Type 23 - Power Generation and MCAS Update (PGMU)-Diesel Generator

Annex A to

Schedule A of

CONTRACT SSA/004/01

Technical Equipment Specification (Diesel Generator)

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ADMINISTRATION

Principal author

Gareth Sutton
PGMU Marine Systems Engineer
0117 317 3503
gdsutton@qinetiq.com

NDP - Naval Design Partnering
Building 240
Bristol Business Park
Coldharbour Lane
BRISTOL, BS16 1FJ, UK
F: +44 (0)117 317 3503

Report authorisation

Checked by:	John Forbes
(signed)	
Approved by:	Gary Lidiard
(signed)	

Record of changes

Issue	Date	Detail of Changes
01	18 July 2013	First Issue
02	22 July 2013	Updated following power system analysis.
03	10 Sept 2013	Power/noise requirements clarified
04	15 Oct 2013	Minor amendments to specific fuel consumption information requirement and fault management.
01	02 March 2015	Reset to issue 1 for Contract Award

Distribution list

G N Lidiard

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1 INTRODUCTION

1.1 Purpose

1.1.1 Technical Equipment Specifications (TES) have been produced by the Naval Design Partnering (NDP) team to define the technical requirements and performance specification for procurable equipment within the Type 23 Frigate (T23) Power Generation and MCAS Update (PGMU) programme.

1.1.2 This TES defines the requirements for the update of the existing T23 Diesel Generators and associated Acoustic Enclosures and Local Control Panels.

1.2 Document Description

1.2.1 This document is divided into the following sections:

Section 1	Introduction;
Section 2	Scope Of Supply;
Section 3	Diesel Generator Set Requirements;
Section 4	Diesel Engine Requirements;
Section 5	Generator Requirements;
Section 6	AVR Requirements;
Section 7	Raft And Acoustic Enclosure Requirements;
Section 8	Radiated Noise;
Section 9	Local Control Panel Requirements;
Section 10	Transverse Requirements - defines requirements for the equipment that are in addition to or are tailored from those specified in the General Technical Requirements (GTR) document;
Section 11	References lists;
Section 12	Acronyms, Abbreviations and Definitions;
Appendix A	Original Design Performance Characteristics of the DG Set.
Appendix B	MCAS signal requirements for the Diesel Generator set.

1.3 Conventions

1.3.1 Unless otherwise indicated, all quantities stated in this specification are per-ship.

1.3.2 Statements in this specification using the term “shall” indicate mandatory or essential requirements. Statements in this specification using the term “should” indicate desirable requirements.

1.4 Relationship to Other Documents

1.4.1 The TES should be considered in context with the following related documents:

a. The T23 PGMU System Requirements Document (SRD);

b. The T23 PGMU General Technical Requirements (GTR);

c. The T23 PGMU DG Statement of Work (SoW);

d. Other T23 PGMU TES documents (to be supplied at Contract Award).

1.4.2 The document hierarchy is detailed within the T23 PGMU DG Invitation to Tender (ITT) pack and in the AWARD assessment package.

1.5 Engineering Standards

1.5.1 Certain requirements within this TES may be specified in terms of 'Engineering Standards'. In such cases, the relevant requirements, where included throughout this document, specify how the Engineering Standard is to be applied to the equipment and Section 11 provides details relating to the identity, configuration status, part/section applicability of the relevant standard and an indication of its 'Non Tradable', 'Tradable' or 'For Design Guidance' categorisation.

1.6 Background

1.6.1 The PGMU project had been 2 separate projects, highly dependent on each other, which have been combined to reduce risk and costs associated with integration. The driver for the PGMU project is the decision to extend the working life of the T23. To enable the life extension (LIFEX), PGMU is aiming to increase the amount of power available, accounting for the systems added since the original design and those currently planned as well as restoring a growth margin to ensure that power is available for future systems until the Out of Service Date (OSD). Also to enable the LIFEX programme, PGMU will overcome potential obsolescence issues in the MCAS system.

1.6.2 The interfaces between the PGMU project and the T23 ship's systems are shown in Figure 1. The equipment contained within the PGMU boundary is shown in Figure 2.

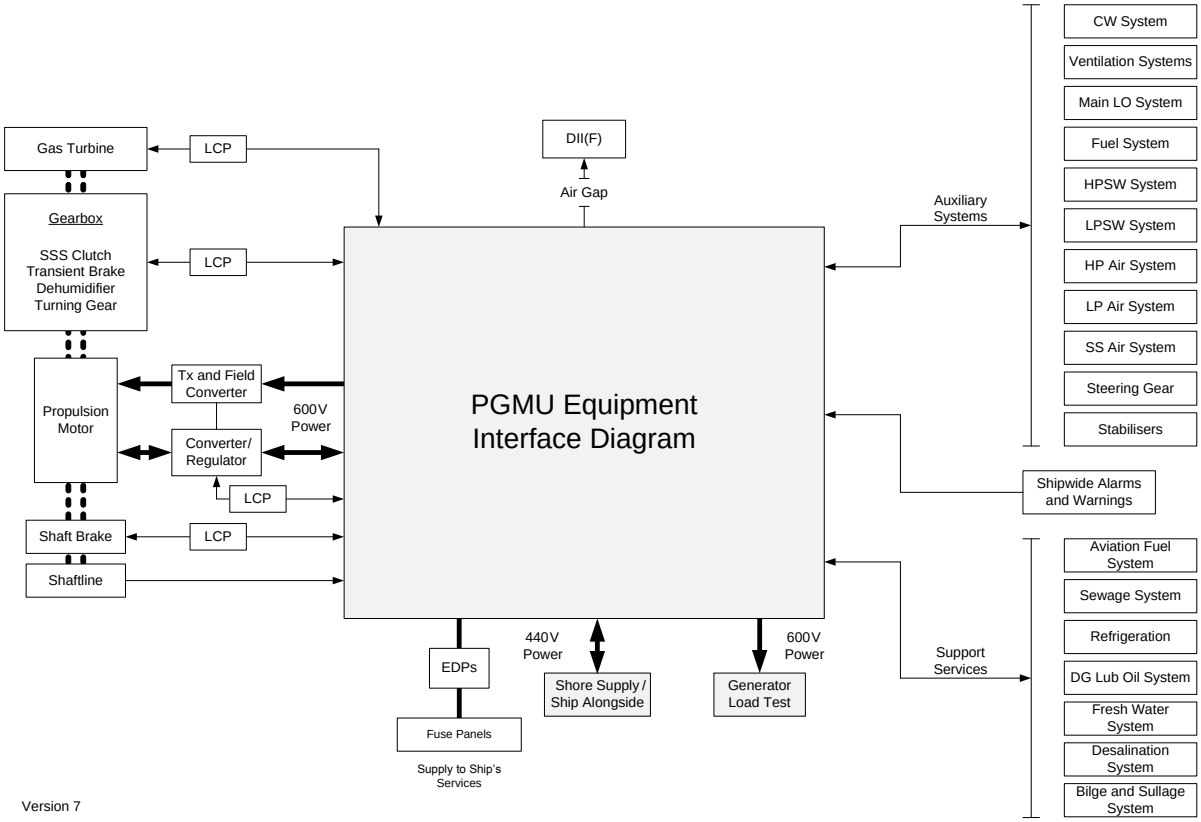


Figure 1 – PGMU Equipment Interface Diagram

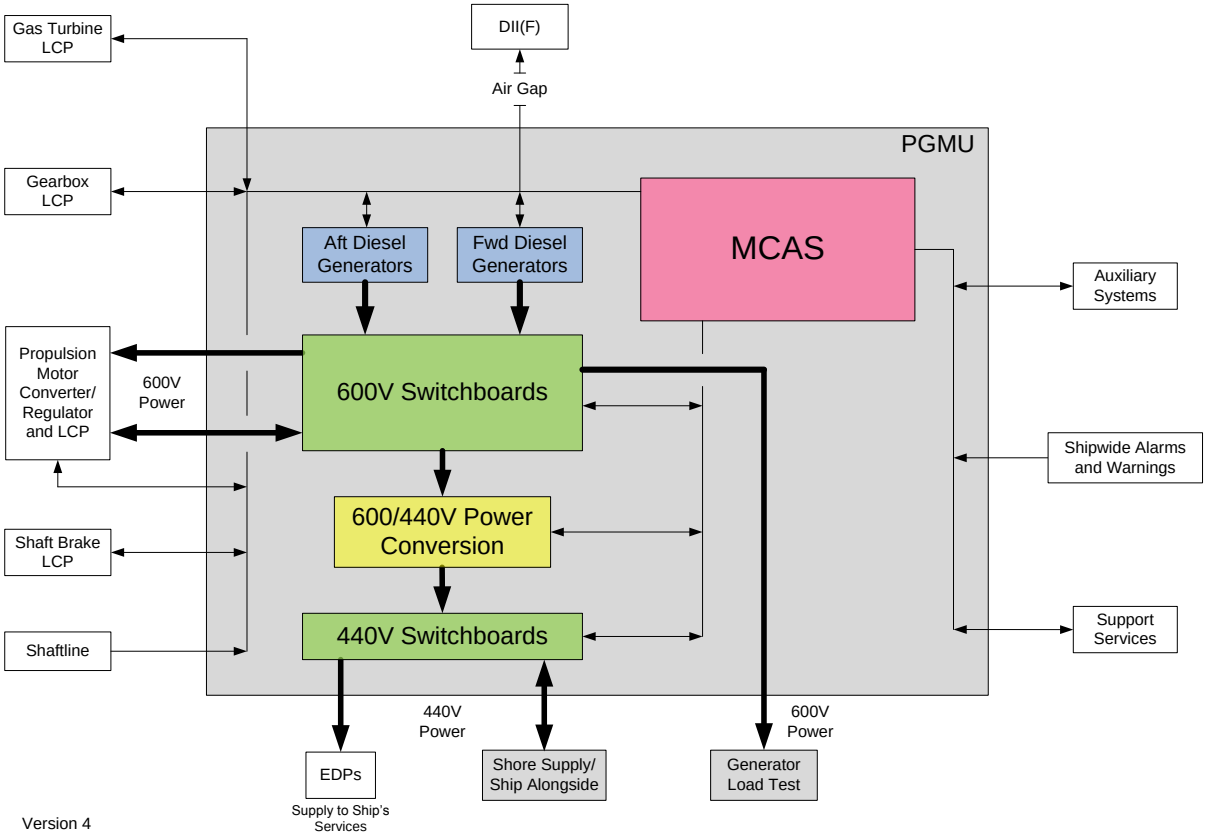


Figure 2 – PGMU Equipment Boundary Diagram

2 SCOPE OF SUPPLY

2.1 General Characteristics

2.1.1 The Type 23 Frigate is currently fitted with four 1.3MW Diesel Generating (DG) Sets which run unattended in parallel operation as required to meet the loads of two 1.5MW thyristor controlled direct current propulsion motors and two 945kW output alternating current Motor Generator (MG) sets. In order to restore design margins in the electrical distribution system to support future capability insertions, it is intended to replace these DG Sets with four new DG Sets rated at a minimum of 1.5MW and a maximum of 1.7MW. These Sets will be required to meet the propulsion load stated above and to supply two new Motor Generator sets rated at 1.25MW.

2.1.2 The four DGs will be installed in two compartments:

a. Two in the Forward Auxiliary Machinery Room (FAMR);

b. Two in the Upper Auxiliary Machinery Room (UAMR).

2.1.3 The four AVRs will be installed in two compartments:

a. Two in the Fwd Switchboard Room;

b. Two in the Aft Switchboard Room.

2.1.4 The Diesel Generator System Scope of supply shall include all equipment deemed by the Contractor to be necessary for safe and reliable operation, including but not limited to the following:

a. Marine Diesel engine;

b. Diesel driven Generator;

c. Coupling between Engine and Generator;

d. Acoustic Enclosure;

e. Raft and Resilient Mount arrangements;

f. Air start system;

g. Manual Turning gear;

h. Lubricating (lub) oil cooler;

i. All facilities required for immediate start e.g. lub oil priming;

j. Additional facilities required to enable engine start from dead ship conditions;

k. Engine driven fresh water pumps, lub oil pumps and fuel oil pumps;

l. Engine driven sea water pumps (FAMR Engines only);

m. Lub oil and fuel oil filters;

n. Exhaust and intake adaptors/ expansion bellows;

o. Exhaust emission control equipment to comply with Maritime Pollution Regulations (MARPOL) Tier II requirements (Ref. 52);

p. Fresh water / sea water heat exchanger(s);

q. Governor;

r. AVR;

s. LCP;

t. Vibration monitoring sensors.

2.1.5 The Vibration Monitoring sensors shall be of a type compatible with test equipment available to and approved by the Royal Navy (RN).

2.1.6 The Contractor shall provide two in number training sets (not including Generator) for use at HMS SULTAN.

2.1.7 The training set shall comprise all elements required to ensure the engine can be run for operator training and used for maintainer training in accordance with the Contractors training requirements.

2.1.8 The training set shall include but, in accordance with the above, not be limited to:

a. Diesel Engine;

b. On engine air start motors;

c. Manual Turning Gear;

d. Lub oil cooler;

e. All facilities required for immediate start, e.g. lub oil priming;

f. Engine driven fresh water, lub oil and fuel pumps;

g. Lub oil and fuel oil filters;

h. Exhaust and intake adaptors/expansion bellows;

i. Fresh water/sea water heat exchanger;

j. Governor;

k. AVR (this is required separately for maintainer training only);

l. LCP.

3 DIESEL GENERATOR SET REQUIREMENTS

3.1 General Performance

3.1.1 The Diesel Generator Set design should be in accordance with the general principles of Defence Standards (Def Stan) 02-313 (Ref. 25) and 08-142 (Ref 32).

a. The Contractor shall highlight in the Tender Response any areas of significant divergence from the above Def Stans.

3.1.2 The normal continuous rated output of each Diesel Generator set shall be:

a. A minimum of 1.5MW and maximum of 1.7MW;

b. 0.65-0.75 Power Factor (lagging);

c. 600V, 3 phase;

d. 61.2Hz nominal.

3.1.3 Each Diesel Generator set should be capable of supplying this power at the extreme tropical ambient conditions stated in the GTR.

a. Any de-rating factor when operating in extreme tropical conditions shall be stated by the Contractor in the Tender Response.

3.1.4 The alternative continuous rated output of each Diesel Generator set shall be:

a. 1.25MW nominal;

b. 0.8 Power Factor (lagging);

c. 450V, 3 phase;

d. 60Hz nominal.

3.1.5 The alternative output power rating should be available at the extreme tropical ambient conditions stated in the GTR.

a. Any de-rating factor when operating in extreme tropical conditions shall be stated by the Contractor in the Tender Response.

3.1.6 The Diesel Generator set shall be able to run at 110% overload in both 600V and 450V modes of operation for one hour in every 12 hours without any detriment to the equipment's specified life.

3.1.7 The Contractor shall explicitly state in the Tender response the service requirements from all ships services (i.e. sea water, High Pressure (HP) air, lub oil etc.) for the correct operation of the DG set in all conditions as defined in the GTR.

3.1.8 The Contractor shall state the volume of high pressure air (at 276 bar) required to effect 6 starts per engine without system recharge (Reference: Def Stan 02-313 (Ref. 25)).

3.1.9 The transient performance of the Diesel Generator set shall provide the correct Quality of Supply in accordance with Def Stan 61-5 (Ref. 38) throughout the Ships power range. The original designed transient performance characteristics are provided in Appendix A, which provide a baseline for the designed performance.

3.2 Dead Ship Condition Starting Arrangements

3.2.1 The Diesel Generator set shall be capable of providing full power to restore essential electrical services from a dead ship condition, as defined by Lloyd's Register Naval Ship Rules (Ref. 51). It can be assumed that stored air will be available to start the Diesel Generator set.

3.2.2 Full Diesel Generator set output power shall be achieved within two minutes following a dead ship start.

3.3 Low Pressure Salt Water

3.3.1 The Contractor shall supply at Tender Response detailed figures for the Low Pressure Sea Water (LPSW) differential pressure across the entire DG set (terminal point to terminal point).

3.4 Terminal Points

3.4.1 The engine shall incorporate terminal points in accordance with Def Stan 02-313 (Ref. 25).

3.4.2 The Contractor shall supply a terminal point diagram at Tender Response.

3.5 Anti-Condensation Heater

3.5.1 Anti-condensation heaters shall be fitted where required in accordance with the requirements set out in the GTR.

3.6 Terminal Boxes

3.6.1 Main and auxiliary terminal chambers for the Generator shall be capable of being left or right handed.

3.6.2 Provision shall be made for terminating all incoming and outgoing cables for the Diesel Generator set for which the conductor cross-sectional area is $6mm^2$ or above by means of copper compression crimped terminal lugs.

3.6.3 Terminal spacing shall ensure that the required air gap clearances are achieved with the lugs fitted.

3.6.4 Cable glands shall be sized so that a pre-terminated cable may be fed through the appropriate gland.

3.6.5 Cable glands shall be of the compression type, suitable for the marine environment.

3.6.6 Cable glands shall ensure that the enclosure integrity is maintained.

3.6.7 Terminal assemblies shall incorporate locking pins and partitions between each and every terminal operating at a voltage higher than 150V and between terminals of a different function irrespective of the operating voltage.

3.6.8 Suitable and adequate cable support and clipping arrangements shall be provided for cables running between the cable entry points and the cable termination points.

3.6.9 All terminals shall be adequately sized, taking due note of ship installation requirements where conductor cross-sectional areas are frequently required to be greater than those required by the current rating to compensate for conductor voltage drops.

3.7 Earthing

3.7.1 Each Diesel Generator set shall be provided with a minimum of two earth studs (one on each side) to enable independent earthing of the Diesel Engine and Generator to the ship's structure.

3.7.2 Earth studs shall be used for earthing the ship's structure only; they shall not be shared, for example with on-plant earth cables.

3.7.3 All sub-assemblies that form part of the Diesel Generator set shall be properly earthed to the main Diesel Generator set structure by means of an earth cable:

a. Reliance shall not be placed on the mechanical fixing arrangement.

3.7.4 Each Diesel Generator set shaft shall be provided with earthing brushes to prevent currents induced in the shaft from affecting the bearings.

3.8 Hardware Budget

3.8.1 The Acoustic Enclosure (excluding maintenance envelope) should not exceed the following dimensions:

a. Length = 6000mm;

b. Width = 2600mm;

c. Height = 3200mm.

4 DIESEL ENGINE REQUIREMENTS

4.1 General Performance

4.1.1 The engine design should be in accordance with the general principles of Def Stan 02-313 (Ref. 25).

a. The Contractor shall highlight in the Tender Response any areas of significant divergence from the above Def Stan.

4.1.2 The engine shall be able to run continuously at 25% rated load.

4.1.3 The engine shall accept either external or engine-driven salt water supplies.

4.1.4 The engine shall enable easy conversion of the basic design to suit the installation in either the FAMR or UAMR

4.1.5 The engine shall facilitate installation in either the FAMR or UAMR without modification to ship systems.

4.1.6 The engine shall have the necessary control equipment to permit the Starting and Stopping of the engine from multiple stations.

4.1.7 The engine shall have sensors to monitor the state and condition under Starting, Stopping, Standby, Normal-Running and Emergency-Running conditions.

4.1.8 The engine shall be fitted with a manual means of turning the crankshaft for maintenance purposes.

4.1.9 The engines shall withstand flooding up to the underside of the engine output shaft.

4.2 Working Fluids

4.2.1 The Contractor shall detail in the Tender Response the preferred list of fuels, oils, greases, lubricants and coolants for the Engine.

4.2.2 The Contractor shall detail in the Tender Response the expected overhaul periodicities resulting from using the products listed in their response to Section 4.2.1 above.

4.2.3 The Contractor shall detail in the Tender Response the Specific Fuel Consumption across the engine's power band from no load to full load in 5% increments.

4.2.4 The Contractor shall detail the Tender Response the limitations (if any), with evidence, in terms of engine life and overhaul periodicity when using each of the fuels, oils, greases, lubricants and coolants listed below:

a. Dieso (F76) to Def Stan 91-4 Issue 9 (Ref. 33);

b. Avcat (F44) to Def Stan 91-86 Issue 6 (Ref. 35);

c. Dieso/Avcat mix of any proportion;

d. OMD113 to Def Stan 91-22 Issue 5 (Ref. 34);

e. AL39/AL71 to Def Stan 01-5 Issue 17 (Ref. 24);

f. Appropriate greases selected from Def Stan 01-5 Issue 17 (Ref. 24);

g. A mixture of Dieso and Biofuels up to a 20% concentration of Biofuel.

4.2.5 Where the Contractor proposes to utilise sea water for lubricating oil cooling the cooler design shall incorporate features to minimise the possibility of sea water contamination of lubrication oil in the event of a cooler leak.

4.3 Heating in Standby Condition

4.3.1 The engine and its associated systems (e.g. cooling water, lubricating oil, induction air and fuel) shall incorporate, or be fitted with, adequate warming-through facilities including those sufficient to achieve suitable engine warming after an extended period of shutdown.

4.3.2 The warming-through temperature shall be sufficient to facilitate starting without reducing engine life or increasing the maintenance requirement.

4.4 Engine Start

4.4.1 The Contractor shall detail in the Tender Response a full breakdown of engine start time from a start signal being received by the LCP to the Generator being ready to take load as directed by the Main Electrical Power (MEPS) system.

4.4.2 The Contractor shall detail in the Tender Response the time taken for the engine to be ready for re-start subsequent to an engine trip.

4.5 Speed Governor

4.5.1 The speed governor shall be continuously rated.

4.5.2 The speed governor shall operate in the “droop” mode.

4.5.3 The droop shall be adjustable (nominally 3.75% ±0.25% of rated speed).

4.5.4 The speed governor should be of an electronic type.

4.5.5 The speed governor shall conform to the requirements for changes of steady-state speed specified in Lloyd’s Register Naval Ship Rules (Ref. 51).

4.5.6 The speed governor control system shall be configured so that it is fail-safe and the output of the fuel injection pumps is reduced to zero if the governor drive shaft or governor servo power supply fails.

4.5.7 The transient performance of the speed governor shall provide the correct Quality of Supply in accordance with Def Stan 61-5 (Ref. 38) throughout the Ships power range. The original designed transient performance characteristics are provided in Appendix A, which provide a baseline for the designed performance.

4.6 Induction Air System

4.6.1 The Contractor shall provide in the Tender Response an indicative design of the induction air system for each engine utilising the current upper deck air inlet positions.

4.6.2 The design should be in accordance with the general principles of Def Stan 02-313 Section 3.4.1. (Ref. 25) Details of these arrangements can be found at Book of Reference (Fiche) BR(F)6620(012) (Ref. 14).

4.7 Exhaust System

4.7.1 The Contractor shall provide in the Tender Response an indicative design of the exhaust system for each engine utilising the current superstructure exhaust arrangements.

4.7.2 The design should be in accordance with the general principles of Def Stan 02-313 Section 3.4.2. (Ref. 25) Details of these arrangements can be found at BRF 6620(012) (Ref. 14).

4.8 AR&M

4.8.1 The Mean Time Between Major Failures shall not be less than 50,000 cumulative engine hours.

4.8.2 The Mean Time Between Failures (MTBF) (repairable and non-repairable at sea) shall not be less than 2700 cumulative engine hours:

a. This figure may need to be divided into repairable at sea failure and those failures otherwise repairable at sea which cannot be repaired due to the non-availability of spares consequent on non-inclusion in the Consolidated Allowance List. In the latter case the MTBF shall be 22500 hours.

4.8.3 The Mean Time Between Faults shall not be less than 250 cumulative running hours.

4.8.4 The maximum probability of Major Uncontained Damage shall be 10^{-6} per engine running hour.

4.8.5 The average Mean Time to Repair (MTTR) for repairable at sea failures shall be less than 4 hours:

a. 95% of times to repair shall be less than 20 hours.

5 GENERATOR REQUIREMENTS

5.1 General Performance

5.1.1 Four in number Generators are required per ship and they shall, in any combination of parallel operation, up to and including all four Generators, generate the electrical power to meet the load requirements of the ship's electrical power system.

5.1.2 The Generator design should be in accordance with the general principles of Def Stan 08-142 (Ref. 32).

a. The Contractor shall highlight in the Tender Response any areas of significant divergence from the above Def Stan.

5.1.3 The Generator shall be of the brushless excitation type.

5.1.4 The Generator shall be self or magnet exciting.

5.1.5 The Generator shall be self-regulating.

5.1.6 The Generator shall be controlled by an electronic AVR.

5.1.7 The Generator shall be wound with a star connected winding.

5.1.8 The Generator neutral, or star point, shall not be connected to earth (ship's structure).

5.1.9 All windings shall be insulated to at least class F.

5.1.10 Machine temperature rises shall be limited to those for class F insulation.

5.1.11 The Generator shall be designed and constructed to withstand a system fault level of 56kA breaking and 143kA peak asymmetrical at the Generator terminals.

5.1.12 The Contractor shall contribute to overall system fault management through management of sub-transient, transient and steady state reactances.

5.1.13 The Generator shall be able to withstand 150 per cent of rated current for a period of 30 seconds without injurious heating.

5.1.14 The Generator shall be capable, in the normal working condition, of accepting the sudden application and removal of the full rated load without machinery damage.

5.1.15 The Generator, when running in the 450V mode of operation, shall be capable of synchronising and running in attended parallel with a 1.25MW rated Motor Generator set.

5.2 Excitation

5.2.1 The excitation system of the Generator should comprise a main exciter, and a Permanent Magnet Generator (PMG) which are to be mounted directly on the Generator shaft and included in the main Generator cooling air circuit.

5.2.2 If the Generator is supplied with an alternative excitation system the Contractor shall demonstrate that the Generator will meet all requirements in this TES.

5.2.3 The rotating rectifier assembly of the main exciter, together with any associated protection or surge suppression devices, shall be such as to ensure that, during normal operation, bad synchronizing or the incidence or clearance of system short circuits, the voltage and current ratings of the diodes are not exceeded.

5.2.4 Where diode protection fuses are fitted, during normal operation, bad synchronizing or the incidence or clearance of system short circuits shall not cause the fuses to rupture.

5.2.5 Where individual diode protection fuses are fitted, the fuse and diode rating shall be such that only the fuse in series with a faulty diode ruptures.

5.2.6 The excitation system shall be such that in the event of one fuse being ruptured, or a diode falling to open circuit, the machine must remain capable of continuously delivering its rated output but, in this condition, normal transient performance requirements need not be achieved.

5.2.7 Where diode protection fuses are not provided, an automatic means of stopping the Generator shall be provided

5.2.8 The PMG shall provide power to the AVR excitation control, protection and surveillance system.

5.3 Harmonics

5.3.1 The Generators shall be capable of meeting the loads imposed by the thyristor converters and MG sets.

5.3.2 The propulsion motor thyristor converter load comprises high percentages of 5th, 7th, 11th, 13th, 17th and 19th harmonics although higher order harmonics will also be present. The harmonic current under different propulsion conditions per Generator are estimated to be as follows:

Condition	Fundamental (Continuous) A	Power Factor (Lagging)	**Harmonic %**					
			5th	7th	11th	13th	17th	19th
1	500	0.35	39	7	9	5	4	-
2	900	0.5	25	9	9	5	5	4
3	1100	0.7	25	9	9	5	5	4
4	1150	0.87	20	11	7	5	3	2
5	1100 (for 15s)	0.35	39	7	9	1	4	-

Table 1 Harmonic Content

5.3.3 All Generator auxiliary equipment shall be able to function satisfactorily when operating from the distorted output voltage.

5.4 Cyclic Loading

5.4.1 The Generator shall be able to supply a load with a cyclic component of 40% rated kW load between peak to peak at a period of between 5 and 15 seconds. The mean load upon which cyclic load will be imposed is between 30% and 85% of rated kW load.

5.4.2 The Generator shall be designed to supply a load with a cyclic component of 25% rated kVA load at a period of between 5 and 15 seconds.

5.5 Cooling

5.5.1 The Generator air cooler shall be of the closed air circuit, water-cooled type, with an enclosure rated to IP44.

5.5.2 When assembled to the Diesel engine the Generator enclosure shall be able to withstand flooding up to the level of the Generator drive shaft.

5.5.3 The Generator air cooler shall be designed in accordance with Def Stan 02-329 Sections 9.6.1 & 9.6.2. (Ref. 26)

5.5.4 The Generator enclosure shall be arranged to provide emergency natural ventilation by means of easily opened doors or covers sited above shaft level.

5.5.5 The door securing arrangements shall be lever operated, screws shall not be used.

5.5.6 In this ventilated condition the machine enclosure shall have an intrinsic protection of at least IP2 as defined in BS EN 60034-5:2001 (Ref. 53).

5.5.7 The Contractor shall provide in the Tender Response, the continuous rated power output of the Generator, when operating in the emergency ventilated state under environmental conditions specified in the GTR.

5.5.8 A recognised method of cooler leak indication shall be provided.

5.6 Malsynchronisation

5.6.1 The Generator and the Diesel to Generator coupling shall be designed to withstand, throughout the life of the Generator, a maximum of twenty 120^{o} malsynchronisations and remain operational without degradation in performance after each and every malsynchronisation.

5.6.2 Any penalty for designing the Generator to withstand the above requirement shall be stated in the Tender Response.

5.7 AR&M

5.7.1 The Generator shall be designed for an MTBF for repairable at sea failures which affect the Generator operation of 30000 running hours minimum.

5.7.2 The Generator shall be designed for an MTBF for non-repairable at sea failures of 80000 hours.

5.7.3 The Contractor shall document the expected failures over 2 in number consecutive eight year periods each covering 30000 running hours identifying those Generator parts which are likely to fail and which are recommended for replacement between each period to restore full reliability for a following period.

5.7.4 The Contractor shall provide, at Tender Response, a predicted MTTR calculation for the Generator.

6 AVR REQUIREMENTS

6.1 General Performance

6.1.1 Each Diesel Generator Set shall be provided with an AVR.

6.1.2 The AVR shall provide a mechanism for selection between 600V and 450V modes of operation.

6.1.3 The transient performance of the AVR shall provide the correct Quality of Supply in accordance with Def Stan 61-5 (Ref. 38) throughout the Ships power range. The original designed transient performance characteristics are provided in Appendix A, which provide a baseline for the designed performance.

6.1.4 The AVR shall incorporate the following functions:

a. Open circuit detection of excitation diode;

b. Short circuit detection of excitation diode;

c. Over voltage protection;

d. Under voltage protection;

e. Over frequency protection;

f. Under frequency protection;

g. Individual protection for parallel running Generators;

h. Local indication of fault and trip conditions;

i. Resetting facilities;

j. Testing facilities.

6.1.5 The AVR shall be capable of operating with zero droop (astatic) or adjustable with quadrature droop compounding.

6.1.6 The AVR shall have transformer voltage drop compensation built into the inner loop.

6.1.7 The AVR shall allow voltage adjustment to be maintained from no load to full load operation and temperatures.

6.1.8 The AVR shall ensure that the breakers are tripped under short circuit conditions, by using the excitation current to assist the generator in maintaining three times full load current, ensuring the generator breakers are held closed while discriminatory protection circuits attempt to clear the fault.

6.1.9 To maintain essential supplies to the ship, differential protection shall be provided by the AVR to discriminate between internal Diesel Generator set faults and faults originating from external parts of the main power system;

6.1.10 This discrimination shall allow time for the external fault management systems to attempt to clear the fault before the AVR initiates internal diesel generator set fault management procedures.

6.2 Motor Generator Set Starting

6.2.1 The MG set induction motor will be started direct-on-line.

6.2.2 The Diesel Generators shall be designed such that it is possible to start this MG induction motor on a single unloaded Diesel Generator under the following conditions:

a. Limited AVR excitation current (“soft start”);

b. Normal AVR excitation current (“normal running”).

6.2.3 During an MG soft start, AVR protection shall be prevented from tripping the Generator supply breaker.

6.2.4 Two Generators running in parallel shall meet the following requirements:

a. With one MG set running and imposing a load on the 600V system of up to 1745kVA, 0.8pf lagging it shall be possible to start a second MG set with the 450V output from the first MG set remaining within the Def Stan 61-5 (Ref. 38) rare transient limits at the user terminals;

b. With both propulsion motors running at 150kW per shaft it shall be possible to start the MG sets sequentially.

6.3 Parallel Operation

6.3.1 The Diesel Generator set shall, when running in 600V operational mode, be suitable for unattended parallel operation with similar Diesel Generator sets.

6.3.2 Load mismatch between parallel running Diesel Generator sets at all loads between 25% load and 100% load on each set shall be no worse that 10% of the MVA rating of each set. The use of interconnecting cables for differential compounding schemes is not permissible.

6.3.3 Quadrature droop compounding schemes shall be arranged to operate with the droop permanently in circuit.

6.3.4 For unattended parallel operation, the Diesel Generator shall be capable of running continuously in parallel with a maximum of three other Diesel Generators of the same type under the control of its AVR and governor at any combined load between 20% and 100% of the combined Generator ratings:

a. Within these load limits, and without adjustment of the AVR or governor, the maximum difference between the actual kilowatt load of a Generator and its proportionate share of the total kilowatt load shall not exceed 10 per cent of the mean of the kilowatt rating of the Generators;

b. The maximum difference between the actual Generator current and its proportionate share of the total current shall not exceed 10 per cent of the mean of the rated current outputs.

6.3.5 In the 600V operating mode, any combination of the four Generators, up to and including all four Generators, shall be able to run in unattended parallel and to share the total electrical load automatically up to and including the total rating of the parallel combination.

6.3.6 Quadrature voltage droop and frequency droop shall be permanently in circuit.

6.3.7 In the 450V operating mode, the Diesel Generator shall be able to synchronise and run in attended parallel, for 5 minutes, with the MG set having the following characteristics:

a. 1250kW, 0.8 pf, 60Hz.

Note: When the Generator is running in parallel an automatic load share system is in operation (MEPS) to reduce the load share difference to within 5% of the Generator rating for any steady load between no load and rated load.

7 RAFT AND ACOUSTIC ENCLOSURE REQUIREMENTS

7.1 Ambient Acoustic Performance

7.1.1 The role of the Type 23 Frigate indicates that the platform must display a very low underwater noise signature in addition to an ability to withstand a high level of shock without detriment to either the platform or its supporting systems. The design of resilient mounting systems for machinery is therefore of paramount importance in achieving the design performance for the platform, with regard to underwater noise and shock resistance and Diesel Generators are classed as major risks to the ship's noise signature.

7.1.2 Contractors shall ensure that they fully understand the requirements for equipment mounting and that any equipment they offer is capable of achieving the standards referenced in the GTR.

7.1.3 Measures are required to minimise airborne and structural noise. They currently differ between the 2 compartments where the UAMR DGs are single mounted and do not have an acoustic enclosure but the FAMR DGs are separately acoustically enclosed and mounted on a compound mounting system. There is an aspiration within PGMU project to provide acoustic enclosures for the UAMR DGs in order to comply with Control of Noise at Work Regulations (Ref 54).

7.1.4 The Contractors shall provide acoustically enclosed DGs for installation into the FAMR:

a. Consideration should be given to retaining the original Acoustic Enclosures in the FAMR where weight and space envelopes permit.

b. Ambient noise levels from the acoustically enclosed DGs shall not exceed a level of 80dB(A) at 1m or more.

7.1.5 The Contractor shall provide DGs for installation onto the UAMR within the given weight and space envelopes:

a. Ambient noise levels from these DGs should not exceed a level of 80dB(A) at 1m or more.

b. The noise levels radiated from these DGs shall not exceed 110dB(A) at 1m or more.

7.1.6 The total environmental noise impact attributable to the DGs shall be limited to 35dB(A) at a distance of 200m.

7.2 General Requirements

7.2.1 The Acoustic Enclose shall conform to the requirements of Def Stan 02-313 Annex E (Ref. 25) except where modified below.

7.2.2 The Diesel Generator set shall be resiliently mounted and acoustically enclosed (but see 8.1.1 below).

7.2.3 The enclosure shall act as an acoustic shield. Ambient and radiated noise requirements are detailed in the GTR.

7.2.4 Acoustic panelling shall satisfy the requirements of Def Stan 02-802 Issue 1 (Ref. 29).

7.2.5 The enclosure shall minimise wild heat emission from the Diesel Generator set into the compartment.

7.2.6 The enclosure shall contain the Diesel Generator set.

7.2.7 The enclosure shall contain the combustion products and contaminants arising from a Diesel Generator set fire.

7.2.8 The enclosure shall be provided with facilities to ensure adequate circulation of air within the enclosure for cooling under all circumstances including emergency cooling of the Generator.

7.2.9 The ventilation outlet from the enclosure shall be fitted with silencers to ensure that noise requirements are not violated.

7.2.10 The enclosure shall be fitted with suitable facilities for purging the enclosure of the residue products of a fire within the enclosure, and/or any build-up of noxious fumes from the Diesel engine.

7.2.11 The facilities for enclosure cooling and purging shall ensure that direct contamination of the Diesel Generator enclosure from outside the ship during a Chemical, Biological, Radiological and Nuclear (CBRN) incident cannot occur, whether the engine is running or shut down, by ensuring that such arrangements do not involve air inlet to the enclosure directly from outside the ship, or exhaust from the enclosure directly to outside the ship.

7.2.12 The enclosures shall be designed to facilitate access to and maintenance of the Diesel Generator set.

7.2.13 The enclosure shall be capable of being disassembled (including the frame) and reinstated to allow the free removal of equipment.

7.2.14 The enclosure should be provided with fixed lighting within the enclosure, with switching arrangements outside the enclosure and adjacent to the enclosure access door.

7.2.15 The number and position of lights within the enclosure should be suitable for viewing necessary instrumentation and general viewing of the complete DG set from outside the enclosure.

7.3 Raft Requirements

7.3.1 Where the Contractor is offering a raft mounted DG set, the raft shall comply with the following requirements:

a. As many of the engine ancillary items as possible shall be mounted on the raft and those items which cannot be so accommodated are to be stated in the Tender Response;

b. The coupled natural frequencies of the raft double mounting system (which presents an underwater radiated noise hazard) should be as far below 20Hz as can be practicably achieved in order to provide maximum attenuation at the Diesel rotational frequency;

c. No natural frequency should lie in the band 10Hz ±1Hz.

7.3.2 The effect of torsional and bending resonances of the raft structural members should be minimised either by suitable structural design or by incorporating adequate damping into the raft structure.

7.4 Fire Protection

7.4.1 The Contractor shall provide a separate fire protection system for the Diesel Generator enclosure that includes a type approved fire detection system and fire suppression system which meets the requirements of Def Stan 02-313, Annex D, Section D3 and Annex E, Section E4 (Ref. 25).

7.4.2 Dependant on the type of system supplied, the system design shall comply fully with the following Standards:

a. CO2 Drench Systems: Def Stan 02-357 part 1 (Ref. 27);

b. Inert Gas Drench Systems: Def Stan 02-357 Part 4 (Ref. 28);

c. Fine Water Spray: Def Stan 02-877 (Ref. 30).

7.4.3 Where CO2 or Inert Gas systems are proposed the following documentation shall be supplied by the Contractor, at Tender Response, in order that a design review of each gas system may be carried out by the Naval Authority (Fire) prior to fabrication or construction:

a. General specification for the system;

b. Schedule of equipment and symbols used;

c. A complete set of calculations, plans, elevations and sectional drawings showing the extent of the protected enclosure and details of each installation. The following shall be identified:

   i. Copies of system design calculations. Where calculations are performed with the aid of a computer, an approved and validated program shall be used. All calculations, including flow calculations shall be submitted to the Naval Authority (Fire) for review prior to installation. Flow calculations, pipe and nozzle sizing shall be carried out in accordance with either BS 5306-4 (Ref 55) or an equivalent specification. Calculations shall show gross gas volumes, concentrations achieved over the holding time, any allowance for losses, discharge times and pipe and nozzle sizes;

   ii. The location of all gas system's equipment relative to significant items of equipment and machinery within the protected compartment;

   iii. The correct location, orientation of the nozzles and the required direction of flow from each;

   iv. Dimensions critical to correct installation, i.e. positioning of pipework and nozzles, are to be shown;

   v. The location and dimensions of pressure relief vents.

d. Schematic isometric drawings showing the proposed layout and routing of the pipework, nozzles, cylinders and all associated control equipment and locations;

e. Piping and Instrumentation Diagrams (P&IDs) including the alarm system;

f. Details of provisions made for gas storage, release mechanisms, warnings and alarms, including relay interfaces with the ships systems.

7.4.4 The fire protection system shall have a 2 shot capability.

7.4.5 A fire alarm panel shall be provided to monitor the status of the fire suppression system.

7.4.6 The fire alarm panel shall be sited on/near the enclosure.

7.4.7 Fire detectors shall be addressable and provide warning locally and to the ship's control positions and fire alarm system via the ship's fitted Fire Smoke and Flood Detection System (manufactured by Graviner).

7.4.8 Fire suppression shall not be initiated automatically on detection of the symptoms of fire within the enclosure.

7.4.9 Fire suppression shall be operated manually from the local control position.

7.4.10 The Fire Suppression shall be capable of being operated remotely, from the MCAS system.

7.4.11 The Contractor shall provide enclosure drains sufficient to drain water following a fire fighting event.

7.5 Engine Induction and Exhaust Systems

7.5.1 The Contractor shall state, at Tender Response, the nominal and maximum acceptable depression at the turbo-blower inlet.

7.5.2 The Contractor shall state, at Tender Response, the nominal and maximum acceptable back pressure at the turbo blower outlet.

7.5.3 All hot surfaces of the Diesel engine trunks within the enclosure shall be lagged.

8 RADIATED NOISE

8.1 General Requirements

8.1.1 The Generator set shall meet the noise and vibration requirements as detailed in this section for:

a. Broadband;

b. Narrowband.

8.2 Broadband

8.2.1 The broadband vibration limits defined below are the maximum vector magnitude acceleration levels on the existing machinery foundation (below mount) assuming the use of a total of eight mounts per machine.

Broadband (1/3rd Octave) Frequency	**UAMR DG**	**FAMR DG**
Hz	***dB re. 10^{-5} m/s^2***	***dB re. 10^{-5} m/s^2***
16	43.6	36.0
20	54.5	43.1
25	40.9	37.3
31.5	63.1	43.3
40	61.6	41.2
50	68.4	42.0
63	73.6	46.8
80	60.8	45.1
100	71.6	49.0
125	78.2	51.5
160	83.2	56.9
200	81.3	49.2
250	74.9	50.3
315	79.5	52.4
400	82.2	54.9
500	80.9	53.5
630	85.8	55.8
800	83.5	57.7
1000	84.5	56.7
1250	85.6	59.5
1600	83.0	60.7
2000	83.9	62.4
2500	87.0	63.8
3150	83.7	67.0
4000	82.2	65.8
5000	81.8	60.3

6300	76.8	52.1

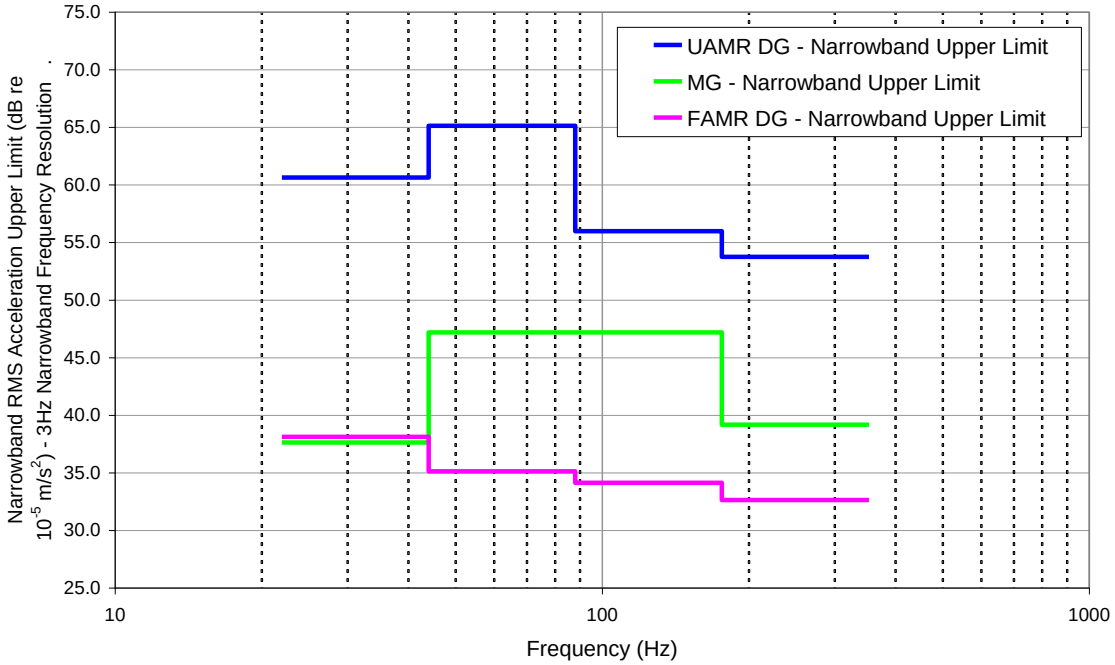
Table 2 - Broadband Vibration Limits

8.2.2 Where significant modifications to the existing machinery foundation are required to meet this requirement, the Contractor shall specify the extent of any reasonable modifications to the foundations to meet the defined limits.

8.3 Narrow Band Vibration Limits

8.3.1 Two narrow band vibration limits are defined below, both of which shall be achieved:

a. The narrow band vibration limits defined below are the maximum vector magnitude Root Mean Square (RMS) acceleration levels of the narrow band tones (3Hz resolution) on the existing machinery foundation (below mount) in each octave band, assuming the use of a total of eight mounts per machine;

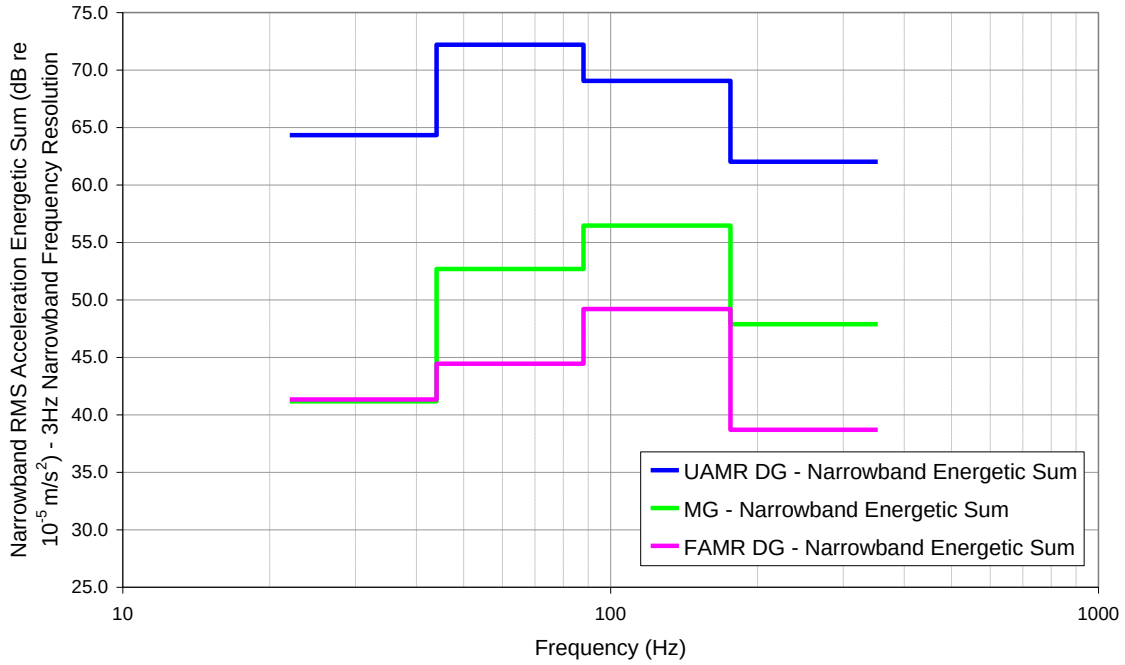


Octave Frequency Band	UAMR DG	FAMR DG
Hz	***dB re. 10^{-5} m/s^2***	***dB re. 10^{-5} m/s^2***
31.5	60.6	38.1
63	65.1	35.1
125	56.0	34.1
250	53.8	32.6

Table 3 - Foundation Narrowband RMS Acceleration Amplitude Limits (3Hz Resolution) in (Octave) Bands

b. The narrow band vibration limits defined below are the maximum vector magnitude RMS acceleration levels of the narrow band tones (3Hz resolution) on the existing

machinery foundation (below mount) energetically summed in each octave band, assuming the use of a total of eight mounts per machine.



Octave Frequency Band	UAMR DG	FAMR DG
Hz	***dB re. 1×10^{-5} m/s^2***	***dB re. 1×10^{-5} m/s^2***
31.5	64.3	41.3
63	72.2	44.5
125	69.1	49.2
250	62.0	38.7

Table 4 - Foundation Narrowband RMS Acceleration Octave Band Energetic Sum Limits of Tones (3Hz Resolution) in (Octave) Bands

8.3.2 Where significant modifications to the existing machinery foundation are required to meet this requirement, the Contractor shall specify the extent of any reasonable modifications to the foundations to meet the defined limits.

9 LOCAL CONTROL PANEL REQUIREMENTS

9.1 Functional Requirements

9.1.1 The existing MCAS system provides remote control and surveillance facilities for all major primary systems on the vessel, including propulsion and auxiliary machinery systems, and uses hard-wired and serial data links. The control of the power generation and distribution systems is undertaken by the MEPS which also uses hard-wired and serial data links. These two systems are completely autonomous. The secondary surveillance system provides continuous monitoring for both systems and uses serial data links only. For the purposes of the PGMU project, the term "MCAS" may be taken to include both MCAS and MEPS controls of the Type 23 Frigate Machinery Installation together with the Secondary Surveillance System.

9.1.2 The existing MCAS system utilises a Control Position Hierarchy which is the preferential order of available operating positions for control of the plant. The highest position in the hierarchy is the normal control position in the SCC (the Operators Console, Supervisors Desk and PECP) followed by successively lower reversionary positions or facilities such as the SECPs and DGLCPs down to on-plant level.

9.1.3 Switches on the existing DGLCPs and SECPs allow remote control to be passed to the next highest level in the Control Position Hierarchy: remote control cannot be "taken" using control positions within the SCC. Selection of local control at a DGLCP results in isolation of that DG from its sub-system controller at the SECP so that only manually selected commands from the DGLCP are obeyed. Selection of remote control at a DGLCP results in control of the DG being passed to the SECP and all local controls, with the exception of emergency stop, being inhibited.

9.1.4 Each SECP routes signals to the PECP in the SCC during Normal operation and provides a reversionary control position for the DG(s). Selection of Primary or Secondary control at the SECP results in control of the sub-system DG(s) from the selected position and disablement of the controls at the unselected position.

9.1.5 Essential hard-wired DG parameters are displayed as status indications at the associated SECP and the PECP irrespective of the local/remote switch positions. Similarly, secondary surveillance data from the DGs is passed to the SCC for display to the operators irrespective of the local/remote switch positions.

9.1.6 Details of the existing interfaces between the DGLCPs and MCAS, including remote control and surveillance functions are provided in BRs 6500(109) (Ref. 11), 6500(110) (Ref. 12) and 6500(112) (Ref. 13).

9.1.7 Instrumentation should be in accordance with Lloyd's Standards for Centralised Control Station (CCS), and be suitable for both local and remote operation.

9.1.8 An LCP shall be provided, offering facilities for DG set local control, surveillance and protection.

9.1.9 The LCP shall interface with the MCAS system, providing facilities for the remote control and surveillance of the DG set.

9.1.10 The interfaces between the LCP and MCAS shall include hard-wired and serial data connections.

9.1.11 The LCP should provide controls and displays that are consistent with the layout and style of the controls that are used elsewhere in the MCAS system:

a. If this is not possible, the LCP controls and displays shall comply with the provisions of Def Stan 00-250 Parts 2 (Ref. 22) and 3 (Ref. 23), for work equipment.

9.1.12 Where the LCP uses Human Computer Interface (HCI) screens for the display of data to the operator, the design of the HCI screens should use the RN IPMS HCI Style Guide. (Ref. 43)

9.1.13 The design of the LCP shall be such that electrical failure or damage to the LCP will not result in the propagation of the failure or damage to the MCAS system.

9.1.14 The LCP shall utilise the existing MCAS power supplies as described in the GTR Section 11.4.

9.1.15 The LCP shall include facilities for starting and shutting down of the Diesel Generator set.

9.1.16 The LCP shall provide associated Alarms/Warnings and Trip indications.

9.1.17 The LCP shall have functionality to support operation of the system when the machinery spaces are unmanned.

9.1.18 The instrumentation shall meet the requirements stated in the GTR, Section 14.

9.1.19 Additionally, if not already covered by the Contractor's 'standard fit', the following parameters shall be monitored as a minimum:

a. Engine status and speed;

b. Vibration levels at key points within the system sufficient to allow condition monitoring of the Diesel Generator System;

c. Lub oil pressures & temperatures;

d. Status and control of oil system pumps;

e. Sump/drain tank oil level;

f. Cooling water (Sea Water & Fresh Water) pressures & temperatures (including the differential temperatures and pressures across heat exchangers);

g. Status and control of all cooling system pumps and valves;

h. Cylinder exhaust temperatures;

i. Air charge temperatures and pressures (including the difference across turbochargers and heat exchangers).

9.1.20 Derived Condition Monitoring Data should be passed to the MCAS system.

9.1.21 Any interlocks in the Diesel Generator set shall be actionable at both the LCP and remote operating positions.

9.1.22 It shall be possible to override the control interlocks at the remote operating position and at the LCP subject to appropriate access controls.

9.1.23 The LCP interlock shall be physically lockable or actionable only by the correct access level log-in.

9.1.24 Any sensor or transducer whose failure will prevent the continued safe operation and surveillance of the Diesel Generator set shall at least be duplicated.

9.1.25 Means for connection of the secondary sensors or transducers shall be readily accessible from outside the affected equipment item.

9.1.26 In cases where failure or incorrect readings at the LCP may result in equipment damage, additional local indications independent of the LCP shall be provided including:

a. Engine Speed;

b. Lub Oil Pressure to Engine;

c. Lub Oil Temperature to Engine;

d. Coolant Outlet Pressure;

e. Coolant Outlet Temperature.

9.2 Remote Surveillance

9.2.1 The LCP shall pass details of channels contained in Appendix B via a network enabled serial data link to the MCAS secondary surveillance system. A list of all current signals within the MCAS systems is provided in VTC Drawing 002 582 501 (Ref. 42).

9.2.2 The Contractor shall provide details of the serial data to be monitored by MCAS to the MCAS Contractor.

9.2.3 The LCP shall provide the following hardwired signals to the MCAS system:

a. DG Group Warning Indications (5 in number);

b. DG Group Warning Audible Annunciation;

c. DG Group Alarms (3 wire);

d. LCP Malfunction (3 wire);

e. DG Common Alarm (3 wire);

f. DG Start/Running;

g. DG Stopping/Shutdown.

9.2.4 The LCP shall provide the following signals hardwired to the SECP:

a. DG Tripped Alarm;

b. DG Group Warning;

c. DG Running;

d. DG Stopped;

e. DG Start Interlocks Complete;

f. Open Breaker Request;

g. Secondary Electrical Control Panel (SECP) Control Available (when remote control is selected at the LCP, the SECP Control Available lamp shall illuminate except when the DG is in a shutdown state or start fail condition).

9.3 Local Control

9.3.1 The following hard-wired DGLCP control functions shall be available from the LCP front panel when the DGLCP local/remote switch is set to local:

a. Diesel Start;

b. Diesel Stop;

c. Frequency Increase/Decrease;

d. Alarm Trip Inhibit;

e. Modify Parameter Limits.

9.3.2 The following DGLCP control functions shall be available from the LCP front panel irrespective of the position of the DGLCP local/remote switch:

a. Local/Remote Control;

b. Accept and Reset of any Warning or Alarm Channels;

c. LCP Power On/Off;

d. DG to standby/maintenance mode (Note: this applies only if the Diesel is stopped);

e. Diesel Emergency Stop.

9.4 Remote Control (at SCC)

9.4.1 The following hard wired Ship Control Centre (SCC) control functions shall be available at all times, irrespective of DGLCP local/remote switch position and SECP Primary/Secondary switch position:

a. Diesel Emergency Stop.

9.4.2 The following hard wired Ship Control Centre (SCC) control functions shall be available when the DGLCP local/remote switch is set to remote, irrespective of the SECP Primary/Secondary switch position:

a. Inhibit Selected Trips.

9.4.3 The following hard wired Ship Control Centre (SCC) control functions shall be available when the DGLCP local/remote switch is set to remote and the SECP Primary/Secondary switch is set to Primary:

a. DG set Start;

b. DG set Stop.

9.4.4 The acceptance of warnings via the serial data link shall be enabled at all times when the DGLCP is available.

9.4.5 The “Inhibit Selected Trips” function should allow the SCC operator to override any of the following parameters which normally would trip an engine:

a. Engine Speed greater than 110%;

b. Lub Oil Temperature to Engine High;

c. Coolant Outlet Pressure Low;

d. Coolant Outlet Temperature from Engine High.

9.5 Remote Control (at SECP)

9.5.1 The following hard wired SECP control functions shall be available when the DGLCP local/remote switch is set to remote and the SECP Primary/Secondary switch is set to Secondary:

a. DG set Start;

b. DG set Stop;

c. Automatic Frequency Increase/Decrease (Note: automatic synchronisation and load sharing functions are inhibited when the DG is stopped);

d. Manual Frequency Increase/Decrease (Note: this function is inhibited if automatic frequency control is selected).

9.6 Remote Emergency Stop

9.6.1 An Emergency Stop of the Diesel Engine shall be initiated by a pull-wire operated by a manually-operated lever situated outside the relevant Auxiliary Machinery Room.

9.7 Warnings General

9.7.1 The LCP shall provide warning information for local display and for remote MCAS systems.

9.7.2 There shall be no interaction between the local acceptance of warnings and the remote facility:

a. Acceptance of warnings locally shall not accept the warning from the SCC MCAS system but acceptance of warnings from the SCC will also accept warnings at the LCP.

9.7.3 All remote group warning signals and associated group warning logic shall remain active at all times regardless of control position selected (unless the DG is shutdown whereby the warning channels are auto-inhibited).

9.8 Alarms - General

9.8.1 The LCP shall provide alarm information for local display at the LCP and remotely at the MCAS Systems.

9.8.2 There shall be no interaction between the local acceptance of alarms and the remote facilities of MCAS:

a. Following an engine trip alarm, the indication at the SCC shall only be reset at the SCC.

9.8.3 Four types of alarm are required to be output from the LCP for annunciation at the SCC and SECP:

a. DG Group Alarm (MCAS Alarm Logic Rack);

b. DG Common Alarm (MCAS Alarm Logic Rack);

c. LCP Malfunction (MCAS Alarm Logic Rack);

d. Group Trip Alarm (MEPS - any Engine Trip Condition).

9.9 Alarms - Remote

9.9.1 The appropriate alarm shall remain until the parameter(s) causing the alarm condition have been cleared and the alarms reset at the SCC.

9.9.2 A malfunction alarm shall not trip the DG but will fail-set the LCP and require reset locally before the malfunction alarm is cleared from the SCC.

9.9.3 Remote Alarms to MEPS – whenever a group warning or common alarm is generated by the LCP a signal to MEPS via volt free closing contacts shall initiate a MEPS warning at the SECP.

9.9.4 The above alarms shall remain until the parameter(s) are cleared and reset at the LCP before being reset at the SECP.

9.10 Environmental

9.10.1 The LCP watertightness shall be iaw IP56.

10 TRANSVERSE REQUIREMENTS

10.1 Shock

10.1.1 The Generator shall meet the requirements for survivability under a shock event as detailed in the GTR.

10.1.2 For the calculation of shock effects on the Equipment the following Grade Curves should be applied:

a. UAMR Equipment: Grade D;

b. FAMR Equipment: Grade AB.

10.2 Removal

10.2.1 It shall be possible to decouple the engine from the Generator to allow either component to be removed from the ship.

10.2.2 To facilitate the removal of the Diesel engine and/or Generator the enclosure shall be designed to be dismantled to component parts which are small enough to remove from the compartment, as specified in GTR Section 7.9.

10.2.3 Suitable lifting and jacking points shall be provided on both the Generator and the Diesel engine to allow both components to be independently manoeuvred within the machinery space.

10.2.4 Suitable lifting points shall be provided on both Generator and Diesel engine to allow independent removal of either component from the ship via a single vertical lift with the equipment held horizontally throughout.

10.2.5 The aft Diesel Generators (located in the UAMR) shall be capable of being removed from the ship through removal openings of dimensions detailed in the GTR which are built into the deck directly above.

10.2.6 The forward Diesel Generators (located in the FAMR) shall be capable of being removed from the ship through removal openings of dimensions detailed in the GTR.

10.3 Maintainer Workload

10.3.1 The Diesel Generator set shall require no more man hours per week of maintenance by on board maintainers to meet all planned and reasonably foreseeable corrective maintenance than currently carried out.

10.3.2 The Contractor shall detail the envisaged onboard maintainer workload at Tender Response.

10.3.3 The Diesel Generator System shall be capable of being maintained by maintainers' of the skill level as detailed in the GTR.

10.4 Testability

10.4.1 All diagnostic indications and maintainer information generated within the system shall be accessible and interpretable by on board maintainers trained in accordance with the Contractor's training deliverables

10.5 Maintenance

10.5.1 Facilities, procedures and appropriate gauges shall be provided to enable alignment checks between the engine and alternator to be undertaken.

10.5.2 Facilities, procedures and appropriate gauges shall be provided to enable crankshaft deflections to be measured.

10.5.3 The Contractor shall ensure that all planned maintenance and servicing of the Diesel Generator set can be achieved without removing the Diesel Generator from the ship.

10.5.4 The Contractor shall provide, at Tender Response, the maintenance envelope for planned maintenance and servicing.

10.5.5 The Contractor shall provide, at Tender Response, the lifting requirements for planned maintenance and servicing.

10.5.6 The Contractor shall ensure that all major component failures that could be reasonably anticipated can be repaired without removing the Diesel Generator from the ship (to include repair of crank or camshaft failures).

10.5.7 The Contractor shall provide, at Tender Response, the maintenance envelope for all major component failures that could be reasonably anticipated.

10.5.8 The Contractor shall provide, at Tender Response, the dimensions of the largest component which may be required to be changed after a major failure.

10.5.9 All engine pressure and temperature level sensors shall be designed for ease of testing.

10.5.10 Test points shall be provided for sampling engine oil and cooling water.

10.6 Drawings

10.6.1 The Contractor shall provide, at Tender Response, documentation including, but not limited to, the following :

a. A General Arrangement drawing of the DG sets;

b. A Product Breakdown Structure;

c. Diagrams of all on-engine systems;

d. Diagrams of loose assemblies;

e. Diagrams showing terminal points, including the output coupling;

f. Diagrams showing withdrawal spaces, maintenance envelopes, lifting arrangements and Centres of Gravity (CofG).

11 REFERENCES

11.1 Books of Reference

Ref. 11	BR6500(109)	Main Electrical Power System, Type 23 Frigates, Edition 96_05 Amendment 02.
Ref. 12	BR6500(110)	Main Electrical Power System (FIDA), Type 23 Frigates, Edition 97_03 Amendment 02.
Ref. 13	BR6500(112)	Main Electrical Power System, Control Equipment, Type 23 Frigates, Edition 95_05 Amendment 05
Ref. 14	BR(F)6620(012)	Diesel Generator Intakes and Exhausts, Type 23 Frigates, Amendment 2 dated 01 Jan 1991.

11.2 Defence Standards

Ref. 21		Not Used.
Ref. 22	Def Stan 00-250 Part 2	Human Factors for Designers of Systems, Particular People-Related Requirements, Issue 01 dated 23 May 2008.
Ref. 23	Def Stan 00-250 Part 3 Section 15	Human Factors for Designers of Systems, Technical Guidance: Work Equipment, Issue 01 dated 23 May 2008.
Ref. 24	Def Stan 01-5	Fuels, Lubricants and Associated Products. Issue 17 dated 31 Mar 2011.
Ref. 25	Def Stan 02-313	Diesel Engines for Marine Propulsion and Auxiliary Machinery, Amendment 1 dated 01 July 2002.
Ref. 26	Def Stan 02-329	Requirements for Heat Exchangers for HM Surface Ships and Submarines (Cat 2) Issue 3 dated 9 April 2010.
Ref. 27	Def Stan 02-357 Part 1	Requirements for Gaseous Firefighting Systems for Machinery Compartments in Surface Ships (Cat 1). Amendment 1 dated 20 July 2011.
Ref. 28	Def Stan 02-357 Part 4	Requirements for Gaseous Firefighting Systems for Main and Auxiliary Machinery Spaces on Surface Ships (Cat 1). Amendment 1 dated 20 July 2011.
Ref. 29	Def Stan 02-802	Requirements for Mineral Wool Products for Acoustic and Thermal Insulation (Cat 2). Issue 1 dated 18 July 2008.
Ref. 30	Def Stan 02-877	Requirements for Fine Water Spray Firefighting Systems for Main and Auxiliary Machinery Spaces on Surface Ships (Cat 2). Issue 2 dated 12 Nov 2009.
Ref. 31		Not Used.
Ref. 32	Def Stan 08-142	Requirements for Main 60 Hz Generators, Issue 03 dated 17 February 2006.
Ref. 33	Def Stan 91-4	Fuel, Naval, Distillate NATO Code F-76: Joint Service Designation DIESO F-76. Issue 09 dated 3 May 2013.
Ref. 34	Def Stan 91-22	Lubricating Oil, Diesel Engine: Severe Service, Grade 40, NATO Code No: O-278 Joint Service Designation: OMD-113. Issue 5 dated 18 Jan 2006.
Ref. 35	Def Stan 91-86 Issue 6	Turbine Fuel: Aviation Kerosene Type: High Flash Type Containing Fuel System Icing Inhibitor NATO Code: F-44 Joint Service Designation: AVCAT/FSII. Issue 6 dated 20 Mar 2009.

Ref. 36		Not Used.
Ref. 37		Not Used.
Ref. 38	Def Stan 61-05 Part 4	Low Voltage Electrical Power Supply Systems Quality of Electrical Power Systems in HM Ships - Issue 4, May 2006

11.3 MOD Documents

Ref. 41		Not Used.
Ref. 42	VTC Drawing 002 582 501	T23 MCAS Signal Schedule Issue 10 dated 16 Aug 1993.
Ref. 43	MOD12J48R08	RN IPMS HCI Style Guide Draft B dated 01 April 2011.

11.4 Other Standards

Ref. 51	LR NSR 2012	Lloyd's Register Naval Ship Rules dated January 2012.
Ref. 52	MARPOL Annex VI	International Maritime Organization - International Convention for the Prevention of Pollution from Ships (MARPOL), Annex VI - Regulations for the Prevention of Air Pollution from Ships
Ref. 53	BS EN 60034-5:2001	Rotating Electrical Machines dated 15 June 2001.
Ref. 54	Statutory Instrument 2005 No. 1643	Control of Noise at Work Regulations dated 2005.
Ref. 55	BS 5306-4:2001 +A1:2012	Fire extinguishing installations and equipment on premises. Specification for carbon dioxide systems dated August 2001.

12 ABBREVIATIONS, ACRONYMS AND DEFINITIONS

12.1 Abbreviations and Acronyms

A	
ACOS	Automatic Changeover Switch
AMR	Auxiliary Machinery Room
AR&M	Availability, Reliability and Maintainability
AVR	Automatic Voltage Regulator
B	
BCD	Build Contract Definition
BR	Book of Reference
BR(F)	Book of Reference (Fiche)
BS	British Standard
C	
CBRN	Chemical, Biological, Radiological and Nuclear
CCS	Centralised Control Station
CODLAG	Combined Diesel Electric and Gas
CofG	Centre of Gravity (of an equipment)
D	
DG	Diesel Generator
Def Stan	Defence Standard
DGLCP	Diesel Generator Local Control Panel
E	
EM	Electric (Propulsion) Motor
F	
FAMR	Forward Auxiliary Machinery Room
FW	Fresh Water
G	
GA	Group Alarm
GTR	General Technical Requirements (document)
GW	Group Warning
H	
HCI	Human Computer Interface
HP	High Pressure
HPSW	High Pressure Sea Water
I	
ITT	Invitation to Tender
J, K, L	
LCP	Local Control Panel
LIFEX	Life Extension (programme)
LP	Low Pressure
LPSW	Low Pressure Sea Water
LR	Lloyd’s Register of Shipping
Lub Oil	Lubricating Oil

M	
MARPOL	Maritime Pollution Regulations
MCAS	Machinery Control and Surveillance System
MEPS	Main Electrical Power System
MG	Motor Generator
MTBF	Mean Time Between Failure (or Fault)
MTTR	Mean Time to Repair
N	
NDP	Naval Design Partnering
O	
OSD	Out of Service Date
P	
P&ID	Piping and Instrumentation Diagrams
PECP	Primary Electrical Control Panel
PGMU	Power Generation and MCAS Update
p.f.	Power Factor
PMG	Permanent Magnet Generator
Q, R	
RMS	Root Mean Square
RN	Royal Navy
S	
SCC	Ship Control Centre
SECP	Secondary Electrical Control Panel
SoW	Statement of Work
SRD	Statement of Requirements Document
SS	Special Service (Air System)
SSS	Synchronous Self Shifting (clutch)
SW	Sea Water
T	
T23	Type 23 Frigate
TES	Technical Equipment Specification
U	
UAMR	Upper Auxiliary Machinery Room
V, W, X, Y, Z	

12.2 Definitions

A	
Auxiliary Equipment	Auxiliary Equipment includes: a. Chilled Water System; b. Ventilation System; c. Main Lub Oil System; d. Fuel System; e. HP Seawater System; f. LP Seawater System; g. HP Air System; h. LP Air System; i. SS Air System; j. Steering Gear; k. Stabilisers.
B	
Broad Band	An unfiltered signal from a wideband source covering part of the frequency response, using bands of normally 1 kHz.
C	
CODLAG Drive	A combination of EM propulsion motors and Gas Turbines used to deliver propulsive power to the platform.
Condition Based Maintenance	Condition-based maintenance is maintenance when need arises, performed after one or more indicators show that equipment is going to fail or that equipment performance is deteriorating.
Control	1. That function of the system that initiates or adjusts operations as needed to achieve the plan, or to maintain variations from system objectives within allowable limits. 2. Types of control are: a. Automatic; b. Manual; c. Servo Manual. 3. The PGMU is to support three automatic modes of control from the SCC or secondary control positions as follows: a. Automatic - Acting in a manner essentially independent of operator influence or control. These sequences will be initiated automatically by PGMU following changes in the system status, for example the sharing of load between Generators when an additional Generator has been started and synchronised; b. Semi-Automatic - Acting with minimal operator intervention. For example a sequence controlled by PGMU (such as an engine start sequence) which requires a manual input from the operator (such as manual synchronisation) before further automatic control such as load sharing; c. Operator Initiated Automatic Control - Employing operator rather than software control logic to initiate a sequence of events which

	then proceed automatically. Typical operator initiated control sequences include engine start to idle, and reconfiguration of propulsion drive modes. 4. Manual - Step by step open-loop control by the operator from the position in control. This may be from the SCC or a secondary control position with the system in remote control, or a system local control panel with the panel in local control. Manual control allows the operator to control individual components of a system, such as opening/shutting a valve or starting/stopping a pump and is the method of controlling most Auxiliary Systems and Support Services. 5. Servo Manual Control - Operator inputs are connected from dedicated input devices directly to the plant items concerned such that changes in machinery state are direct responses to specific operator commands. Servo manual controls are outside the PGMU boundary. 6. The PGMU system Control Position Hierarchy shall be: a. Remote - Automatic and Manual control using the MCAS system: i. From the Ship Control Centre (Operators Console, Supervisors Desk and PECP); ii. From the Fwd and Aft Switchboards (SECP). b. Local - Automatic and Manual control using system Local Control Panels independent of the PGMU; c. On Plant - Manual control using on plant actuators, hand wheels and buttons. On plant control is to give basic and emergency local control and machinery protection without the involvement of PGMU.
Cruising State	Normal peacetime operating state.
D	
Damage Control State	A ship's posture defining the manning active aboard the ship and the equipment in use.
Dead Ship Condition	'Dead ship condition' means that the entire machinery installation, including the power supply, is out of operation and that the auxiliary services for bringing the main propulsion systems into operation (e.g. compressed air, starting current from batteries, etc.) and for the restoration of the main power supply are not available.
Draw	The act of demanding current, therefore electrical power, from a set of electricity source supply terminals.
Distribute	Delivering to the intended recipients.
E	
Electrical/Electronic Interfaces	Electrical/Electronic Interfaces include connections to: a. 600V and 440V power systems; b. Converted power supplies; c. Sensors; d. Actuators; e. LCPs; f. Equipment starters.
EM	Electric Motors used for propulsion.
EM Drive	Electric Motors used to deliver propulsive power to the platform.

EM Max	Electric Motors delivering their maximum propulsive power. If in CODLAG drive, the contribution of the Electric Motors to overall propulsive power with the EM Bias control set to 100%.
EM Zero	Electric Motors delivering their minimum propulsive power. If in CODLAG drive, the contribution of the Electric Motors to overall propulsive power with the EM Bias control set to 0%.
End of Life Margin	Capacity within the platform in terms of space, weight and electrical power above and beyond that required at the time of manufacture to account for additional equipment to be fitted later and growth in the platform itself.
Essential Equipment	All equipment on ACOS.
Events	Events include: a. Authorised Maintainer access (Login/Logout); b. Telegraph order changes and acknowledgements of engine and revolution settings; c. Use of manual inhibits and enabling of warning parameters; d. Changes to Modifiable Parameters including coefficients, constants and warning trigger levels; e. Resetting of stored information by the operator; f. Modification of Log Contents and selection of parameters for recording; g. Operation of plant override facilities; h. Plant and system configuration changes; i. Alarms and alarm status changes; j. Warnings and warning status changes; k. MCAS system faults including data channel failures and serial data link failures; l. Unauthorised attempts to access MCAS.
External Location	On deck, on shore and alongside.
F, G	
Generate	To independently produce.
H, I	
Inhabited Spaces	All normally accessible locations within the ship.
Internal Location	Within the ship.
J, K, L, M	
Monitor	Automatically and continuously compare gathered plant data against pre-set criteria and, where the criteria are exceeded or faults are detected, raise alarm or warning indications to the operator or initiate an automatic control response.

N	
Narrow Band	A filtered signal from a wideband source, using bands of 1 kHz or less.
O	
Operate	To put into, or to continue in, operation or activity; as, to operate a machine.
Operator	A person who is responsible for operating a system and is defined to be an integral part of the system.
Out of Limits Operation	A situation in which the measured parameters from equipment are outside the normal bounds within which the equipment is expected to run. This generally indicates a fault and will produce an alarm or warning.
P	
Propulsion Equipment	Propulsion Equipment includes: a. Gas Turbines; b. Gearboxes including: i. SSS Clutches; ii. Transient Brakes; iii. Dehumidifiers; iv. Turning Gear. c. Propulsion Electric Motors including: i. Converter/Regulators. d. Shaft Brakes; e. Shaftline Equipment.
Propulsion Functions	Those systems required to allow the platform to 'Move' in the maritime environment functions. This encompasses all equipment in the propulsion train.
Propulsion State	A level of propulsive power on a scale of: Full Ahead, Half Ahead, Stop, Half Astern, Full Astern.
Q, R	
Running State	Whether equipment is on or off.
S	
Shaftline Equipment	Shaftline Equipment includes: a. Plummer Bearings; b. Torsionmeters; c. Shaft Speed sensors.
Ship Services	All equipment within the platform required for the safe operation of the vessel and the provision of Hotel Services to support both personnel and equipment.
Support Services	Support Services include: a. Aviation Fuel System; b. Sewage System; c. Refrigeration Plant; d. DG Lub Oil System; e. Fresh Water System;

	f. Desalination Plant; g. Bilge and Sullage System.
Switchboard Room	A compartment containing a 600V switchboard, a 440V switchboard and a Secondary Electrical Control Panel.
T	
Third Octave Band	A range of frequencies covering one third of an octave.
U	
Underwater Radiated Noise	The component of vibration transmitted through the ship-water interface.
V, W, X, Y, Z	