting battery.
 - .3 Start the unit only in the presence of the Departmental Representative and allow to warm up. Stop the unit if abnormal conditions are encountered.
 - .4 Check for any leakage from the exhaust system, fuel system, cooling system and lubricating oil system.
 - .5 Adjust vibration isolators.
 - .6 Observe and ensure that the lubricating oil pressure and coolant temperatures are within limits and no harmful vibration or sounds are evident.
 - .7 Ensure that the voltage is within the operating parameters and that the automatic voltage regulator is operating correctly.
 - .8 Ensure that the manual voltage control is operating correctly.
 - .9 Ensure that the frequency is within the operating parameters and that the electronic governor is operating correctly.
 - .10 Check the engine air ventilation system for proper operation.
 - .11 Check the operation of all engine-mounted protective sensing devices and adjust as necessary.
 - .12 Check the phase sequence of the normal power supply and of the emergency power supply; ensure that they are in the same sequence.
 - .13 Check the operation of the electronic controller protection, transfer, timing, metering, and annunciator functions and adjust as necessary.
 - .14 Check the operation and calibration of the analog metering and adjust as necessary.
 - .15 Apply the electrical load, read the meters, and correlate these readings.

3.5 SITE TESTS

- .1 Provide written notification to the Departmental Representative ten working days in advance of the test date.
- .2 Repeat all factory tests on site for 12 hours with 100% load of prime rating. Provide fuel for testing and leave full tanks on acceptance.
- .3 Provide resistive load banks to suit and all required cabling and connections.
- .4 The manufacturer's site technician to check and verify installation at the job site, including all electrical and mechanical connections provided by the Contractor. Insure correct phase rotation of generator prior to final connection to system.
- .5 If necessary, adjustments shall be made to the control circuitry and tests shall be repeated until it is proven to the Departmental Representative that the system operates correctly. The system will not be accepted until all tests are successfully completed.
- .6 Provide all the required test equipment to conduct the acceptance tests. Refer to 1.8. Factory Witness Test.
- .7 Upon completion of load test, run the unit connected for a minimum period of two hours to show load carrying ability, stability of voltage and frequency, and satisfactory performance of the engine cooling system.
- .8 At the end of the test run, check the battery voltage to demonstrate the battery charger has returned to fully charged state.

3.6 COMMISSIONING INCLUDING RELATED AUXILIARY SYSTEMS

- .1 Commission complete power generating system. Allow two days minimum for testing and instruction to operating and maintenance staff.
- .2 The manufacturer's representative shall be prepared to remain on site until all defects that may occur in the installation are corrected. Include all costs in this contract.
- .3 Complete two (2) copies of data sheets. Data sheets to be signed by the supplier's field technician and the Departmental Representative.
- .4 Provide one (1) copy immediately to the Departmental Representative. Make additional copies as required and include one (1) copy in each Operating and Maintenance Manual.

END OF SECTION