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SOLICITATION AMENDMENT
MODIFICATION DE L'INVITATION

The referenced document is hereby revised; unless otherwise indicated, all other terms and conditions of the Solicitation remain the same.

Ce document est par la présente révisé; sauf indication contraire, les modalités de l'invitation demeurent les mêmes.

Comments - Commentaires

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Title - Sujet CCGS Griffon -VLE	
Solicitation No. - N° de l'invitation F7049-200157/A	**Amendment No. - N° modif.** 017
Client Reference No. - N° de référence du client F7049-200157	**Date** 2023-07-24
GETS Reference No. - N° de référence de SEAG PW-$$MD-029-29039	
File No. - N° de dossier 029md.F7049-200157	**CCC No./N° CCC - FMS No./N° VME**

Solicitation Closes - L'invitation prend fin
at - à 02:00 PM Eastern Daylight Saving Time EDT
on - le 2023-08-30 Heure Avancée de l'Est HAE

F.O.B. - F.A.B.
Plant-Usine: ☐ **Destination:** ☐ **Other-Autre:** ☐

Address Enquiries to: - Adresser toutes questions à: Jeddi, Loubna	**Buyer Id - Id de l'acheteur** 029md
Telephone No. - N° de téléphone (873) 455-3835 ( )	**FAX No. - N° de FAX** (819) -

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Signature **Date**

Canada

Solicitation Amendment # 17

This amendment is hereby raised :

1. **To include Questions and the Responses for the solicitation.**

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1. **Questions and the Responses for the solicitation.**

Q#1: SOW item 14.6

Reference is made to the following spec items in 14.6 Switchboards:

C.2.5	Switchboards must meet criteria 1-7 (i.e. Class C) of the standard IEC 61641 "Enclosed low- voltage switchgear and control gear assemblies – Guide for testing under conditions of arcing due to internal fault", or equivalent (i.e. CSA C22.2 No. 0.22-11 or ANSI/IEEE C37.20.7-2007 Type 2C standard for Arc-resistant functionality in compartments adjacent to the compartment in which the arc occurs).
C.2.6	Switchboard must meet the CSA C22.2 No. 0.22-11 or ANSI/IEEE C37.20.7-2007 Type 2B standard for maintaining Arc-resistant functionality in designated low-voltage compartments.
C.2.7	Switchboards must be designed with arc flash mitigation and protection, i.e., seals, increased housing strength and blast venting systems to direct internally released energy away from personnel working in proximity to the enclosures.

It is our determination that with the maximum bolted fault current of ~22kA and a maximum clearing time of 0.45s on any of the 460V busses (as indicated in the Griffon Arc Flash study in the bid package), there is no need for increased housing strength, blast venting, or any other extrinsic arc flash mitigation technics. For further support reference is made to the definition of an Arc flash hazard within CSA standard Z462 - Workplace electrical safety:

Arc flash hazard — a dangerous condition associated with the possible release of energy caused by an electric arc.

Notes:

(1) *An arc flash hazard can exist when energized electrical conductors or circuit parts are exposed or are within equipment in a guarded or enclosed condition, if a person is interacting with the equipment in a manner that could cause an electric arc. Under normal operating conditions, enclosed energized equipment that has been properly installed and maintained is not likely to pose an arc flash hazard.*

(2) *See Table 4 for examples of activities that could pose an arc flash hazard.*

(3) *See Clause 4.3.3 for arc flash hazard analysis information.*

The take-aways here are that well maintained, enclosed energized equipment is not likely to pose an arc flash hazard. But, you can also follow on to table four to see some different types of equipment and activities that could pose a hazard:

Table 4 (Continued)

Task(s) performed on energized equipment	Hazard/ risk category	Rubber insulating gloves required?	Insulated and insulating hand tools required?
600 V class motor control centres (MCCs)[2] (except as indicated) (continued)			
Work on control circuits with exposed energized electrical conductors and circuit parts 120 V or below, exposed	0	Y	Y
Work on control circuits with exposed energized electrical conductors and circuit parts greater than 120 V, exposed	2*	Y	Y
Insertion or removal of individual starter "buckets" from MCC[3]	4	Y	N
Application of safety grounds after voltage test	2*	Y	N
Removal of bolted covers (to expose bare energized electrical conductors and circuit parts)[3]	4	N	N
Opening of hinged covers (to expose bare energized electrical conductors and circuit parts)[3]	1	N	N
Work on exposed energized electrical conductors and circuit parts of utilization equipment fed directly by a branch circuit of the panelboard or switchboard	2*	Y	Y
600 V class switchgear (with power circuit breakers or fused switches)[4]			
Perform infrared thermography and other non-contact inspections outside the restricted approach boundary	2	N	N
CB or fused-switch operation with enclosure doors closed	0	N	N
Reading a panel meter while operating a meter switch	0	N	N
CB or fused-switch operation with enclosure doors open	1	N	N
Work on exposed energized electrical conductors and circuit parts, including voltage testing	2*	Y	Y
Work on control circuits with exposed energized electrical conductors and circuit parts 120 V or below, exposed	0	Y	Y
Work on control circuits with exposed energized electrical conductors and circuit parts greater than 120 V, exposed	2*	Y	Y
Insertion or removal (racking) of CBs from cubicles, doors open or closed	4	N	N
Application of safety grounds after voltage test	2*	Y	N
Removal of bolted covers (to expose bare energized electrical conductors and circuit parts)	4	N	N
Opening of hinged covers (to expose bare energized electrical conductors and circuit parts)	2	N	N

(Continued)

The Main and Emergency 460V SWBDs would fall into the category of 600V Class SWGR with power circuit breakers – note that as the Griffon's 460V is less than the 600V equipment in consideration, the hazard would also be less (less chance of arcing). You can see that the Hazard Risk category is 0 for operating disconnects, and breakers, and also reading meters while changing selector switch points. Circled in red above is a reference to note 4 of the table, which reads:

Notes:
[1]*Maximum of 25 kA short-circuit current available and maximum of 0.03 s (2 cycle) fault-clearing time.*
[2]*Maximum of 65 kA short-circuit current available and maximum of 0.03 s (2 cycle) fault-clearing time.*
[3]*Maximum of 42 kA short-circuit current available and maximum of 0.33 s (20 cycle) fault-clearing time.*
[4]*Maximum of 35 kA short-circuit current available and maximum of 0.5 s (30 cycle) fault-clearing time.*

This is letting you know that for well maintained, enclosed 600V SWGR with power Circuit Breakers, that have an available short circuit current of less than 35kA and a fault clearing time of less than half a second, the Hazard Risk Category is 0 for the highlighted activities. The recommended PPE in category 0 locations is:

Table 5
Protective clothing and personal protective equipment
(See Clauses 4.3.7.3.10, 4.3.7.3.15, and H.1 and Tables 4 and H.1.)

Hazard/risk category 0	
Protective clothing, non-melting (as specified in ASTM F 1506) or untreated natural fibre	Shirt (long sleeve) Pants (long)
Other Protective Equipment	Safety glasses or safety goggles (SR) Hearing protection (ear canal inserts) Leather gloves (AN) (Note 2)

Please keep all of the previous information in consideration when reading the following request:

We would propose rebuilding the Main and Emergency SWBDs in place, and properly enclosing them to achieve a Hazard Risk Category of 0. Reference is made to the document 10009718-CCGS GRIFFON-ELECTRICAL SURVEY page 1/75:

> In general, recommendations include the complete replacement (or rebuilding) of the main and emergency switchboards, 460V Essential MCC, the 460V Non-Essential MCC and the 460V Emergency MCC as well as a significant numbers of power circuit breakers. This equipment should be considered as long lead items.

The other option of complete replacement would be prohibitively difficult to achieve with the same footprint and maximizing re-use of healthy feeder cables. A rebuild of the SWBDs would address the issues identified in the survey, modernize the power management, control, and protective elements, as well as ensuring all the GOOD condition cables can be re-used, along with all the circa 2015 MCCBs to ensure maximum value for Canada. A rebuild would re-use the structure, and bus (with proper inspection and cleaning), and include new exterior steel and doors to properly provide ingress protection. Can the specification be amended to include the rebuild option.

A#1: Since the requirements that the switchboard must fit the existing footprint and must have arc-flash mitigation cannot be achieved together, the CCG has agreed that the existing switchboard cabinets and bus bars may be reused.

Delete the existing SOW item 14.6 – SWITCHBOARDS and replace it with the following SOW item 14.6 – SWITCHBOARDS_***REV 01.***

Edit is shown in bold italics and highlighted.

14.6 SWITCHBOARDS _ REV 01

14.6.A Identification

A.1 The Contractor must remove and replace the vessel's existing Main and Emergency Switchboards and all associated components. ***Alternately, the Contractor must strip down to the frames and overhaul the existing Main and Emergency Switchboards with new doors, breakers, equipment, safety features, and all associated components.*** The full requirement is to procure, supply, ***and*** install, ***or overhaul;*** commission; and test new RO approved, modern switchboards incorporating the best modern practices for control, metering, and protection.

A.2 The Contractor must procure the services of a Single System Supplier and Integrator (SSSI) that is tasked to work with the defined FSRs, to design and integrate the switchboards with a power management system, the updated ship service generator (SSG) OEM control systems, the Alarm and Monitoring System, the Bow Thruster Control System, and the Propulsion Control System.

A.3 The work of this SOW item must be carried out in conjunction with the following SOW items:

10.12 – Emergency Generator;
11.28 – Hull Cut-Outs;
12.23 – Dock and Sea Trials;
13.1 – Ship Service Generator;
14.2 – Motor Control Centres;
14.10 – Megger Test;
14.11 – Electrical Studies;
14.13 – Shore Power System;
19.1 – Propulsion Control System;
19.2 – Bow Thruster Control; and
19.3 – Alarm and Monitoring System.

14.6.B References

B.1 Equipment Data

B.1.1 Main Switchboard Bus Bar details:

Main Switchboard 460 V Bus Bar	
Model:	ITE HE Series
Main Bus Bar Size	3C - 4" x ¼" copper per phase

Rated at:	25,000 A, 480 V
Estimated Short Circuit:	13,171 A
Main Switchboard 240 V Bus Bar	
Model:	ITE EF Series
Main Bus Bar Size:	3C - 1" x ¼" copper per phase
Rated at:	18,000 A, 240 V
Estimated Short Circuit:	7,508 A
Main Switchboard 120 V Bus-Bar	
Model:	ITE EF Series
Main Bus Bar Size:	3C – 1-1/2" x ¼" copper per phase
Rated at:	18,000 A, 240 V
Estimated Short Circuit:	11,658 A

B.1.2 Emergency Switchboard Bus Bar details:

Emergency Switchboard 460 V Bus Bar	
Model:	ITE HF Series
Main Bus Bar Size:	3C – 2" x ¼" copper per phase
Rated at:	25,000 A 480 V
Estimated Short Circuit:	12,333 A
Emergency Switchboard 120 V Bus Bar	
Model:	ITE EF Series
Main Bus Bar Size:	3C – 1-1/2" x ¼" copper per phase
Rated at:	18,000 A 240 V
Estimated Short Circuit:	7,935 A

B.1.3 List of Molded Case Circuit Breakers over 100 kW:

Breaker	Description	Identification & Location	Frame Size	UV Trip	Serial #
1	Steering Gear Feeder #1	P-1 Main Switchboard Fr 2	ABB – SACE TMAX T4L-250	No	BF7A011563

2	120 V Essential Via XFMR Bank	P-3 Main Switchboard Fr 1	ABB – SACE TMAX T5L-400	No	BF7A011561
3	FWD Deck Machinery Power Panel	NP-4 Main Switchboard Fr 6	ABB – SACE TMAX T5L-400	No	BF7A011562
4	AFT Deck Machinery Power Panel	NP-5 Main Switchboard Fr 6	ABB – SACE TMAX T5L-400	No	BF7A011560
5	Buoy Crane HPU	NP-6 Main Switchboard Fr 6	ABB – SACE TMAX T5L-400	No	BF7A011563
6	460 V Power Panel Forward	NP-7 Main Switchboard Fr 6	ABB – SACE TMAX T5L-400	No	BF7A011574
7	240 V Non-Essential Bus Via XFMR Bank	NP-3 Main Switchboard Fr 6	ABB – SACE TMAX T5L-400	No	BF7A011564
8	240 V Galley Power Panel	NP-31 Main Switchboard Fr 7	ABB – SACE TMAX T4L-250	Yes	BC11206110
9	Spare	NP-1 Main Switchboard Fr 6	N/A	N/A	N/A
10	Spare	NP-8 Main Switchboard Fr 6	N/A	N/A	N/A
11	Spare	P-4 Main Switchboard Fr 1	N/A	N/A	N/A
12	Spare	P-5 Main Switchboard Fr 2	N/A	N/A	N/A
13	Steering Gear Feeder #2	EP-1 Emer Switchboard Fr 1	ABB – SACE TMAX T4L-250	No	BF71228375
14	Emer Bus #1	EP-9 Emer Switchboard Fr 1	ABB – SACE TMAX T4L-250	No	BF7A011570
15	Emer Bus #2	EP-10 Emer Switchboard Fr 1	ABB – SACE TMAX T4L-250	No	BF7A011567

B.1.4 List of Draw Out Circuit Breakers

Breaker	Description	Identification & Location	Type	UV Trip	Serial #
1	Emergency Generator	EG2 Emergency Switchboard	ITE K-600 (upgraded)	Yes	46732-M12-1-7A
2	Ship Service Bus Tie In Breaker (Upper Tie)	EBT-2 Emergency Switchboard	ITE K-600 (upgraded)	Yes	410704A-01095
3	Emergency MCC	EP-2 Emergency Switchboard	ITE K-600 Manual (upgraded)	No	93188
4	SSG #1	SSG-1 Main Switchboard FR 1	ITE K-600 (upgraded)	Yes	93186

5	SSG #2	SSG-2 Main Switchboard FR 2	ITE K-600 (upgraded)	Yes	93179
6	SSG #3	SSG-3 Main Switchboard FR 3	ITE K-600 (upgraded)	Yes	93177
7	Shore Supply	SP Main Switchboard FR 4	ITE K-600 (upgraded)	Yes	93180
8	Essential MCC	P-2 P504 Main Switchboard FR 5	ITE K-600 Manual (upgraded)	Yes	93185
9	Load Relief Breaker	LRB P502 Main Switchboard FR 5	ITE K-1600	Yes	93742
10	Non-Essential MCC	NP-2 P505 Main Switchboard FR 4	ITE K-600 Manual	Yes	93184
11	Emergency Bus Tie (Lower Tie)	EBT P503 Main Switchboard FR 3	ITE K-600	No	93182
12	Spare K600 #1 (set as spare EGen Breaker)	Stored in XFMR Room	ITE K-600 (upgraded)	Yes	93178
13	Spare K600 #2 (Set as spare Upper Tie)	Stored in XFMR Room	ITE K-600	Yes	99662
14	Bow Thruster	BT Main Switchboard FR 3 (backside)	Schneider Masterpact NT08 H1	No	9092029-001
15	Spare K1600	Upper Motor Room	ITE K-1600	No	ITE 1600 AF

NOTE: (Upgraded) means rebuilt and fitted with electronic trip unit.

B.2 Drawings and Documents

B.2.1 The following drawings must be considered as Guidance Drawings only, as defined in the G.1.7 Drawings section of the General Notes.

Drawing Number	Drawing Title
732905	CCGS Griffon General Arrangement – 2 sheets; Sheet 1 – Rev K, Sheet 2 – Rev J
766401	CCGS Griffon Electrical Plant Schematic Wiring Diagram
521-822-001	Ship Service Switchboard Arrangement (2003 Upgrades) – 9 Sheets
D-680196	Arrangement, SS Swbd (Legacy)
C-680337	Elementary Diagram, SS Swbd – 10 Sheets (Legacy)
D-680333	Wiring Diagrams, SS Swbd – 8 Sheets (Legacy)
A-6802896	SS Swbd, Bill of Materials – 23 Sheets (Legacy)
09-0625-001	Emergency Switchboard Schematic Diagram (2009 Upgrades) – 6 Sheets
D-680195	Arrangement, Emer. Swbd – 2 Sheets (Legacy)
D-680339	Connection Diagrams, Emer. Swbd – 4 Sheets (Legacy)
A-6802990	Emer. Swbd, Bill of Materials – 17 Sheets (Legacy)
P032200-00	Elementary Drawing – Propulsion Control System by TECHSOL (sheets D include MCR Mimic lamps)

G05-RSTOPSCH Rev 2 2017	CCGS Griffon – Remote Stop Schematic
Document Number	**Document Title**
10009718	CCGS Griffon – Electrical Survey, Rev 1.2 (31 Aug 2022)
10009718 Appen. A	CCGS Griffon – Master Breaker List
10009866	CCGS Griffon – Arc Flash Study Rev.2.PDF
10009866	CCGS Griffon (ETAP) Power Model_20220428.zip
N/A	2003 Griffon Short Circuit Current Calculations
N/A	2003 Griffon Switchboard Bus Bar Electrical Forces Calculation
93001-01	CCGS Griffon – A-Frame Vibration Analysis for WSP
N/A	Interspec CCGS Griffon 2024-2025 VLE – Paint Specification

B.3 Regulations and Standards

B.3.1 The Contractor must ensure all work completed in this SOW item complies with the following Standards and Regulations and must take into account other applicable Federal/Provincial Regulations and/or Standards not specifically listed. It is the responsibility of the Contractor to ensure that all requirements specified in the General Notes (GN) are taken into consideration and applied to this SOW item's defined Work requirements. This SOW item may mention certain specific requirements from the General Notes. However, this does not exempt the Contractor from considering and including any other references from the GN that should also be applied and included for this SOW item's Work. ALL requirements must be assessed and included, when applicable, for the Work described in this SOW item:

	Title	**Supplied By:**
FSM Procedures		
CCG/5737	Fleet Safety Manual	CCG
7.B.4	Hotwork	CCG
7.B.5	Lockout and Tagout	CCG
7.B.6	Electrical Safety - Working on Energized Electrical Conductors or Circuit Parts	CCG
Publications		
EKME/MGCE #4221535	CCG Technical Bulletin 2021-03 – Routine maintenance of circuit breakers and their protective relay systems	CCG
CCG TB 07-2021	CCG Technical Bulletin 07-2021 – CCG Vessel Thermography Inspections	CCG
IEEE C37.20.7	***IEEE Guide for Testing Switchgear Rated Up to 52 kV for Internal Arcing Faults***	***Contractor***
Standards		
TP 127	Ships Electrical Standards	Contractor
IEEE-45	Recommended Practice for Electric Installations on Shipboard	Contractor
IEEE 1584	Guide for Performing Arc-Flash Hazard Calculations	Contractor

IEC 61641	Enclosed low-voltage switchgear and control assemblies – Guide for testing under conditions of arcing due to internal fault	Contractor
IEEE C37.20.7	Guide for Testing Switchgear Rated Up to 52 kV for Internal Arcing Faults	Contractor
IEC 61363	***IEC 61363-1, Electrical Installations of Ships and Mobile fixed Offshore Units***	***Contractor***
CSA C22.2 No. 022 - 2011	Evaluation methods for arc resistance ratings of enclosed electrical equipment	Contractor
CSA Z462 – most recent edition	***Workplace Electrical Safety***	***Contractor***
UL 845	***Standard for Safety Motor Control Centers***	***Contractor***
Regulations		
SOR/2010-120	Maritime Occupational Health and Safety	Contractor
Canada Labour Code	Canada Labour Code (R.S.C., 1985, c. L-2)	Contractor
OHSA	Occupational Health and Safety Act, R.S.O. 1990, c. O.1 WebLink: OHSA or provincial equivalent	Contractor

B.4 FSR Requirement

B.4.1 In conjunction with the SOW items identified in Para. A.3 the Contractor must provide the services of a qualified SSSI, who must be responsible for the overall design, supply, coordination, and integration of all of the requirements as defined within this SOW item.

B.4.2 The Contractor must demonstrate that the selected SSSI has the relevant experience, ability, and capacity to perform this work.

B.4.3 The same SSSI must be used for this section and section 14.2 – Motor Control Centers.

B.4.4 The SSSI must ***overhaul the existing switchboards or*** supply and integrate new Main and Emergency Switchboards, buses, associated ancillary systems, control systems, and other related components and equipment through a single supplier (wherever possible). The SSSI must be responsible for the full system design, hardware supply, integration of new systems, and the integration of new systems with the retained existing equipment and systems.

B.4.5 The SSSI must ensure the coordination and integration of the requirements as defined in the SOWs identified in Para. A.3.

B.4.6 The Contractor, through the SSSI, must provide any parts or devices necessary for the safe and fully functional operation of the overall switchboards and control packages defined in the individual SOW items. The SSSI must provide all integration and control functionality required for efficient and correct operation of these systems whether or not such devices or integration functions are specifically indicated through the applicable specifications.

B.4.7 The SSSI must also provide the services of an authorized OEM FSRs for the electrical equipment and components supplied by the SSSI and/or Contractor, to oversee the full installation as well as the related commissioning, testing, certification, and provide the training required to the vessel's operating personnel, as detailed under the training section of this SOW item.

B.4.8 The SSSI ~~***will***~~ ***must*** act as the commissioning lead for this project. The SSSI must be responsible for designing, conducting, and overseeing a full range of Dock and Sea Trials that includes all functions of the switchboards, power management systems, integration with other vessel systems, and verification of all circuits and safeties. The SSSI and FSRs must attend the vessel's Dock Trials and Sea trials and prove all the power management functions in an operating condition and under full load.

B.4.9 The Contractor must employ the services of a Toromont Power System Engineer (FSR) for the engineering design, supply, and installation of the Caterpillar OEM controllers with Allen Bradley HMI. The Toromont Power Systems FSR must provide engineering services to design, update drawings, supply, and integration of the new SSG Caterpillar (OEM) controllers. The controllers will include sensors, governors, load control, and load shedding systems into the new switchboards. The FSR for engineering design and integration of the SSG controllers is:

Toromont Power Systems
Chris McMullen
Retrofit Specialist
T: 705-238-0722
E: cmcmullen@toromont.com

The Contractor must provide an allowance of $10,000 in its bid to cover the cost of the FSR, including any living expenses (accommodations, meals, transportation, etc.). Upon completion of work, the Contractor must submit the FSR's final invoice, along with copies of all supporting documentation attesting to the actual cost(s). The $10,000 allowance will be adjusted up or down using a PWGSC 1379 Work Arising or New Work form, as required.

B.4.10 The Contractor must employ the services of JMP Solutions (FSR) for the integration of all systems described in this SOW with the Alarm and Monitoring System (AMS). The FSR contact information is:

JMP Solutions (Burlington)
Ken Pottruff
Business Development Manager
T: 905-464-2428
E: Ken.Pottruff@jmpsolutions.com

The Contractor must provide an allowance of $10,000 in its bid to cover the cost of the FSR, including any living expenses (accommodations, meals, transportation, etc.). Upon

completion of work, the Contractor must submit the FSR's final invoice, along with copies of all supporting documentation attesting to the actual cost(s). The $10,000 allowance will be adjusted up or down using a PWGSC 1379 Work Arising or New Work form, as required.

B.4.11 The Contractor must employ the services of Kongsberg Marine (FSR) for the integration of all systems described in this SOW item with the Bow Thruster Control System. The FSR contact information is:

Kongsberg Maritime CM Canada Ltd.
Ted Gurr
Head of Aftermarket Sales
T: 902-488-4153
E: ted.gurr@km.kongsberg.com

The Contractor must provide an allowance of $10,000 in its bid to cover the cost of the FSR, including any living expenses (accommodations, meals, transportation, etc.). Upon completion of work, the Contractor must submit the FSR's final invoice, along with copies of all supporting documentation attesting to the actual cost(s). The $10,000 allowance will be adjusted up or down using a PWGSC 1379 Work Arising or New Work form, as required.

B.4.12 The Contractor must employ the services of AKA Energy Systems (FSR) for the integration of all systems described in this SOW item with the Propulsion Control Systems. The FSR contact information is:

AKA Energy Systems
Tanuj Sahny
Project Manager
T: 902-620-4882, M: 782-377-1679
E: tjsahny@aka-group.com

The Contractor must provide an allowance of $10,000 in its bid to cover the cost of the FSR, including any living expenses (accommodations, meals, transportation, etc.). Upon completion of work, the Contractor must submit the FSR's final invoice, along with copies of all supporting documentation attesting to the actual cost(s). The $10,000 allowance will be adjusted up or down using a PWGSC 1379 Work Arising or New Work form, as required.

B.4.13 ***The SSSI must ensure that the new or overhauled switchboards design, construction, and testing are approved and accepted by a Recognized Organization as defined by TCMS under the delegated statutory inspection program (DSIP). The current RO responsible for inspecting the Griffon is the American Bureau of Shipping (ABS).***

14.6.C Statement of Work

C.1 General

C.1.1 The design, installation, construction, and equipment for both the Main and Emergency Switchboards must comply with TP 127, Transport Canada Marine Safety (TCMS) and RO requirements.

C.1.2 The Contractor must ensure and confirm that all equipment supplied ***and overhauled*** is in accordance with TCMS and RO electrical requirements. All switchboards and components supplied must have RO type approval for their application in this system.

C.1.3 The Contractor must ensure that the new Main and Emergency Switchboards are seamlessly integrated together and with the existing shipboard electrical and electronic systems. Where communication links are used in the design (e.g., for communication of metering/alarm/monitoring data to an external system) the bus type and communication protocol must not be proprietary.

C.1.4 The broad scope of services to be provided by the Contractor are as follows:

1. Active interaction with the SSSI, FSRs, and the suppliers of all electrical components needed for this SOW item to ensure a reliable and safe electrical system, complete with its associated controls and monitoring systems.
2. Ensuring that the preliminary and detailed design drawings (coordination level drawings) and the documents for finalization of both the Main and Emergency Switchboard layout/arrangements, are provided to the RO for review and approval. Copies of the same documents must also be provided to the TA for review and acceptance. Final versions of the drawing (as-fitted) must be approved and stamped by the RO, and copies provided to the TA as detailed in the Documents section.
3. Ensuring that ~~the~~ ***if*** new switchboards being installed, ***that they*** are a type approved by both "certifying authorities" as defined by TP 127, and the RO. Proof of type approvals must be provided to the TA prior to the purchase and supply of the new switchboards.
4. Schedule, coordinate, and lead progress and development meetings between the SSSI, FSRs, RO, TA, and Contracting Authority (CA). The minimum scheduling of meetings will be monthly. Additional meetings may be scheduled as required throughout the contracting period.
5. Overall responsibility for the installation and correct functionality of the new ***or overhauled*** switchboards at the completion of the work period.

C.1.5 Prior to commencing the defined work, the Contractor must arrange to have a full Electrical Load Analysis of the ship service electrical plant. The studies must include Short Circuit Current Calculations, Switchboard Bus Bar Electrical Force Calculations, Breaker Coordination Study, and Arc Flash Study. The results of these calculations and studies and calculations must be compared with previous calculations and studies performed by both Canal Marine & Industries Inc. to verify and ensure that the proposed new switchboards ***or the proposed overhauled switchboards*** are designed to the requirements of the electrical

load analysis and will provide the level of equipment protection as defined by TCMS regulations and the RO requirements. A copy of any available previous studies will be provided to the Contractor by the TA. A copy of the Contractor's Electrical Load Analysis including the aforementioned studies and comparison results must be provided to the SSSI, the RO, and the TA.

C.1.6 The Contractor must survey the existing switchboards and confirm the switchboard footprints, bus bar details, power cable entries, control cable entries, service access, and cable details (sizes/terminations).

C.1.7 Both the Main and Emergency Switchboards must be designed for efficient and functional power control and distribution. As a minimum, but not limited to, this must include the following:

1. Control and protection of power requirements of the vessel;
2. Control of the SSGs;
3. Functionality for operating the three (3) SSGs in parallel;
4. Functionality for operating the Emergency Generator (EGen) on the Emergency bus alone (from the EGen Room and the Machinery Control Room (MCR));
5. Functionality for operating the EGen on the entire bus (Main and Emergency together);
6. Functionality for operating the entire bus system on shore power;
7. Functionality for the transfer of power between available sources;
8. Fit the footprint of the existing switchboards, and
9. Integrated power management (i.e., auto start/online) and preferential load control.

C.1.8 ~~The n~~ ***New or Overhauled*** switchboards must, at a minimum, but not be limited to, be 100% compatible with, and designed, for the existing electrical consumers of the vessel and that all breakers being supplied, as part of the design, must be new, be of the latest technology, and are like-for-like replacements with regards to the number and ***approximate*** locations as currently found in the existing switchboards. ***Layout changes that improve the functionality of the system will be considered by the TA during the design phase.***

C.1.9 ~~The n~~ ***New or Overhauled*** switchboards must maintain, at a minimum, the existing spare capacity in way of spare power distribution breakers for future use and expansion.

C.1.10 The SSG controls and associated switchboard wiring must be configured to provide for parallel operations. The switchboard must have at least three (3) modes of operation:

1. Local/Manual: where control is conducted at the switchboard by an operator;
2. Automatic: where certain power management decisions (e.g., blackout recovery, load dependent starts etc.) are determined by the automated power management system, and
3. Semiautomatic: where all automatic functions and protections are in place but must be initiated by the operator.

C.1.11 After the SSSI has completed the new switchboard builds at their facility, a Factory Acceptance Test (FAT) must be performed to receive RO approvals and to prove the operability/capability of the new switchboards to meet their performance criteria. At a minimum this FAT test must be witnessed by the attending AR. A full test report must be provided by the SSSI and must be signed off by the attending AR and copies must be provided to CCG.

C.1.12 CCG reserves the right to provide personnel to visit the SSSI's facilities during the fabrication phase of the switchboards as well as attending the FATs, at the SSSI's facilities. These visits will be at CCG's expense. For such cases, the Contractor must provide at least one hundred and twenty (120) days notice for trials at their premises should these facilities be abroad and sixty (60) days notice for any trials at SSSI's premises in North America.

C.1.13 ***For overhauled switchboards, a simulation program must be performed to prove operability/capability of the new design to meet their performance criteria and to receive RO approvals. After installation, a Site Acceptance Test (SAT) must be performed to receive RO approvals and to prove operability/capability of the new switchboards to meet their performance criteria. At a minimum the simulation and SAT test must be witnessed by the attending AR and TA. Full test reports must be provided by the SSSI and must be signed off by the attending AR and copies must be provided to CCG.***

C.1.14 ***CCG reserves the right to provide personnel to visit the SSSI's facilities during the design and overhaul phase of the switchboards as well as attending the simulations at the SSSI's facilities. These visits will be at CCG's expense. For such cases, the Contractor must provide at least one hundred and twenty (120) days notice for trials at their premises should these facilities be abroad and sixty (60) days notice for any trials at SSSI's premises in North America.***

C.2 Main And Emergency Switchboard Requirements

C.2.1 The existing Main and Emergency Switchboards must be removed and replaced with new, ***or they must be modified by the Contractor to meet the requirements detailed in this specification.***

C.2.2 Switchboards must meet or exceed all the construction, installation, location, design, and equipment requirements for "Switchboards Other Than Propulsion Control Panels" as detailed in TP 127.

C.2.3 Switchboards must be of a dead front type, have suitable drip shields above, have closed backs (not open mesh screens), and have a minimum IP 23 protection. Cable penetrations through the bottom of the switchboards must at a minimum meet the fire protection rating of the deck they are penetrating. ***The switchboards enclosures must be designed and constructed to meet the following requirements:***

a. *Constructed for indoor use (constructed for indoor or outdoor use is also acceptable)*

b. *Provide a degree of protection to personnel against access to hazardous parts*

c. *Provide a degree of protection against ingress of solid foreign objects.*

d. *Both items b) and c) OR Protection from particles or objects larger than 12.5mm in diameter.*

e. *Provide a degree of protection with respect to harmful affects on the equipment due to ingress of water (dripping and light splashing)*

f. *Item e) OR Protection against vertically dripping water when the item is tilted at 15 degrees from its normal position.*

g. *Rear access panels must be new construction, and must suitably bolted and not hinged.*

h. *All doors must be sealed or gasketed.*

i. *Panels shall be of substantial construction to prevent vibration and hinged panels and doors of dead front switchboards shall be provided with positioners and stops.*

j. *Front access panels to switchboards and electrical distribution panels must be new construction and have keyed hinged doors requiring a specialized tool to open. All switchboard sections must be equipped with doors that accept padlocks to restrict access to unauthorized personnel.*

k. *Within the front panels, there must be barrier panels bolted in place. The barrier panels must compartmentalize, isolate, shield and protect personnel from the higher voltage systems while the front panels are opened. Existing barrier panels requiring modifications by expanding openings may be reused provided that the Contractor demonstrates in the engineering phase that they have sufficient strength. Existing barrier panels that require modification by closing existing openings must be disposed of and replaced with new barrier panels. Insert patches must not be used.*

l. *Non-conducting barriers (i.e. insulated fiberboard) must be installed at each module frame space to create segregation. Bus bars must pass freely through these barriers.*

m. *Temperature rises and total temperatures at maximum rated current shall be in accordance with IEEE C37.20.1, Clause 5.5. Heat generated by the power cables shall be included in the temperature rises.*

n. *Hose testing during SAT is not permitted.*

C.2.4 ~~The Emergency Switchboard, in addition to the aforementioned requirements, must have a closed back panel with sufficient IP protection that prevents the ingress of blowing rain and/or snow. As currently fitted, when the EGen is running and the EGen Room starboard side air louvres are open, rain/snow enters the existing emergency switchboard panels and contacts the bus bars. This condition must be corrected during this upgrade.~~ ***As well as meeting the design requirements above, the Emergency Switchboard enclosures must be designed to meet the additional requirements listed here:***

a. Provide a degree of protection with respect to harmful affects on the equipment due to ingress of water (rain, sleet, snow) OR;

b. Protection against water spray at any angle up to 60 degrees from vertical, whether that spray is oscillating or has a counterbalanced shield.

C.2.5 ~~Switchboards must meet criteria 1-7 (i.e. Class C) of the standard IEC 61641 "Enclosed low-voltage switchgear and control gear assemblies – Guide for testing under conditions of arcing due to internal fault", or equivalent (i.e. CSA C22.2 No. 0.22-11 or ANSI/IEEE C37.20.7-2007 Type 2C standard for Arc-resistant functionality in compartments adjacent to the compartment in which the arc occurs).~~

C.2.6 ~~Switchboard must meet the CSA C22.2 No. 0.22-11 or ANSI/IEEE C37.20.7-2007 Type 2B standard for maintaining Arc resistant functionality in designated low voltage compartments.~~

C.2.7 ~~Switchboards must be designed with arc flash mitigation and protection, i.e., seals, increased housing strength and blast venting systems to direct internally released energy away from personnel working in proximity to the enclosures.~~

C.2.8 Switchboards and electrical distribution panels must have insulating barriers around live current carrying buses in the form of bus bar insulation, where possible, and insulating fire rated polycarbonate barriers to reduce the possibility of accidental contact with live current carrying conductors. ***New switchboards must come with isolating barriers to separate each frame section. Overhauled switchboard must have isolating barriers installed to separate each frame section of the switchboards.***

C.2.9 ~~Switchboards and electrical distribution panels must have keyed doors requiring a specialized tool to open. All switchboard sections must be equipped with doors that accept padlocks to restrict access to unauthorized personnel.~~

C.2.10 Switchboards must be equipped with RO approved infrared (IR) windows for the purpose of conducting live thermal scans of the switchboard main connections and bus work together with the generator connections. IR windows must be sized and located to allow for useful inspections of the required equipment. IR windows must be clear unobstructed crystal infrared transparent window assemblies that are suited for quantitative measurement based on thermography and must be certified for a marine environment by an RO, have an ingress protection (IP) rating equal to IP 65 or better, rated to 200°C or greater, have a broadband transmission allowing both visible spectrum wavelengths and the infrared wavelengths to transmit through the lenses, and have a permanently attached hinged solid metal impact and load resistant cover secured or opened for viewing access by nonremovable fasteners. ***The Contractor must refer to Canadian Coast Guard Technical Bulletin TB 07-2021 "CCG Vessel Thermography" Annex II for design and installation requirements of the IR windows. The Contractor must include pricing for the complete supply and installation of twenty (20) each of 3 inch and twenty (20) each of 4 inch IR windows. The Contractor must provide a price per unit to allow adjustment based on actual use. The Contractor must coordinate with the TA to determine the exact number and location of the IR windows required to meet the observation requirements detailed in TB 07-2021. The final cost will be adjusted by PWGSC 1379 based on the final requirement***.

C.2.11 ***Overhauled switchboards (or*** New switchboards***, if provided)*** must meet or exceed the capacity and functionality of the existing Main and Emergency Switchboards. ***The Contractor must demonstrate to the TA and RO (ABS) in the engineering and design phases that the switchboards will pose no Arc Flash Hazard Risk (i.e. no Arc Flash PPE required) as defined in CSA Z462 - latest edition for the operators performing the following functions:***

a. Reading a panel meter while operating a meter switch.

b. Normal operation of a circuit breaker (CB), switch, contactor, or starter

c. Voltage testing on individual battery cells or individual multi-cell units.

d. Removal or installation of covers for equipment such as wireways, junction boxes, and cable trays that does not expose bare, energized electrical conductors, and circuit parts.

e. Removal of battery intercell connector covers.

f. Perform infrared thermography and other non-contact inspections outside the restricted boundary approach. This activity does not include opening of doors or covers.

g. Work on control circuits with exposed energized conductors and circuit parts, 120V or below without any other exposed energized equipment over 120V including opening of hinged covers to gain access.

h. Arc-resistant switchgear Type 1 or 2 (for clearing times of <0.5 s with a prospective fault current not to exceed the arc-resistant rating of the equipment) and metal enclosed interrupter switchgear, fused or unfused or arc resistant type construction, tested in accordance with CSA C22.2 No. 022 or IEEE C37.20.7:

- ***Insertion or removal (racking) of CBs from cubicles;***
- ***Insertion or removal (racking) of ground and test device; or***
- ***Insertion or removal (racking) of voltage transformers on or off the bus***

C.2.12 The power distribution system must replicate the existing power distribution schematic as closely as possible.

C.2.13 New switchboards***, if provided,*** must fit within the space ***currently*** occupied by the existing Main and Emergency Switchboards.

C.2.14 The power distribution system must reuse, where possible, existing power conductors and distribution cabling as fitted. Cables being reused must be visually inspected and insulation resistance measured (i.e., Megger) before reuse.

C.2.15 The Contractor must provide a report of cables removed, cables reused, and new cables installed. The report must identify cables, include the condition of the reused cabling (visual, insulation resistance/megger), and details of any new cables used.

C.2.16 All electromechanical and electronic equipment in the Main and Emergency Switchboards dating from the original construction and the 2003 VLE must be renewed.

C.2.17 The Contractor ~~must~~ ***may*** reuse, where possible and at the recommendation of the SSSI, all power distribution molded case circuit breakers over 100 kW (ABB SACE TMAX style) that were renewed in 2015. Otherwise, the Contractor must renew all power distribution MCCBs over 100 kW.

C.2.18 The Contractor must renew all power distribution MCCBs equal to or under 100 kW. These are original to the vessel.

C.2.19 The Contractor must simplify the switchboard in accordance with best modern practices for control, metering, and protection.

C.2.20 The Contractor must incorporate new power management load management and controls through the use of modern electronically controlled breakers. (i.e., under-voltage trips,

selective load shedding, power limitation of selected equipment, and/or auto start-online generator control).

C.2.21 The Contractor must integrate the new Caterpillar OEM DCU/HMI generator controls.

NOTE: Note the distance between bus bar poles and bus bar to ground differs between Class societies (LR/ABS) and TP 127 **Table 9-2.** The Contractor is to ensure that the switchboards meet the higher standard, which is TP 127.

C.3 Draw Out Circuit Breaker Renewals

C.3.1 The switchboards must be fitted with new RO approved draw out style circuit breakers to replace those in of paragraph B.1.4

C.3.2 List of Draw Out Circuit **Breakers**.

C.3.3 The replacement draw out circuit breakers must all be from the same manufacturer and of the same style. Where possible, a single frame size must be used to cover a range of settings. This will limit the total number of breaker sizes in use and optimize the number of spares required.

C.3.4 The draw out circuit breakers must be mounted to the front of the switchboards. Generator incomer breakers must be positioned directly below the generator gauges and controls. The Bow Thruster breaker must be relocated from the back to the front of the Main Switchboard.

C.3.5 Draw out circuit breakers must have the following characteristics:

1. Be automatic type (motorized stored energy/spring charge mechanism). Mechanisms that utilize motorized actuators in lieu of manual lever mechanisms (i.e., where a motor acts on the lever mechanism) are not acceptable;
2. Be suitable for protection at the maximum fault current as calculated within the Short Circuit and Coordination Study;
3. Have adjustable electronic trip units suitable to match or exceed the existing breaker trip curves. Breakers must be able to integrate with a load management system for automatic control of opening/closing when required;
4. Provide overload and short circuit protection for their associated equipment, as determined by the short circuit and coordination study;
5. Withstand the presence of vibrations that are persistent and have a high amplitude in a specific frequency range. See Griffon Vibration Analysis for hull frequency measurements;
6. Shock resistance that meets or exceeds 1.4G vertical, 1.0G transverse, and 1.0G longitudinal forces;

7. Suitable for high temperature and humidity range in a saline environment. Operating temperature range to meet or exceed -25 °C to +70 °C, and storage temperature to meet or exceed -40 °C to +70 °C. Temperature rise must be limited to 50 °C;
8. Safety features to include key lock or padlock in open position; key lock or padlock in racked-in, tested, and racked-out positions;
9. Under voltage release as required by breaker function and location;
10. Manual open/closing release on the breakers;
11. Electronic open/closing release;
12. Rewind motor for springs;
13. Visual indicators on the breakers for breaker operating state (open, closed, ready to close i.e., charged). Breaker status must be viewable from a position in front of the switchboard with the doors closed. In cases where the breaker status is not visible mechanically (i.e., visible lever), pilot lights can be utilized instead.
14. Output for breaker operating state (i.e., open, closed, ready to close)
15. Each automatic breaker control circuit must include an operation counter. This must be of an electromechanical type (not purely electronic).

C.3.6 The Contractor must supply and configure a total of four (4) spare draw out circuit breakers. Sizes must be ranged to cover all breaker locations. The spare breakers provided must be identified and labelled as spares for use, have their trip settings pre-set to match the trip curves of the following locations. Trip curves will be determined in 14.11 Electrical Studies. The preferred assignment of the spare breakers is:

1. Load Relief breaker;
2. Bow Thruster breaker;
3. SSG/EGen Breaker, and
4. Ship Service Tie (Upper Tie).

C.3.7 The spare breakers must have the functionality for settings to be field modified by vessel personnel for emergency use in all remaining locations. The Contractor must provide the TA with written instructions for modifying the settings for use in all locations. This must include instructions for removing and bypassing/disabling the UV trip functions if not they are not required at a particular location.

C.3.8 The replacement breakers must be new, modern replacements that have OEM manufacturer support and spares expected to be available for a minimum of twenty (20) years past the completion of the VLE.

C.3.9 The replacement breakers must, at a minimum, maintain the functionality and capacity of the existing circuit breakers with respect to operation, frame size, accessibility for maintenance, and under-voltage (UV) operation.

C.3.10 The must replacement breakers provided must be capable of being controlled from the vessel's new power management system for preferential load control.

C.3.11 For each breaker (installed and spare), the Contractor must provide the TA with documentation indicating the following information:

1. Breaker Data: date manufactured, manufacturer, model, frame, serial number, and location on vessel;
2. Trip Unit data: secondary injection ratings, manufacturer, model, and serial number;
3. Trip Unit Setting: long delay pickup and delay, short delay pickup and time, and ground (instantaneous) pickup and time;
4. Insulation and contact resistance readings (for baseline reference against future inspections);
5. Electrical Data: voltage, full load current, and any integrated CT ratios;
6. Breaker trip curve, approved and stamped by the RO;
7. All additional information regarding settings, UV trips, or preferential trip controls;
8. The Contractor must demonstrate and document the trip function settings of all breakers (installed and spares) by primary injection on all three phases;
9. The trip function settings must also demonstrate and document the trip function settings of all breakers by secondary injection on all three phases. When secondary injection is performed, the Contractor must provide the secondary injection current values, the current transformer ratio, and the corresponding calculated primary current, and
10. Verification of the breaker trip settings must be demonstrated by the Contractor and witnessed by the TA and RO at the Contractor's facility. The RO must approve all breakers (installed and spares) prior to delivery and installation/storage.

C.4 **Molded Case Circuit Breakers (MCCB) Under 100 kW**

C.4.1 The Contractor must identify and renew all legacy MCCBs (under 100 kW) on the Main and Emergency Switchboards. The Contractor is to verify the number and size of the breakers, but may use the following list as a guide for the affected breaker distribution systems:

1. 120 V Emergency Switchboard Essential Bus (on Emergency Switchboard);
2. 120 V Emergency Distribution Bus #1 (on Emergency Switchboard);
3. 120 V Emergency Distribution Bus #2 (on Emergency Switchboard);
4. 240 V Non-Essential Bus (on Main Switchboard), and
5. 120 V Essential Bus (on Main Switchboard).

C.4.2 MCCBs must protect against thermal overloads, short circuits, and ground faults.

C.4.3 The Contractor must identify which MCCBs currently have undervoltage (UV) trip devices and ensure the replacement MCCBs provide the same function.

C.4.4 As part of the load management system, the Contractor must identify any MCCBs under 100 kW that require preferential trip control (i.e., electronic trip units), and ensure the replacement MCCBs provide that function.

C.4.5 MCCBs must, as much as possible, be of a single supplier and style to allow for optimization of spares and replacements carried.

C.4.6 The replacement breakers must be new, modern replacements that have OEM manufacturer support and spares expected to be available for a minimum of twenty (20) years past the completion of the VLE.

C.4.7 The Contractor must supply the TA with spare breakers and components to cover all styles and sizes installed. Quantities of spares must be a minimum 20% of the fitted breakers style and set points. For example, if there are nine (9) identical breakers, the Contractor must supply two (2) spares. If there is a single breaker, the Contractor must provide one (1) spare. Spares must be drop in and not require modification on the vessel before use.

C.5 Molded Case Circuit Breakers (MCCB) Over 100 KW

C.5.1 The MCCBs over 100 kW are listed in table B 1.3 '' **List of Molded Case Circuit Breakers over 100 kW**''.

C.5.2 All switchboard MCCBs over 100 kW (SACO TMAX) were renewed in 2015. The SSSI must determine if the existing MCCBs over 100 kW are compatible with the new ***or overhauled*** switchboards. ***In the switchboard design and engineering phases,*** The SSSI must verify that the ***current*** model of SACO TMAX breakers on board will be supported for another twenty (20) years of expected service life. ***If the current model support is anticipated to cease within 10 years, the Contractor must notify the TA and determine a solution with the TA.***

C.5.3 The SSSI must determine which existing MCCBs over 100 kW require integration with the new vessel power management system (i.e., electronic control for opening/closing required).

C.5.4 If they are to be reused, the SSSI must inspect, test, and maintain the MCCBs as required in TP 127 and according to the manufacturer's recommendation for a breaker of this age.

C.5.5 If, ***due to compatibility issues with the switchboards,*** the SSSI determines that the aforementioned MCCBs over 100 kW cannot be reused, then the SSSI must renew them with new and compatible MCCBs units to match the switchboard distribution system.

C.5.6 MCCBs must protect against thermal overloads, short circuits, and ground faults.

C.5.7 The Contractor must identify which MCCBs currently have undervoltage (UV) trip devices and ensure the replacement MCCBs provide the same function.

C.5.8 As part of the load management system, the Contractor must identify any MCCBs over 100 kW that require preferential trip control (i.e., electronic trip units), and ensure the replacement MCCBs provide that function.

C.5.9 MCCBs must, as much as possible, be of a single supplier and style to allow for optimization of spares and replacements carried.

C.5.10 The replacement breakers must be new, modern replacements that have OEM manufacturer support and spares expected to be available for a minimum of twenty (20) years past the completion of this contract.

C.5.11 The Contractor must supply the TA with spare breakers and components to cover all styles and sizes installed. Quantities of spares must be a minimum 20% of the fitted breakers style and set points. For example, if there are nine (9) identical breakers, the Contractor must supply two (2) spares. If there is a single breaker, the Contractor must provide one (1) spare. Spares must be drop in and not require modification on the vessel before use.

C.6 Caterpillar OEM Generator Controllers (DCU/HMI Kits)

C.6.1 The EGen controller is not being modified at this time. The Contractor must ensure that it is integrated into the new system.

C.6.2 The three (3) SSGs are being renewed in SOW item 13.1 – Ship Service Generators, must be equipped with Caterpillar OEM DCU/HMI controller kits. The Contractor must obtain these customized kits from the Toromont FSR. These kits will include:

1. Three (3) x Caterpillar OEM DCU/HMI controller kits;
2. Three (3) x generator sensor suites to mirror current installation;
3. Three (3) x engine junction boxes;
4. Three (3) x best source supplies for control, and
5. Three (3) x custom-built generator harnesses.

C.6.3 Each of the three (3) SSG's will be refitted with Woodward model EGB2P governor actuators. These actuators have a backup mechanical speed setting. If signal from the electronic governor control is lost, this actuator will default to a set speed and operator in speed/frequency droop mode. A typical set point is 62.5 Hz unloaded.

C.6.4 The Contractor is responsible supplying and running all cabling between the SSGs, power sources, switchboards, AMS, etc. Field wiring and conduits required between the control panels and each SSG must be supplied and installed by a licensed marine electrician via the Contractor. Full details of wiring requirements will be available from the Toromont FSR. The Toromont FSR is responsible for terminations at the SSGs and Main Switchboard.

C.6.5 The Contractor must identify a spare 120 VAC circuit and run new power cabling to each of the SSG controllers.

C.6.6 The Contractor must renew the governor actuator control wires and terminations, and pin-and-socket (Amphenol-style) plug connection between the SSG and the Main Switchboard.

C.6.7 The power supply for the DCU/HMI kits uses “best source” from either 120 VAC supply or two (2) 24 VDC UPS in parallel with an isolator block.

C.6.8 The existing SSG 24 VDC power supply is located in the lower Engine Room and uses two (2) 24 VDC battery banks in parallel with an isolator block. One bank is powered by the Main Bus, and the other by the Emergency Bus. The Contractor must inspect and verify if the two (2) existing 24 VDC battery banks and battery chargers are suitable for reuse. If not, the Contractor must supply and install two (2) 24 VDC battery backup power systems in parallel with an isolator.

C.6.9 Each function served by the “best source” power systems must produce a “loss of control power redundancy” alarm when any single power source fails.

C.6.10 The Contractor must use the Toromont FSR for the following services:

1. Engineering services to design, update drawings to reflect new control for the Caterpillar OEM controller;
2. Engineering services for design of final SOP, MOP for system integration;
3. Project management and project customer support;
4. Tuning of system using external load banks;
5. Commissioning, and
6. SAT reports and sign off.

C.6.11 The Contractor must procure the services of the Toromont FSR to remove and retain for reuse the three (3) Woodward model EGB2P governor actuators. The Contractor must wrap in plastic, box securely, and store in a dry and heated storage facility until needed for reinstallation.

C.6.12 CDVR’s (voltage regulators) will be supplied through the alternator reconditioning in 13.1 – Ship Service Generator.

C.7 **Master Control Panel**

C.7.1 The Contractor must supply, install, and integrate a Toromont TECS100 (Toromont Electronic Control System) master control panel (or equivalent HMI master control system) in the MCR as part of the Main Switchboard panels.

C.7.2 The TECS100 or equivalent must meet the following requirements:

1. Type approvals as required by the RO;
2. Nonredundant Allen Bradley Compact Logix PLC with remote I/O racks system for each SSG. The PLC I/O system must be expandable;

3. One (1) x 15” HMI touch screen for interface;
4. Three (3) x Woodward 2301E digital load sharing and speed controllers;
5. Three (3) x Woodward DSLC-2 synchronizer and load control;
6. Controls for Auto/Manual synchronizing of the SSGs. Manual synchronizing must function independent of the master control HMI, and be demonstrated to work if there is a complete failure of the master control HMI unit;
7. Redundant power supplies with automatic “best source” selection. Each function served must produce a “loss of control power redundancy” alarm;
8. SSG metering, alarms, and data must be displayed in the master control HMI;
9. Ethernet switches, auxiliary relays, controls must be supplied as required for integration of the systems;
10. SSG and bus analogue meters as detailed in C.8 must be displayed on the Main Switchboard panels. Instruments and indication must be sized, scaled, and red-lined marked as required by TP 127. Analogue meters must measure bus values in a way that is fully independent from other metering, and therefore redundant, and
11. SSG circuits and buses must have operational/condition indicating lights mounted in the front of their relative switchboard panels. The colour of the indicating lights must follow **Table 17-4** of TP 127.

C.7.3 Automatic start, connect, and load must be conducted dependent upon load, if another source is faulted or alarmed, or as part of a blackout recovery. A priority sequence must be set for the SSGs which must be adjustable by the operators.

C.7.4 Each of the SSGs must have an operator selected switch for standby mode. In standby mode, the vessel power management system must be able to automatically start and connect to the bus additional SSG as loads require. This option must only be selectable when the vessel is on SSG power, and not shore power or emergency power. For conditions when only one (1) SSG is connected to the bus, the standby option must have a priority option for the two (2) standby SSG (i.e., primary standby SSG and secondary standby SSG). Once connected in standby mode, the incomer will stay on the bus until disconnected by the operator. The Main Switchboard must have distinctly coloured indicator lights mounted at each SSG panel to indicate visually whether the unit is in standby mode or not. The lights must be visible to the operator from the far side of the MCR.

C.7.5 It must be possible to synchronize and connect SSGs manually to the bus via controls at the Main Switchboard cabinet doors. While advanced power management features may be lost, it must be possible to support the bus from a SSG without the intervention of higher level (external to switchboard) vessel management functions.

C.7.6 If an incomer loses communication/interface with other functions (e.g., between governing controllers) it must remain still possible to connect it to the AC bus. Default mode of operation must be speed droop for load sharing.

C.7.7 The Contractor must procure engineering services for the following:

1. Design and update drawings to reflect the new control for the TECS PLC/HMI (or equivalent);
2. Design of Final SOP, MOP for system integration;
3. Project management and project customer support;
4. Tuning of the system using external load banks;
5. Commissioning, and
6. SAT reports and sign off.

C.7.8 New system must provide dynamic kW and kVAr load sharing.

C.7.9 Field wiring to all Caterpillar equipment must be terminated by the Toromont FSR.

C.8 Switchboard Cabinets

C.8.1 All switchboard cabinets must meet the regulations and requirements of TP 127 and the RO.

C.8.2 Miscellaneous items include, but are not limited to:

1. Nonconducting handrails;
2. New nonconducting mats throughout the entire MCR and EGen Room;
3. Switchboard nameplates and equipment labels secured to the switchboards, manufactured in a format and material compliant with TP 127;
4. Pilot lights must be LED type (not incandescent);
5. Interior lights must be provided to illuminate the control circuits and devices. These must be operated by a manual switch on the assembly (rather than door-switch operated);
6. All feeds must be clearly labelled and identifiable with cross reference to the single line drawing (i.e., circuit number appears both on label and on single line). The existing circuit numbers must be retained. The size of the distribution breakers (frame size) must also be provided on the labels, and
7. Controls must be mounted in the sections that they control. For example, the controls for an incomer breaker must be positioned above that physical breaker. In cases where space is an issue, some control devices must be physically located adjacently through consultation and approval with the TA.

C.8.3 Each SSG and the EGen must have its own cabinet as detailed in TP 127.

C.8.4 All existing control, metering and protection devices must be replaced with new (**CFM**) and cannot be reused as part of the new system.

C.8.5 Panel front meters are to have a redline on the meter dial face to indicate maximum or nominal values for the equipment being monitored. New voltmeters and ammeters must be able to be switched to display values for each individual phase.

C.8.6 All control and disconnect equipment for a particular SSG (e.g., breakers, controls, gauges, indicating lamps, displays) must be mounted in or on the cabinet for that SSG.

C.8.7 Digital communications links can be utilized for communication with remote monitoring/metering/HMI systems and devices. Critical functions, such as protection, must not rely upon such communication links. However, if this is intended, via the use of fiber optic links for example, details must be submitted to the TA for consideration and approval. Communication technologies/protocols must not be proprietary.

C.8.8 The functions of protection and control must be kept separate. They must not be merged into a single incomer control device. Sensing devices (PTs and CTs) must also be separate from control and protection functions and rated/classed appropriately for their service. The SSG circuit breaker and the controls must be physically separated in different cubicles.

C.8.9 Each SSG cabinet (three (3) in total) must have the following components:

1. Solid state reverse power relay with trip indicator and reset;
2. Solid state over current relay with trip indicator and reset for emergency load shedding via the Load Relief breaker. This is independent of and in addition to intelligent load management by the vessel power management system;
3. Alternator anticondensation space heater switch with “On” indicating light;
4. SSG control in “Manual/HMI” with indicating lights;
5. Circuit breaker control switch;
6. Synchronizer with initiate pushbutton and “Auto-Synch” indicator light;
7. Electronic Governor control, with “Run/Idle” selector switch;
8. Spring return speed trim control (to be supplied loose by OEM);
9. Spring return voltage trim control (to be supplied loose by OEM);
10. Voltmeter with position control switch for “Off, A-B, B-C, and C-A” readings;
11. Ammeter with position control switch for “Off, Phase A, B, and C” readings;
12. Wattmeter;
13. Frequency meter;
14. Power factor meter, and
15. Hour meter.

C.8.10 The EGen remote display in the MCR must have the following components:

1. Circuit breaker control switch;
2. Governor control switch;
3. “Man/Auto” selector switch;
4. “Start” pushbutton;

5. Voltmeter with position control switch for “Off, A-B, B-C, and C-A” readings;
6. Ammeter with position control switch for “Off, Phase A, B, and C” readings;
7. Wattmeter;
8. Frequency meter;
9. Power factor meter;
10. Excitation voltmeter;
11. Running indicator light, and
12. Circuit breaker status indicator lights (Open/Closed).

C.8.11 The Shore Supply Panel must have the following components:

1. Solid state reverse power relay with trip indicator and reset;
2. Voltage Balance relay;
3. Circuit breaker control switch;
4. Voltmeter with position control switch for “Off, A-B, B-C, and C-A” readings;
5. Ammeter with position control switch for “Off, Phase A, B, and C” readings;
6. Wattmeter with kilowatt hour counter;
7. Frequency meter;
8. Power factor meter;
9. Phase Sequence meter;
10. Incoming shore power phase selector switch;
11. Shore power indicator lights (power present, phase rotation OK, voltage OK), and
12. Circuit breaker status indicator lights (Open/Closed).

C.8.12 The Paralleling Panel must have the following components:

1. Bus bar voltmeter with position control switch for “Off, A-B, B-C, and C-A”;
2. Bus bar frequency meter;
3. Synchronizing selector switch;
4. Synchroscope with position control switch, and
5. Synchronizing lights.

C.8.13 Other Main Switchboard components required:

1. Emergency Switchboard (Lower Tie breaker) circuit breaker control switch;
2. Emergency Switchboard (Lower Tie breaker) circuit breaker status indicator lights (Open/Closed);
3. Bow Thruster breaker control switch;
4. Bow Thruster breaker status indicator lights (Open/Closed), and
5. 3-phase grounding light indicators with an independent audible alarm and latching silence function for every isolatable section of the 460 V/ 240 V/ 120 V main buses.

C.8.14 The EGen cabinet in the EGen Room must have the following components:

1. Solid State reverse power relay with trip indicator and reset.
2. Solid state over current relay with trip indicator and reset for emergency load shedding via the Load Relief breaker. This is independent of and in addition to intelligent load management by the vessel power management system;
3. Alternator anticondensation heater switch with “On” indicating light;
4. EGen control in “Local/Remote” with indicating lights;
5. Circuit breaker control switch;
6. EGen breaker control “Local/Remote” switch;
7. Speed trim control;
8. Voltage trim control;
9. Voltmeter with position control switch for “OFF, A-B, B-C, and C-A” readings;
10. Ammeter with position control switch for “OFF, Phase A, B, and C” readings;
11. Wattmeter;
12. Frequency meter;
13. Power factor meter, and
14. Hour meter;

C.8.15 Other Emergency Switchboard requirements:

1. 3-phase grounding light indicators with an independent audible alarm and latching silence function for every isolatable section of the 460 V/ 240 V/ 120 V emergency buses.
2. 3-phase grounding light indicators with an independent audible alarm and latching silence function for the 120 VAC essential bus located on the EGen section of the Emergency Switchboard.

C.8.16 Ground Fault Detection (GFD):

1. The Main and Emergency 460 V Service buses are nominally an ungrounded system which means that a ground fault (phase to ground) is not to directly lead to loss of service and is not to be a “high energy” event. However, ground fault detection is required for primary and secondary distribution systems.
2. The Contractor must provide a ground fault monitoring and alarm system for all voltage levels of the power distributions.
3. A ground fault detection system is required for each voltage level, the system must continuously monitor the ground fault and provide audible and visual alarm for all AC systems and indication at the switchboards and be able to be integrated to the vessel’s AMS.
4. Audible alarms and indicating lights must be mounted on the panels where the system grounds are being monitored. Grounding alarms must integrate with the AMS so that a ground on any bus system activates is repeated and identified in the AMS. The

ground fault detection arrangement must be replicated on both sides of the tie breakers to ensure monitoring is complete when the tie is open.

5. A ground fault detection device must be employed to monitor the windings of the SSG and EGen when they are not running and not connected. This is in addition to, and separate from, the Bus Ground Fault Detection measures described above.
6. Ground fault detection must not initiate trips of the EGen or other equipment. Alarms will be annunciated at the Emergency Switchboard (e.g., via alarm pilot light) and made available to the vessel's external AMS by "dry contact". The ground fault monitoring and alarm system must include ground lights with a test switch on each switchboard.

C.8.17 ***The Contractor must provide the TA with a list of all switchboard components and, within that list, identify the critical spares and the recommended spares for the switchboards.***

C.9 Generator Protection Logic

C.9.1 The SSSI must collaborate with the provider of the vessel's Short Circuit and Coordination Studies as per SOW 14.11 – Electrical Studies.

C.9.2 In general, the EGen must only be tripped, via its incomer breaker, in the event of short circuit (that is not instantaneously cleared by an affected feeder), or a significant/damaging overspeed. The Short Circuit and Coordination Study will be required to show coordination between the incomer breakers and the various emergency load feeders.

C.9.3 TCMS regulation TP 127 make no distinction between Emergency Generators and Auxiliary Generators regarding overload protection. The SSSI can put forward an alternative philosophy, for the EGen only, for consideration by CCG. A higher risk of thermal damage may be tolerable in the case of the EGen. High load and overload alarms must be provided both at the Emergency Switchboard and via the vessel's AMS.

C.9.4 Short circuit protection must be included in the EGen incomer. However, a short time trip must be utilized to provide an opportunity for the affected feeder breaker to trip instantaneously, preserving the Emergency Bus.

C.9.5 SSG and EGen electrical protection functions must be consolidated into a single new electronic trip unit circuit breaker within each incomer and must consist at a minimum but not limited to:

1. Reverse Power Protection;
2. Over/Under voltage protection;
3. Over/Under frequency protection;
4. Loss of Excitation (generator takes excessive reactive power from bus);
5. Communication links with the numerical protection relay allow warnings, alarms, trip data etc. to be communicated to external vessel systems (AMS and vessel

management systems). It is not considered necessary for communication links to play an active role in protection. Any such proposal must be made in consultation with the TA. Communication links, whatever their role, must not use proprietary technologies or protocols; and

C.9.6 In addition to preferential tripping of the Load Relief breaker, the EGen must use protection functions such as tripping of the Upper Tie breaker, followed by tripping of main incomer breaker if the condition persists, as a strategy. This will also be addressed under the scope of the Short Circuit and Coordination Studies and all protection settings must be determined under that scope.

C.9.7 Generator status (health and readiness) must be monitored by the incomer. The incomer must include pilot light indications to show the engine status in addition to monitoring of the EGen by the vessel's AMS.

C.9.8 The functions of protection and control must be kept separate. They must not be merged into a single incomer control device. Sensing devices (PTs and CTs) must also be separate from control and protection functions and rated/classed appropriately for their service.

C.9.9 The incomer breaker must include instantaneous protection and it must be possible to disable or adjust this above the generator fault current as determined from its decrement curve.

C.9.10 Overexcitation protection must be provided by the automatic voltage regulator (AVR). The numerical protection relay in each SSG incomer must provide a backup protection function. The SSSI must verify any adjustable settings of the AVR and ensure they are in compliance with the protection strategy as defined by the Short Circuit and Coordination Studies.

C.9.11 Lockout functionality must be implemented such that, subsequent to certain trips, it is not possible to reclose the breaker until a manual reset has been performed at the incomer. Lockout must be a function of the numerical protection relay or an external resettable electromechanical device. Trip types requiring lockout will be clearly stated within the Short Circuit and Coordination Studies. **NOTE**: Trips occurring as a result of incomer Emergency Stops must engage lockout.

C.9.12 Trip coil supervision from the numerical protection relay must be provided. This typically involves the use of a continuous low-level current through the trip coil of the breaker that is detectable by the relay but well below the level required to cause a trip.

C.9.13 PTs and CTs used for protection and metering must be appropriately categorized and rated for those functions. Note: Existing PTs and CTs must be removed and replaced with new ones.

C.9.14 Protection functions must remain active, whether the switchboards are in Local/Manual, Semi-Auto, or Auto control.

C.9.15 A ground fault detection device must be employed to monitor the windings of the SSG and EGen when they are not running and not connected. This is in addition to, and separate from, the bus ground fault detection measures described throughout.

C.10 Synchronizing with Bus

C.10.1 Automatic synchronization must be achieved through the action of the governor controls within generator incomers. Each autonomous generator incomer function must be able to self-synchronize with the live bus on the other side of the open breaker. Designs that use a shared synchronizer multiplexed between functions will not be acceptable.

C.10.2 Biasing of the speed setpoint must be the method by which the generator output will be brought into phase with the live bus prior to breaker closure. Upon closure, the system must revert to normal load sharing operation. The governing controls must be responsible for synchronization of generators.

C.10.3 A means of checking the phase alignment must be employed. This can consist of a synch check relay. The operation of this device must be presented visually on the section door (e.g., “synchroscope” and “synch check” combo device).

C.10.4 Dead bus closure of incomer breakers, and tie breaker, must be facilitated. The system must allow for synchronization across the open tie breaker when a generator supports the bus on each side.

C.10.5 As required by TP 127 Section 9.5, an alternative manual method of synch and close must be provided for each generator incomer.

C.11 Basic Power Management Logic

C.11.1 The system must be able to function under the following three (3) operational conditions. The operator must be able to select which operating condition to choose and be able to override the more automatic system with a selector switch.

1. **Auto –** Certain power management decisions are made by the automated vessel power management system. For example, the vessel power management system controls the generators and load shedding. This must be an HMI interfacing with an electronic control system (i.e., TECS100 or equivalent). The system must monitor the bus load and number of generators online. Offline units are in “stand-by” mode. The system must automatically start, connect breakers, and adjust load sharing of additional generators on the bus as load demand requires. The system must also trip non-essential loads when intelligent load shedding is required. The operator selects which generators are “standby” and their priority for coming online. There must be an option for the operator to select “Generator Not Available”.
2. **Semi-Auto –** All the automatic functions and protections are in place but are initiated by the operator. The operator controls the selection of generators. Power

management of generators is decided by the operator and not the vessel power management system. Selection of this option and the pushbuttons required for use must function independently of any HMI screens and electronic control systems (i.e., TECS100). The initiation of the "Auto-Synch" pushbutton permits the synchronizer to notch the paralleling parameters of a running generator with the on-line source. When the parameters are within acceptable limits, the incoming generator breaker must close automatically.

3. **Local/Manual -** Control is conducted at the switchboard by an operator. The paralleling parameters of the generator are manually adjusted. The incoming source is paralleled with the bus by manual operation. Selection of this option and the pushbuttons required for use must function independently of any HMI screens and electronic control systems (i.e., TECS100). The circuit breaker is closed by operation of the circuit breaker control switch with interlocking through the synchronizing selector switch. The incoming source can also be connected to the dead bus without synchronizing. The switchboard requires a synchroscope and dark synchronizing lights for this purpose. A local automated process can still be involved in bringing that action to completion. For example, an "unload and open" push button must be provided for manual control at the incomer door. The governor incomer controller must remain in supervision of the resulting process.

C.11.2 The Contractor must supply and install a flashing warning light at each SSG which acts as a visual warning that the engine is about to start. Before the vessel power management starts a SSG, the light must flash for as a warning to personnel in the vicinity of the SSG. The exact colour and length of time is to be determined by the SSSI with the RO and TA.

C.11.3 In all operator modes, it must be possible for an operator to request a start from the switchboard power management system, irrespective of current load. The operator must be able to specify the desired source for addition to the plant. This will allow the crew to parallel an additional source prior to starting a known large load/heavy consumer.

C.11.4 The system must be able to recover from a dead bus (i.e., blackout). Power supplies must come from the corresponding incomers for breaker control, breaker permissive, spring winding, etc., but must also allow for blackout recovery by the following methods. The SSSI must propose to the RO and TA alternate power supplies or "best source" power supplies as required.

1. EGen starts automatically and incomer breaker closes to supply a dead emergency bus. This must be compliant with TP 127 and RO requirements;
2. Operator controls EGen start and breaker closing to supply a dead emergency bus only. Must be capable of being done locally (EGen Room) and remotely (MCR);
3. Operator closing of Upper Tie breaker when the Emergency bus is live and the main bus is dead. Must be capable of being done locally (EGen Room) and remotely (MCR);

4. Operator closing of the Upper Tie breaker when the main bus is live and the emergency bus is dead;
5. Operator synchronizing of the main and emergency buses and closing the Upper Tie breaker;
6. Operator closing of the shore power breaker when the main bus is dead;
7. Operator closing of a SSG breaker when the main bus is dead;
8. Systems requiring duplex power supplies (i.e., Upper Tie breaker) may use an interlocked key-switch for selecting a power source (currently installed) or a SSSI supplied "best source" power option;
9. In Auto Mode, blackout recovery must automatically start and connect a SSG when the main bus is dead (Upper Tie breaker and incomer breakers are open). This process must be supervised by the Woodward service generator incomer controls. There must be a delay period associated with the blackout process (to be set during commissioning);
10. If optional Semi-Auto mode is used, the switchboard must switch to automatic mode during a blackout recovery and revert to the previously selected control mode once blackout recovery is complete, and
11. The blackout recovery will be disabled when the switchboard is set to Local/Manual control.

C.11.5 The EGen auto-start controller (Matrix 16) is being retained. The SSSI must integrate this controller with the Emergency Switchboard and incomer breaker controls to achieve the following:

1. The control of the incomer and the Emergency Switchboard must be kept as simple as possible. Complex networked controllers must be avoided. The incomer must interface with the EGen so that it can determine its status, start it if necessary (in the event that the incoming feed from the Main Switchboard is lost) and connect it.
2. The EGen incomer function must be considered autonomous. In other words, it must contain all resources required for effective control, metering, and protection. It must not rely upon external means of control although it must report status/alarms to external monitoring systems as required. The Emergency Switchboard must autonomously detect a blackout condition, start the EGen, connect it and monitor/protect it.
3. If an incomer controller losses connection/communication with any external system or device, it must remain possible for the EGen to perform its role.
4. The functions of protection and control must be kept separate. They must not be merged into a single incomer control device. Sensing devices (PTs and CTs) must also be separate for control and protection functions and rated/classed appropriately for their service.

5. A means of testing the operation of the Emergency Switchboard must be provided. This can consist of procedures that simulate the loss of the incoming feed from the Main Switchboard, or procedures that otherwise demonstrate full functionality.

C.11.6 Local Emergency Stop controls must remain active irrespective of control function (Automatic or Local/Manual). The following actions, at a minimum, must be possible both automatically and locally/manually:

1. Start, synch, connect and load up the SSG;
2. Run the SSG without connecting (if desired);
3. Unload and disconnect the SSG;
4. Stop the SSG, and
5. Incomer Emergency Stop (opens the breaker AND stops the SSG).

C.11.7 The SSG, once disconnected by the Main Switchboard in Auto mode, must be allowed a cool down period before being stopped. This period must be supervised by the corresponding incomer control (prior to sending a “stop” command) or by the SSG itself (in response to a “cool down and stop” command from the incomer).

C.11.8 The Upper and Lower Tie breakers are in series. The EGen is sized to power the main and emergency buses when both the Upper and Lower Tie breakers are closed. The EGen incomer breaker and the Upper and Lower Tie breakers trip settings have been set to reflect this capacity. This function must be maintained.

C.11.9 The Upper Tie breaker:

1. Does not form part of any intelligent load management systems;
2. Is manually controlled from EGen Room or remotely from MCR;
3. Opens during a blackout (UV trip);
4. Currently, the Upper Tie breaker is powered by dual operational modes selected by key switch. In “Normal” mode the breaker control is powered from the Main Bus and either the shore power or an SSG breaker must be closed. In “Emergency” mode the breaker is powered from the Emergency Bus and the breaker can be closed when the main bus is dead. The SSSI may maintain this arrangement or suggest an alternate “best source” power supply system to be reviewed by the TA, and
5. Must be interlocked so that it cannot be closed, nor remain closed, while the Lower Tie breaker is open.

C.11.10 The Lower Tie breaker does not have an UV trip and remains closed during a blackout. It is not part of any intelligent load management systems. It will only trip on overcurrent. It must be interlocked so that if the Lower Tie breaker is opened (overcurrent or opened manually), the Upper Tie breaker will automatically open.

C.11.11 Paralleling logic requirements:

1. The EGen must be able to load share with the SSGs if both tie breakers are closed;
2. Vessel and shore power must parallel together. Transferring from vessel to shore power and back must have seamless power transition and must not result in "micro blackouts";
3. When transferring from vessel power to shore power, only one (1) SSG breaker may be closed. When transferring to shore power, the SSG breaker must open automatically within thirty (30) seconds after synchronizing if the operator has failed to open it;
4. When transferring from shore power to vessel power, the Shore Power breaker must open automatically within thirty (30) seconds after synchronizing if the operator has failed to open it;
5. In manual mode, the synchroscope permissive must be set so that the appropriate incomer must be selected before its breaker can be closed. In Auto or Semi-Auto mode, the synchroscope may be left "Off".

C.11.12 The Bow Thruster breaker must be interlocked so that it can only be closed when at least two (2) SSG breakers are closed. The Bow Thruster breaker must open automatically when this condition is not met.

C.11.13 The Load Relief breaker must open by preferential trip when any single SSG or the EGen exceeds 90% Full Load Current (FLC) of that generator for eight (8) seconds. This is a safety measure from the original switchboard design that must be independent of any other load management system.

C.12 Intelligent Vessel Power Management System

C.12.1 The SSSI must design, supply, install, and incorporate an intelligent vessel power management system that conforms to all TCMS and RO regulations for power management.

C.12.2 At the outset of the contract, the Contractor arrange a meeting with the SSSI, FSRs, RO, and TA to determine the optimal approach to a vessel power management of the vessel's switchboards. The Contractor must collaborate with the above listed parties and present recommended vessel power management priorities that address typical operation conditions for the vessel. The final approach must be approved by the TA. The vessel power management system must meet the following functions:

1. Meet all defined electrical requirements for operation as detailed by TCMS;
2. Meet all defined requirements for operation as detailed by the RO;
3. Monitor the bus condition (i.e., number of generators connected to the bus, the available capacity of the bus, and the available capacity of each individual incomer);
4. Intelligently increase bus capacity by automatically starting and connecting standby SSGs as available;
5. Intelligently control main bus load by temporarily (i.e., 0-10 seconds) by limiting the power being used by the Bow Thruster until other systems can be brought online or

other loads are shed. The SSSI must work with Kongsberg FSR to integrate the new MCon Bow Thruster Control System to provide this function. Limiting the power available to the thruster should be a last resort to prevent a blackout and must not limit the power in any way that puts the vessel in danger. The Kongsberg FSR must be consulted as to what is reasonable power limitations, but the SSSI should begin with a target of limiting the thruster to no less than 85% power;

6. Communicate the bus condition with the AMS, and
7. Intelligently shed load by opening NP breakers, listed below, as required. Any loads that are shed must log an alarm and activate the AMS annunciator.

C.12.3 The following loads are to be considered for selective load shedding by the vessel power management system:

1. Fwd Deck Machinery (NP-4);
2. Aft Deck Machinery (NP-5);
3. Non-Essential MCC (NP-2);
4. 240 V Non-Essential Bus (NP-3);
5. 240 V Galley Distribution (NP-31);
6. 460 V Hyd Power Pack Dist. Panel (NP-7), and
7. Buoy Crane Hyd Power Unit (NP-6)

C.12.4 An indication of the positions at which loads are shed (i.e., breaker sequencing) must be included in the vessel's new single line drawing. The tiers of load shedding must be clearly shown.

C.12.5 Load shedding must produce alarms at the switchboard and report them externally to the vessel's AMS.

C.12.6 Automatic load dependent starts must be implemented when in Automatic operation. Integration with an external vessel management system must be facilitated. The external system must be capable of monitoring the status of the power sources and requesting them to be brought online. The management system must not automatically take power sources offline but can provide indication that they can be taken offline.

C.12.7 The governor controllers in the SSG incomers will supervise unloading prior to disconnection and loading subsequent to connection. **NOTE**: It must be possible to disconnect immediately, without unloading, in certain circumstances (e.g., incomer or generator Emergency Stop).

C.12.8 A means of overriding normal load sharing must be provided. This must allow an operator to establish a "base load" for a SSG. This must be supervised via the governor control devices.

C.12.9 The vessel power management controls must not have the ability to control loads, only sources. The exception is load shedding which must be supervised by the controls. The SSSI may suggest a system by which power is temporarily limited to large loads, such as the Bow Thruster, other than by disconnecting them (e.g., via interface with VFDs for the purpose of power limitation). Any proposed methodology must be submitted and preapproved by the TA.

C.12.10 An interface by which, in Auto mode, an additional source can be brought online must be included. The crew would typically use this when it is planned to run a heavy consumer (i.e., as a pre-emptive move).

C.13 Load Sharing

C.13.1 Load sharing must be implemented for all possible combinations of sources when SSG's are in parallel. The following methods are considered acceptable:

1. Frequency droop based on active power throughput. Voltage droop based upon reactive power throughput. Droop to be predictable (according to defined droop curves implemented after synch and close is complete). After synchronization, at the instant of tie breaker closure, the system must revert to droop operation.
2. Frequency and voltage droop as described above in para. (a). However, a system of compensation/tracking can be employed such that frequency setpoint of the grid converter can be raised/lowered or biased by external action of a load-sharing system, so that plant frequency is maintained at 60 Hz.

C.13.2 Other methods of load sharing will be acceptable but must be preapproved by both the RO and the TA.

C.13.3 A method must be utilized that ensures compatibility of the existing generators under the control of the governing Load Sharing Modules.

C.13.4 Load sharing communication lines must not be shared with other functions (e.g., communication with the AMS).

C.14 Alarm and Monitoring System (AMS)

C.14.1 In addition to the indications and alarms presented at the switchboard (specified within this document or included according to the regulations being applied, such as TP 127), the SSSI must work with the SSG FSR (Toromont) and AMS FSR (JMP) to interface the switchboard, generator controls, and the external AMS together.

C.14.2 A communication link must be established to each numerical protection relay within the switchboard. In addition, a communications link must be established to Woodard controls. These communication links must be nonessential for manual switchboard functionality.

C.14.3 The interfaces with the switchboard will allow the AMS to identify:

1. Trips and other protective actions that occur within the switchboard. The trip type (e.g., ANSI code) and location;
2. Metering data from each incomer to include, at a minimum; current, voltage, kW, kVAr and/or power factor, frequency. Note that, for SSGs, this information must be communicated by an alternative control (e.g., Woodward) instead of the numerical protection relay;
3. SSG incomers must communicate engine RPM, temperatures, pressures, winding temperature readings, and DCU alarms for AMS display;
4. SSG incomers will communicate basic engine status (e.g., ready, running, faulted). Note that detailed SSG engine data (alarms and monitored values) must be collected by the AMS through direct interface with the engines;
5. Current at major feeders;
6. Ground fault or isolation alarms (including magnitude);
7. Load shedding alarms (indicating tier);
8. Switchboard status (Local/Manual, Semi-Auto, or Auto);
9. Load control status (e.g., normal sharing or base load etc.), and
10. Loss of control power redundancy (where applicable, on a per function basis).

C.14.4 The above must be considered a minimum. Additional alarms and status monitoring may be necessary depending upon the nature of the system proposed by the SSSI.

C.15 MCR Mimic Panel

C.15.1 The Contractor must integrate the Power Generation section of the MCR mimic panel with the switchboards. See Techsol drawing P-032200-00 sheets D.

C.16 Switchboard Removals & Installation

C.16.1 The Contractor is responsible to isolate, lockout, and tagout all circuits including isolation of both the Main and the Emergency buses. The Contractor is responsible to provide power, lighting, and heating to the vessel during the time that the switchboards are undergoing replacement. All temporary power is to be at the Contractor's expense and all power supplies to the fire detection systems must be maintained. The Contractor must factor in the loss of the power services provided by the switchboards to insure there is no impact to the production schedule.

C.16.2 As the installation of the new switchboards may be scheduled during the winter months, the Contractor must be responsible for ensuring that the temperature of the interior spaces of the vessel are maintained above freezing at all times.

C.16.3 The Contactor must take every precaution needed to prevent damage or contamination of any equipment, material, and systems caused by breakage, ingress of contaminants, dirt,

debris, water, weather, and freezing. Failure to do so will require the Contractor to provide the necessary remedial action at their expense.

C.16.4 The Contractor must inspect the existing through decks and through bulkhead cabling penetrations/systems and reuse them unless there are deficiencies noted. If replacements or repairs are required, they will be completed via PWGSC 1379 Work Arising or New Work form.

C.16.5 All new Contractor installed wiring must be labelled and supported as per the General Notes and indicated on as fitted drawings. The Contractor must reapply identifying labels to all reused cables. Cables being reused must be visually inspected and Meggered before reuse.

C.16.6 The Contractor must provide a report of cables removed, cables reused, and new cables installed. The report must identify cables, include the condition of the reused cabling (visual, Meggering), and details of any new cables used.

C.16.7 The existing Main and Emergency Switchboards must be disconnected both mechanically and electrically and removed from vessel. The removed switchboards and all associated removed components must be retained, stored in a dry condition, and loaded into the cargo hold prior to the vessel's departure. The Contractor must determine the best transit routes for removal and installation of the switchboards and include all costs.

C.16.8 All wiring that is designated to remain for reuse must be clearly identified and permanently marked as per the Identification section of the General Notes.

C.16.9 The Contractor must isolate, mark, disconnect, and protect all connections leading to the current Main and Emergency Switchboards. The Contractor must strip out both switchboards and their associated components; and then install the newly constructed Main and Emergency Switchboards in accordance with these specifications and the manufacturer's instructions.

C.16.10 The Contractor is responsible for all work to remove the existing switch board and installation of the new switchboards into the MCR and EGen Room. The Contractor is responsible to replace all removals required for the removal and replacement of the switchboards including any insulation and removed hull plate.

C.16.11 The Contractor must work with the SSSI to coordinate removals and installation of the Main and Emergency Switchboards with other equipment removals as covered under SOW item 11.28 – Hull Cut-Outs.

C.16.12 Before cutting the temporary openings, all interference items must be temporarily removed and set aside to allow access to the bare steel/aluminium of the exterior hull section/bulkhead to be removed. This must include any combustible materials in adjoining spaces (ceiling tiles and bulkhead panels, etc.) that may be affected by the cutting process.

C.16.13 The Contractor must provide adequate temporary shelter for any equipment, compartments or spaces affected by this work. The Contractor must take appropriate precautions to properly protect any machinery, equipment, that may be damaged by exposure, movement of material, rain/snow, sand or sand dust paint, welding, and any other aerial particles. Any damage will be the responsibility of the Contractor to repair at the Contractor's expense.

C.16.14 Bulkhead insert internal surfaces must be reinsulated using new approved rock wool type insulation and faced as per the existing insulation found elsewhere within each compartment.

C.16.15 The Contractor may utilize, wherever possible, the existing foundations to mount the new equipment. Minor modifications of the old foundations to suit the new equipment may be required and will be covered via a PWGSC 1379 work arising or new work form. The Contractor must prepare and paint the seats as per CCG paint specification and install the switchboard frames with all new **CFM** fasteners which must be torqued in to place. The torquing of the foundation fasteners must be witnessed by the TA.

C.16.16 The Contractor is responsible for installing all components that have been removed to aid in the installation of the frame back into the switchboards and connecting the system as per the manufacturer's instructions.

C.16.17 The Contractor is responsible for connecting the switchboard sections to each other in accordance with the manufacturer's guidance documentation.

C.16.18 The Contractor must ensure full protection of the new switchboards throughout the work period. Any damage incurred must be repaired at cost to the Contractor.

C.16.19 Once installed, the Contractor must make all connections to the switchboard components. The Contractor must include all costs to have the SSSI's FSR on site to confirm the installation and commission the switchboards.

C.16.20 All incoming and outgoing control connections must be made in accordance with the approved switchboard schematic and wiring diagrams. After wiring is completed, all connections must be carefully checked against the diagrams to ensure that all connections are correct and proper.

14.6.D **Proof of Performance**

D.1 **Inspection Points**

D.1.1 Hold Point 1: Prior to fabrication and installation of the new switchboards and related components, the Contractor must submit five (5) printed copies of the revised drawings to the TA and RO for approvals. The drawings must show not less than the following modifications and details:

1. Bills of material, referencing part number, description, quantity, and manufacturer of all Contractor (including SSSI and FSRs) supplied components;
2. Elementary diagrams;
3. Interconnections to other FSR component systems;
4. Arrangements;
5. Short Circuit Calculations;
6. Breaker Coordination Study;
7. Bus Bar Electrical Force Calculations;
8. Arc Flash Study, and
9. Cable Studies.

D.1.2 Hold Point 2: All work performed must be inspected to the satisfaction of the attending AR and the TA.

D.1.3 Hold Point 3: The Contractor must demonstrate to the TA that the new switchboard cabinets are secured to their respective foundations and each other as per the manufacturer's installation requirements.

D.1.4 Hold Point 4: The Contractor must inspect bus splices and outgoing connections to ensure that a good clean contact is obtained before bolting tight. The Contractor must demonstrate to the TA the cleanliness of the connection points prior to tightening. The Contractor must present the tightened connections to the TA.

D.1.5 Hold Point 5: After wiring is completed, all connections must be carefully checked against the diagrams to ensure that all connections are correct and proper.

D.1.6 Hold Point 6: The Contractor must complete testing of all the incoming, outgoing cables, the switchboard bus and bonding switchboard cables and producing cable and bus test reports for the testing conducted. Testing is to include but is not limited to the following:

1. Continuity resistance; for each of the cable cores and bond cables;
2. Insulation: core to core, core to screen, core to earth (vessel hull);
3. New switchboard buses: phase to phase, phase to earth (vessel hull); and
4. The Contractor must Megger test both switchboards.

NOTE: The testing procedure criteria and Pass/Fail values for all cables, bond and bus must be confirmed and agreed to in advance with the switchboard FSR, TA, and AR prior to any testing commencing.

D.2 Testing / Trials

D.2.1 General

D.2.2 The SSSI will act as the commissioning technician for this project. The SSSI must be responsible for designing, conducting, and overseeing a full range of Dock and Sea Trials

that include all functions of the switchboards, power management systems, integration with other vessel systems, and verification of all circuits and safeties. The SSSI and FSRs must attend the vessel's Dock Trials and Sea trials and prove all the power management functions in an operating condition and under full load.

D.2.3 The Contractor must develop, prepare, and provide a test and trials booklet complete with the associated trials sheets that will be used during the commissioning and testing of the upgraded Main and Emergency Switchboards. Copy of this booklet must be submitted to the TA four (4) weeks prior to trials commencing for review and to allow for any additional test procedures that the TA may require to be added.

D.2.4 The switchboards must have a shipboard test together with the runup and load test of the SSGs to prove the integrity of the generation plant. The test must include but not limited to followings:

1. Automatic start and paralleling of incoming SSGs;
2. Semi-Automatic paralleling of the incoming SSGs;
3. Manual paralleling of incoming sources;
4. Functional tests of all protective relays;
5. Functional tests of automatic load sharing between SSGs;
6. Functional tests of load shedding and power management;
7. Functional tests of preferential and undervoltage trip systems;
8. Functional tests of metering and indicating system;
9. Functional tests of generator speed control and voltage adjustment;
10. Functional tests of circuit breaker control, and
11. Insulation and high pot tests.

D.2.5 The Main and Emergency Switchboards are to be tested in accordance with TCMS and RO requirements for certification. All functions of the individual service generator panels are to be verified onsite. These are to include the trials for the generator circuit breakers and must include, but not be limited to the following:

1. Reverse power trip;
2. Undervoltage protection;
3. Overcurrent protection;
4. Proper calibration of all meters, kW, ammeter, voltmeter, frequency meter;
5. Proper operation of the automatic voltage regulators (AVRs);
6. Proper operation of the voltage control trim pot;
7. Proper operation of the generator speed control;
8. Proper parallel operation of all three service generators;
9. Proper operation of automatic and manual paralleling functions for all three service generators;
10. Proper parallel operation of all three SSGs to the emergency bus and EGen;

11. Electrical interlock testing for paralleling operations with shore power supply, and
12. Electrical interlock testing for the start-up sequence for the Buoy Handling Crane and the Bow Thruster.

D.2.6 The Contractor must not energize the switchboards for the first time until the SSSI's Commissioning technician (FSR) is present and had time to review/test and confirm all connection points.

D.2.7 The Contractor, in collaboration with the SSSI, must arrange and be responsible for developing a test and trials schedule for the operational and load testing each of the electrical switchboards after their final installation and connections. The Contractor must work with the SSSI's FSR and the Toromont Power Engineer (FSR) to commission each switchboard and complete a full test of all functions of both installations. The operational and load tests must be performed with both the attending AR and the TA in attendance.

D.2.8 Prior to any operational test on newly installed switchboards, all circuits and cabling must be megger tested in accordance with TP 127 and IEEE 45. Reports must be presented to the attending AR and the TA for verification and acceptance.

D.2.9 The Contractor must prove that the switchboard functions are as per the performance requirements set out by the switchboard manufacturer. All tests must be to the requirements and satisfaction of the RO and the requirements of this SOW item.

D.2.10 Load tests requiring utilising an electrical load must be carried out using a suitable Contractor's supplied reactive load bank. If power is required for other services onboard the vessel during load tests, those services must be supplied from a source other than the machine being tested. After all load testing is completed, the switchboards must be tested utilising the generators during dock trials. All generator control and electrical protection devices must be tested utilising the vessel's power. Final testing must be completed during sea trials under all operational conditions. CCG crew will be available for sea trials to operate the vessel.

D.2.11 After completion of all operational tests, all relays must be set and calibrated. All trip indicators on the relays must be checked to see that they function properly.

D.2.12 **Switchboard Commissioning**

D.2.13 Once each of the switchboard installations have been completed, and is ready for operation, the Contractor must be responsible for the necessary commissioning and start-up tests required. The commissioning and testing must only be done under the full guidance of the authorized SSSI Electrical Field Engineer.

D.2.14 All controls, metering, alarms, and shutdowns must be proven functional, with their operations witnessed to the satisfaction of all both the attending AR and the TA.

D.2.15 The Contractor must arrange to perform the necessary commissioning and testing required to certify the switchboards for operation. This certification testing must be accomplished in accordance with the RO and as a minimum the following tests must be carried out:

1. **Prior to commissioning each new switchboard, must have the following visual/mechanical tests performed by the Contractor:**

   i) General Visual and Mechanical Inspections;

   ii) Wiring and Bolted Connection Checks;

   iii) General Wiring Checks;

   iv) Moving Parts and Interlocks, and

   v) Insulators and Barrier Checks.

2. **Prior to commissioning each new switchboard, must have the following electrical tests and or verifications performed by the Contractor:**

   i) Bolted Connection Electrical Tests;

   ii) Insulation Electrical Tests;

   iii) Dielectric Withstand Tests;

   iv) Control Wiring Electrical Tests;

   v) Instrument Transformers Tests;

   vi) Circuit Breakers and Switches Tests;

   vii) Control Power Transfer Scheme Test;

   viii) Metering Electrical Tests;

   ix) Current Injection Tests;

   x) System Function Test;

   xi) Cubicle Heaters Test, and

   xii) Surge Arresters.

D.2.16 The Contractor is responsible for recording all results from the aforementioned tests and all tests must be witnessed by both the attending AR and the TA.

D.2.17 Schedule and trial test results must be submitted to both the attending AR and the TA in accordance with the Documentation section of the General Notes.

D.2.18 After testing is completed, the Contractor must perform a post-trials inspection of the equipment. The inspection must confirm the condition and torque of all holding and securing fasteners, bus splices, wiring securing devices, cabinet hardware, covers, etc. The Contractor must perform the inspection in the presence of the TA and AR.

D.3 Certification

D.3.1 The new switchboards and their associated equipment/components must be designed, approved, constructed, tested, trialed, inspected, and certified in accordance with the Rules of the designated RO and TCMS. All functional switchboards tests/trials, inspections must be completed on a fully assembled switchboard at the factory before shipping.

D.3.2 All original RO and TCMS (where applicable) approval certificates for all system components must be submitted to the TA prior to the acceptance of this item.

D.3.3 The Contractor must provide proof of RO inspection and acceptance of all aspects of the new switchboard installation, commissioning, testing, and function.

D.3.4 The testing equipment used must be calibrated and the calibration details attached to the test reports. Test equipment calibration details must be included for each individual test.

D.4 Documentation

D.4.1 General

D.4.2 A full documentation package must be provided for each of the new switchboards. This documentation must include, but not be limited to, the following:

1. Electrical Single Lines and Schematics for control, power and protections;
2. Complete Bill of Materials (BoM) with type approval certificates;
3. Mechanical drawings;
4. Interconnect drawings to other vessel systems;
5. Operation procedures;
6. Maintenance procedures;
7. A documentation registry;
8. Factory Acceptance Test procedures and results;
9. Site Acceptance Test (SAT) procedures and results, and
10. Functional descriptions.

D.4.3 Th SSSI must provide an updated electrical single line drawing for the vessel as a whole.

D.4.4 Finalized drawings must be signed and stamped approved by the RO and come complete with a signed and stamped cover letter from the RO detailing which drawings have been accepted and approved by the RO.

D.4.5 An original descriptive document (set of functional descriptions) must be produced that describes each switchboard functionality in detail. This must include descriptions of interfaces with external systems (such as generators, AMS, and vessel management systems). Sequences of operation must be described. Chosen philosophies of operation (such as load sharing, protection, and synchronization) must be described. Where appropriate functional logic flow diagrams must be provided.

D.4.6 The document described above must take an integrated approach to functional descriptions. It must not simply be a list of devices with a description of the role of each. The emphasis must be on describing switchboard functionality while making reference to devices (not describing devices while making reference to switchboard functionality). OEM manuals – presented as Appendices and referenced from within functional descriptions – will be acceptable. However, the submission of OEM manuals alone (without descriptions of switchboard functionality) will not be considered a suitable documentation package.

D.4.7 Documentation must be supplied to the TA within five (5) working days of receipt in an electronic .pdf format. However, final documentation delivery must also include files in the original format of production (e.g., AutoCAD, MS Word, MS Excel etc.).

D.4.8 In addition to the above, the Contractor must also provide all documents listed below to the TA:

1. Copies of the Short Circuit, Coordination and Arc Flash Studies;
2. Copies of all Test Certificates for all circuit breakers and electrical components install and requiring proof of certifications as required by the RO and TCMS;
3. All original RO certificates, TCMS Notices of Compliance and current RO electrical equipment type approval certificates. Type approval certificates must be valid at completion of the installation for at least six months, and
4. The computer software models of the Short Circuit Current Calculations, Coordination Studies, and Arc Flash Studies.

D.4.9 The Contractor must provide the TA with the report of the Contractor's work in both electronic and hardcopy formats outlining the details of the installation and any alterations/repairs made prior to the acceptance of this item.

D.4.10 **Switchboard Electrical Schematics**

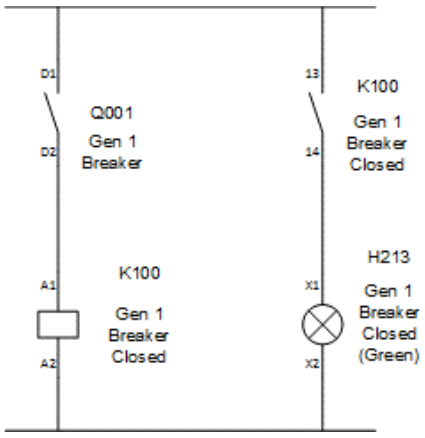
D.4.11 The Contractor must make reference to the Drawings and Manuals section of the General Notes as to the documentation requirements for the switchboard installation drawings and the requirements for the switchboard operational and maintenance manual requirements.

D.4.12 The Contractor must be responsible for updating all drawings affected by the work of this SOW item to as-fitted. The Contractor must provide a list of all existing drawings that are superseded by new drawings.

D.4.13 A complete set of electrical schematics and one lines are to be produced for both the new Main and Emergency Switchboards. This includes previously existing equipment where applicable. It must be possible for the older electrical drawings to be archived (no longer needed for fault finding or for reference during any future electrical modifications).

D.4.14 Components must be numbered and given a consistent name within the electrical schematic set as per example below:

Example:



D.4.15 The Contractor must note that:

1. As well as a number, each component is given a meaningful name;
2. The naming must be consistent. It is the same each time the component appears in the electrical schematic set. For example, if a Relay appears twice (once as a coil and once as a contact), it has the same name each time. (If a relay has multiple contacts the naming must be consistent with a clear indication of the multiple contacts on the relay).
3. Components are shown on the schematic in their deenergized state (in accordance with recognized modern practice), and
4. Components are named after their active state.

D.4.16 This method must also be applied to device input and output naming. For example, a PLC input must be named as well as numbered. A meaningful name might be “Service Generator Running”. When the input is high (on) it means the service generator is running. Less meaningful names, such as “Service Generator Status” will not be acceptable.

D.4.17 Switchboard electrical schematics must be seen as a tool for commissioning, fault-finding and as an aid to understanding of functionality (not just as a tool for manufacturing).

D.4.18 **Calculations:**

D.4.19 In coordination with SOW item 14.11 – Electrical Studies, on completion of all specified electrical work, the Contractor must prepare an "as-fitted" load analysis and must make the latest copy available to the TA for submission to the RO. At the completion of all project work, the Contractor must provide the following:

1. Three (3) copies of the final load analysis and calculations of the as-fitted electrical system;
2. An electronic copy of the final load analysis and calculations of the as-fitted electrical system in Microsoft Excel format. This must be done in accordance with the Documentation Section of the General Notes;
3. Electronic copies of the as-fitted:

    i. Electrical single line diagram, and,
    ii. Switchboard schematics and connection drawings.

D.4.20 In coordination with SOW item 14.11 – Electrical Studies, on completion of all specified electrical work, the Contractor must prepare an as-fitted short circuit current analysis and must make the latest copy available for approval to the RO and the TA. At the completion of all project work, the Contractor must provide the following:

1. Three (3) copies of the final approved short circuit current analysis and calculations of the as-fitted electrical system; and,
2. An electronic copy of the final approved short circuit current analysis and calculations of the as-fitted electrical system in Microsoft Excel format. This must be done in accordance with the Documentation Section of the General Notes.

D.4.21 On completion of all specified electrical work, the Contractor must prepare an "as-fitted" electrical single line drawing and must make the latest copy available to the TA.

D.4.22 An electronic copy of the final approved short circuit current analysis and calculations of the as-fitted electrical system in Microsoft Excel format. This must be done in accordance with the Documentation Section of the General Notes.

D.4.23 **Switchboard Manuals**

D.4.24 The Contractor must compile and provide a comprehensive Switchboard Manual for both the Main and Emergency Switchboard installations. These manuals must include all general information in sufficient detail to support the operational and maintenance requirements of both switchboards.

D.4.25 Each Switchboard Manual, including any necessary annexes and supporting documents, must fully describe all features of each system and document its production, tests, trials, and certification.

NOTE: Original RO certificates and certificates of compliance must be provided to the TA. Copies of these documents are also to be included in the each of the respective manuals.

D.4.26 Each manual must be presented in the following format with its individual sections defined as follows:

i. Table of contents;
ii. Index to documents (separate manuals);
iii. Maintenance manual;
iv. Recommended spares;
v. Operator and safety manual;
vi. Training manual;
    1 – Description;
    2 – Certification;
    3 – Arrangement drawings;
    4 – Electrical system schematics;
    5 – Control and safety system schematics & all main incoming and distribution breakers settings;
    6 – Electrical load analysis and electrical studies;
    7 – Miscellaneous;
vii. Annex i (separate document);
    A. Illustrated parts breakdown diagrams;
    B. Detailed parts list;
viii. Annex ii (separate document);
    A. Supplier manuals (**CFM**);
ix. Annex iii (separate document);
    A. RO certificates, TCMS notices of compliance;
    B. Material & equipment certificates;
    C. Tests and trials records, and
    D. Safety data sheets (SDS).

D.5 Training

D.5.1 The Contractor must be responsible for developing a predelivery familiarization training program on the new switchboards and their associated systems.

D.5.2 The Contractor must deliver a Training Plan and program schedule for all training, to the TA for review and comments, not later than six (6) weeks prior to the delivery of the vessel.

D.5.3 The Contractor must be responsible for developing and providing two (2) separate predelivery familiarization training programs on both the new Main and Emergency Switchboards and their associated electrical systems. All training must be provided in English at the Contractor's facility and aboard the vessel, while the vessel is at the Contractor's facility. Training must be performed by either the SSSI who oversaw the

installation, commissioning, and testing or by another qualified representative agreed upon by the TA.

D.5.4 The Contractor must also be responsible for developing and providing a Training Manual intended for the instruction of the vessel's personnel. As a minimum, the manual must cover the following topics:

1. Review of general switchboard safety;
2. Familiarization with the operation of the installed Main and Emergency Switchboard and its control systems (both at the local and remote locations);
3. Synchronizing procedure from one system to the other system;
4. Safety matters and safety systems, particular to the Emergency Switchboard installation;
5. Practical operational instructions, and
6. Maintenance and troubleshooting procedures.

D.5.5 All training material developed must be delivered in both in hard and in soft copy and in English.

D.5.6 Each course participant must receive a hard copy version of the training manual, and this must be available to them during their training for reference purposes.

D.5.7 Predelivery familiarization training must:

1. Be provided for a maximum of twelve (12) CCG personnel per course with one (1) course given for each crew shift (A & B). The TA will be responsible for arranging and coordinating the availability of the required personnel from each crew shift;
2. Provide training on the safety systems and safe operation of the switchboards and their control systems including practical operational experience, and
3. Provide training regarding the maintenance and troubleshooting of both switchboards.

End of Solicitation Amendment #017.