1 - INTRODUCTION

The present document describes the enquiry for **five (5) Medium Speed Dual Fuel Generator Engines with SCR** to be installed on board of an ocean-going Cruise Passenger Vessel for world-wide cruises.

DF Generator Engines shall be certified for installation in Gas Safe Machinery Space.

Accessibility to ordinary maintenance tasks shall be granted at each component that needs particular inspection / overhauling. Interfaces with the external systems shall be according Builder standards and following detailed engineering of the Builder.

The entire scope of supply shall be following all the specific requirement stated in this document and relevant references, plus what is specifically necessary accordingly to the standard design of the equipment to grant the relevant safe and reliable operation.

The Scope of the Work has to include:

3.0 - SCOPE OF SUPPLY

3.1 - RESPONSIBILITIES

Ancillaries & associated systems		
WBS	L010	
		REFERENCE SPECS
		DESIGN
		FUNCTIONAL
S		Piping system (inside the engine/ packages)
SY		External piping system
S		Electrical systems (internal engine/ packages or panels))
SY		External electrical systems
S		Purchasing technical specification
S		Class approval
		CO-ORDINATION
SY		Coordination plans supply
S		Check and approval (if necessary/required)
SY		Building plans supply
S		Check and approval (if necessary/required)
		DETAILED
S		Dimensional/lay-out drawings
S		Equipment & material lists & spares according to Spares section
S		As built
		SUPPLY
S		Equipment
S		Material
S		Cable for connections (internal engines/packages or panels))
SY		Cable for all external connections
S		Piping for connections & accessories (internal engine/packages)
SY		External piping connections & accessories
		SPARE PARTS & TOOLS
S		Spare parts shall be delivered in accordance with Recommendation by Classification Society and as per Spare Parts and Tools section
		ERECTION
SY		Installation

3.2 - DESCRIPTION OF THE ACTIVITIES INCLUDED IN THE SCOPE

The Supplier will be responsible of the following activities:

3.2.1 - DESIGN

Functional and executive designs of the system and its components.

The Supplier has also to provide all the necessary indications for correct erections and interconnection of the main units and packages and for correct interface between the supplied system and the others ship systems (mechanical and electrical ones).

For the equipment selection and design, the Supplier shall consider the maximum allowed dimensions related to the available spaces on board according to the following arrangement.

3.2.2 – RISK ASSESSMENT

The Ship will be equipped with an LNG Storage and Supply System that will undergo a Risk Assessment process. Considering that Dual Fuel Engines are part of the LNG System, Supplier is requested to participate to all the Risk Assessment steps and will provide, in his area of responsibility, all the information, documentation and studies deemed necessary for the Risk Assessment itself.

Main phases foreseen for Risk Assessment are :

- HAZID
- FMEA
- HAZOP

3.3 - SUPPLY

The supply of a complete system as follows:

- Number three (3) 12 cylinders V Dual Fuel Engine with Selective Catalytic Reduction System (S.C.R.) and Gas Valve Unit F/C tag :
    - Engines **XB/274 B - D - E**
    - SCR **XA/253 B - D – E**
    - GVU **XD/274 B – D - E**
- Number two (2) 9 cylinders L Dual Fuel Engine with Selective Catalytic Reduction System (S.C.R.) and Gas Valve Unit F/C tag :
    - Engines **XB/274 A – C**
    - SCR **XA/253 A – C**
    - GVU **XD/274 A – C**

manufacturing. A detailed schedule to be foreseen for project monitoring after purchase order.

Drawing description	Time schedule
Tab F – DEVIATION LIST	With offer
Tab.A2 – Supply Information	With offer
Tab.A3 – Automation Signals	With offer
Tab.A4 – Spare Parts Lists	With offer
Maintenance Information	With offer
DIMENSIONAL DRAWINGS	With offer
Preliminary P&I or enriched process flow diagrams	With offer
ELECTRICAL DRAWINGS – BLOCK DIAGRAM	With offer
Double wall equipment ventilation preliminary pressure loss curves	With offer
Performance curves VS Methane Number	With offer
ENGINEERING DELIVERABLES	With offer
PRELIMINARY PROJECT SCHEDULE	With offer

Any offer without the above mentioned documentation will not be considered acceptable.

3.4.2 - DEVIATIONS

Any deviation from Ship Specification, inquiry specification and documents mentioned in it must be clearly listed using the relevant form attached (Tab F) for discussion and acceptance . Deviation list agreed will be part of purchase technical specification (E5). Any deviation of the supply not managed by means of the above mentioned procedure will be treated as defect.

TAB F DEVIATION LIST

Document nr	Page #	Requirement	Supplier comment and proposal	FC statement	Status

3.4.3 - DOCUMENTATION TO BE PROVIDED AFTER ORDER

All drawings shall be clearly marked with the reference number and title/description assigned by Fincantieri according to the following table.

The time schedule for all the documents foreseen after the order is indicated and it shall be agreed between parties before the order placement. The final agreed scheduling will be included in the Technical Specification for Order and will be considered as an integral part of the contract.

	Drawing description	Time schedule
	Dimensional drawing of all the items included in the scope with piping connections and foundation complete with seatings and resilient mounting arrangement for foundations. 3D CAD model for equipment and main components	30 day after order
	Piping and instrumentation diagram (P&ID) complete with • component & instrument list • mass & heat balance calculations • evidence of battery limits	30 day after order
	Electrical and automation drawings complete with • Component list • Signal list • Dimensions of panels and main electrical components	60 day after order
	Details drawings and accessories booklet	30 day after order

Dimensional drawing of all the items included in the scope for SCR with piping connections and foundation complete with seatings and resilient mounting arrangement for foundations. 3D CAD model for equipment and main components	30 day after order
Piping and instrumentation diagram (P&ID) for SCR complete with • component & instrument list • mass & heat balance calculations evidence of battery limits	30 day after order
Electrical and automation drawings for SCR complete with • Component list • Signal list • Dimensions of panels and main electrical components	60 day after order
Main Diesel Engine and SCR Blockdiagram (*)	30 day after order
FAT procedure	According to ATN340301
Operating / Instruction manuals (copies and formats as per ATN340301)	Within the delivery of the units to the Ship Yard
Procedure for delivery and test of units onboard	30 days after FAT

In addition to above the following to be included:

- List of engineering deliverables shared between parties to be updated on a regular basis
- Project scheduling shared between parties to be updated on a regular basis
- Quality Control Plan

4.0 – GENERAL DESCRIPTION OF THE ENQUIRY

4.1 - SHIP SITE CONDITIONS

According to Tab.A1 attached.

1.1 GENERAL

1.1.1 INTRODUCTION

If not otherwise stated or modified in the Specification, the standard, workmanship, quality of materials, finish and complexity of hull, machinery, auxiliaries, ventilation, piping, ducting and electrical installations, machinery spaces and technical rooms, voids, trunks and tanks etc of the Vessel shall be equivalent to Hull 6310 Sun Princess as built (Reference Ship), and the standard, workmanship, quality of materials, finish and complexity of all the passenger and crew spaces as accommodation, public rooms, and open decks of the Vessel shall be equivalent to Hull xxxx Mardi Gras according to A2 Drawings.

1.1.2 SHIP PURPOSE

The vessel is to be designed and built as a passenger vessel for worldwide all season operation, including Suez Canal transit.

1.1.3 OPERATING ENVIRONMENT

Machinery and equipment, including such as installed in exposed locations, shall be capable of being operated at a minimum ambient external air temperature of -10 deg C and maximum air external temperature of +35 deg C. The vessel's machinery shall be designed to operate in a sea water temperature range of 0 deg C minimum to +32 deg C maximum. For HVAC detailed conditions see Section 9.

1.1.4 CYBERSECURITY RISK MITIGATION MEASURES

A concept for implementation of Cyber Security prevention is to be developed by Buyer with the Builder and the systems suppliers at early design stage and consequently applied to the entire system architecture.
Cybersecurity risk mitigation measures shall be identified, implemented and verified for the following systems and all related or interfaced subsystems:

- ESD
- HVAC Automation
- IAMCS
- SMCS
- INS
- any other Class relevant Safety Systems
- Propulsion Control System
- Stability Computer System
- VDR
- Dynamic trim and support system

The design and system architecture of the systems is to respect and support the requirements of Cyber Security prevention.
The IEC62443 is to be used by all parties as a guideline for assessment, implementation and verification.

The Builder and system suppliers are to provide an asset inventory of all involved components as a basis for the cyber security assessment.

1.2 ENERGY BALANCES

1.2.1 GENERAL

The Builder is to provide preliminary steam and electrical energy balances as detailed in Appendix XXV and Appendix XXVI.

According to Article 1.8 of the Contract, Builder shall procure that a certificate, issued by the Classification Society, is provided confirming the Vessel's Energy Efficiency Design Index (EEDI).

The method of calculating and verifying the EEDI shall be according to IMO resolution MEPC.245(66) as amended by MEPC.281(70), and MEPC.254(67) as amended by MEPC.261(68). The exclusion of diesel-electric propulsion from calculating the EEDI formula referred to in MEPC 245(66) shall not be applicable in this instance.

For clarification, the terminology of MEPC 245(66) with respect to the SFC of the 'auxiliary generators' shall be taken as referring to the SFC of the main generators of the Vessel.

A preliminary value of the EEDI is shown in the calculation given in Appendix XXII of the Specification. The procedure for the development of and verification of the EEDI shall be carried out with the Classification Society according to the procedures given in MEPC.254(67) as amended by MEPC.261(68).

The calculation of the EEDI submitted to the Classification Society shall be submitted to Owner prior to the start of ship construction. The approved value of the EEDI shall be the new reference for the verification and certification process.

See Section 7.1 for more details for electrical load balance requirements.

1.2.2 OPERATIVE ENGINE CONDITIONS

At a draft of 9.30m when running the dual fuel main engines on LNG with a methane number ("MN") of 70 (at engine inlet with charge air receiver temperature of 45 deg. C) the Vessel shall:

- achieve a speed of not less than 15.0 knots with a sea margin of 15% with four (4) main engines running (one (1) of the largest engines out of service) on an MCR not exceeding 80%,(see condition "Navigation operational" in Appendix XXV)
- achieve a speed of not less than 20.5 knots with a sea margin of 15% on an MCR of not exceeding 90%, (see condition "Navigation design" in Appendix XXV)
- Be able to operate with one engine only in harbour operating conditions. Eg an 9 cylinder rather than a 12 cylinder engine . (see Appendix XXV)

in each case the available engine power when running between MN 80 and 70 (at engine inlet with charge air receiver temperature of 45 deg. C) shall not be less than what is provided in Section 15 LNG Storage and Supply System.

1.12 INSPECTIONS, TESTS AND TRIALS

1.12.5.1 FACTORY ACCEPTANCE TESTS (FAT)

Builder will submit, for approval, a schedule detailing all the FAT's proposed for the Project no later than six (6) months after signing of the contract. The schedule, once agreed, will be transformed in to the FAT table containing all the details, such as: equipment type, serial number, dates, procedures submitted, remarks status, FAT completion
For management of the remarks, the Factory Acceptance test will be considered as an inspection call and therefore relevant remarks, if any, will be added to the inspection call database with a proper code in order to grant a proper tracking of its status.
The FAT table will be updated by the yard and forwarded to the Buyer monthly showing information on progress made, issues, if any, found and relevant action to be taken.

Builder will provide FAT date confirmation 30 days in advance in order to arrange attendance. In addition the communication will also include:

- A copy of the FAT procedure
- Reference drawings

In case of equipment supposed to be identical to the one of the reference vessel Builder will ask to the supplier to highlight all the changes and will provide the information to Buyer accordingly

Machinery and equipment is to be tested according to the manufacturer's standard procedure to demonstrate compliance with the Contract and/or Specification.

The specific fuel consumption of the main diesel engines is to be ascertained during the engines shop trials and testing is to include the following tests:

- Official fuel consumption tests at 85% MCR
- Functional and fuel consumption measurements at the following part loads 35%, 50%, 75%, 100% and (110% only in MGO mode) MCR.

After each shop test the engine is to be dismantled to allow the examination of one cylinder line in its entirely and to examine the fuel injection system.

1.12.5.2 DOCK/QUAY TESTS AND TRIALS

Dock/quay tests and trials are to be performed to demonstrate that the performance requirements and functionality of equipment and systems as described in the approved design documentation, the Specification and in the Contract are met, to the extent such compliance can be demonstrated without requiring the Vessel to be at sea.

After installation on board the ship, and prior to sea trial taking place, the engine/alternator sets are to be tested with electrical load provided by the ship's services and/or resistance load tanks and are to include the following tests:

- Full load testing of each engine
- Testing of the safety system for each engine
- Testing of the engine over-speed trip devices
- Testing of the engine speed control for response.
- Testing and the change-over from "normal" to back-up speed control operation and testing of response with the back-up speed control.
- Testing of the alternator and relevant cubicles switchboard protection devices.
- Preliminary setting verification of the alternator voltage regulator.

Dockside Trials necessary for the Sea Trial are to be completed before the vessel proceeds to sea. The trial is to demonstrate that all available systems have been commissioned. All systems associated with the safety of the vessel at sea are to be commissioned and tested and accepted by Local Authority (e.g. RINa) to obtain permission for the vessel to proceed to sea.

1.12.7 SEA TRIALS

Sea trials are to be performed to demonstrate that the performance requirements and functionality of the equipment and systems as described in the Specification and in the Contract are met and this requires the Vessel to be at sea.

An Initial Sea Trial is to be carried out during which the Builder makes final adjustments to the vessel's systems under sea going conditions. During said Initial Sea Trial Official Tests will be carried out.

The Sea Trial is to be carried out in accordance with an agreed schedule. A description of the trials, the time allocated to each trial, the form of the report to be used, the location of the trial area will be submitted by the Builder at least 6 weeks prior to the sea-trials for Owner's approval The method of measuring ship's speed and shaft power is to be agreed by the Buyer prior to the start of this sea trial.

During the Sea Trial the vessel is to be loaded to reach, as far as possible, the design draught and trimmed to even keel.

The trials carried out is to include, but is to be not limited to, the following:

7.	Crash stop and astern running		Crash stop (100% MCR) Duration of astern running to be agreed

9.	a) lower point at about 35%	a) One double run	
	b) 53% power setting Contractual Service Speed Trials	b) Two double runs	
	c) 75% power setting	c) Two double runs	
	d) Contractual Maximum Speed Trial	d) Two double runs	
	On each run, the shaft power and the rev/min are to be measured simultaneously		
	e) Log calibration		
	f) Endurance trial	6 hours at 100% MCR Propulsion Motors	
	g) UMS test		

13.	Noise and vibration measurements	At one speed	Refer to relevant Section of Specification
14.	Navigational equipment	As appropriate during trials	

16.	Thermographic survey of main engines, boilers and exhaust ducts within engine room	As appropriate during trials	

During the course of the Acceptance Sea Trial, the effectiveness of the fuel transfer and treatment system is to be demonstrated using the highest viscosity fuel oil which is available, within the specified maximum viscosity.

The lubricating oil purifiers is to be tested using oil at the viscosity which would apply with handling the specified fuels.

The results of the Acceptance Sea Trial together with calibration data and correction calculations is to be delivered to the Owner in preliminary form no later than 1 week after completion of trials for the Owner approval.

The approved results in triplicate, is to be delivered to the Owner at delivery of the vessel.

1.12.8 POST SEA TRIAL INSPECTIONS

On completion of sea trials the Builder is to open up for inspection in the presence of the Owner's representative, a number of machinery items and carry out tests as may be requested by the Owner.

These inspections and tests are to include but not limited to:

- On each main diesel engine one complete cylinder line including its main and big end bearings and if any defects are found the other cylinder units of this engine.
- Any machinery or equipment which has been found to be deficient in its operation or for which abnormal operating conditions have been observed.

1.16 SPARE PARTS AND SPECIAL TOOLS

Spare parts and special tools are to be supplied by the Builder in accordance with the recommendations stated in the applicable Rules and Regulations and as follows:

Spare Parts and Special Tools are to be provided in accordance with the equipment manufacturers recommendations on the basis of the following documents and adjusted in accordance with the Technical Specification of the Vessel:

1. 006232 A3 N230 310 Accommodation Areas Outfitting Spare Parts
2. 006310 A2 N220 302 Outfitting Spare Parts And Tools List
3. 006310 A6 N280 301 Electrical Spare Parts And Special Tools List
4. 006310 A5 N270 302 Mechanical Spare Parts & Tools

Where applicable, the quantity of spare parts or material shell be increased by a factor to be mutually agreed taking into account the larger size of the vessel.

Spare Parts for Pods are to be provided in accordance with the manufacturer recommendations, as per the corresponding spare parts for the Pod system provided on Hull 6310 Sun Princess.

Note: no spare turbocharger is included in the scope of supply of the spare parts list.

1.21 TRAINING

A series of lectures is to be arranged by the Builder to familiarize the ship staff with the machinery, equipment and systems.

The lectures are to be given, by specialists of the subcontractors, for the following subjects:

2.3 – EXHAUST EMISSIONS

2.3.1 – SMOKE OPACITY MEASUREMENTS

Smoke obscurity meters (opacimeters) are to be fitted in the exhaust gas ducts of the diesel engines and of the Oil Fired Boilers.

The analogue signals from the Diesel engine opacimeters are to be interfaced with the digital display of the smoke obscurity and the repeater panels are to be installed in ECR

6.1 – Machinery Design Concepts

The twin screw propelling machinery is to be located aft in various rooms arranged in accordance with the General Arrangement and Machinery Arrangement drawings. The rooms will contain the electric generating sets, their auxiliaries, the auxiliary boilers, with their associated auxiliary equipment. Two fully azimuthing propulsion units are provided.

All electrical machinery and associated auxiliary equipment are to be designed for 45°C ambient air temperature and 36°C fresh water cooling temperature.

Main machinery is divided into two independently operating parts. Each part includes the main engines with necessary Marine Gas Oil feed module/ Gas Valve Units, lubricating oil and cooling systems.

All pumps are to be located in order to maximize the net positive suction head at the pump intake and to facilitate the self-venting of the system and to avoid cavitation. The lay-out of the gratings in way of pumps is to allow unimpeded access for maintenance. Pump glands will be accessible from the plate level without moving plates. Where this is not possible (e.g. gland ≥ 300 mm below plate level) an unrestricted access will be provided with, if necessary, a ladder and platform. The pump gauge boards will be positioned facing the walkway.

The plant will include but not be limited to:

Two (2) Azimuthing Podded Propulsion (APP) units.

Five (5) main generators driven by dual fuel diesel engines (manufacturer to be confirmed)

Two (2) emergency radiator cooled diesel driven generators.

LNG storage and supply systems suitable for the dual fuel engines and dual fuel fired steam boilers (as defined in Section 15 - LNG Specification),

Auxiliary machinery for machinery and hull services.

Two (2) dual fuel auxiliary boilers, complete with natural gas / marine gasoil burning plants

Five (5) exhaust gas economizers using the exhaust gas of the main diesel generating sets.

Five (5) RO plants

Pipes, exhaust gas ducts, silencers and spark-arresters

Floors, gratings, ladders, etc.

Various tanks (as defined in 6.13.5.)

Metering and control instruments

Workshops and stores (as defined in Sec 6.13.3)

Lifting gear

Spare parts, outfits and special tools (as defined in Sec 1.16)

6.2 – Electric generator sets

6.2.1 – Main generator

Five (5) main A.C. generating sets will be installed, driven by:

1. 3 x 12 cyl. V dual fuel engines,
2. 2 x 9 cyl. L dual fuel engines,

The engines shall be rated at 1.3MW/cyl. MCR power, 600 rpm, 11 kV, 60 Hz, IMO Tier 3 compliant (LNG or MGO plus SCR)

Engine with associated systems shall be capable to run on Natural Gas or MGO fuel with viscosity not lower than 2 cSt before the fuel pumps.

The required performance is to be achievable in tropical conditions i.e. 32°C sea water temp. 36°C low temperature fresh water central cooling system and 45°C air temperature.

The summer and winter harbour load of the vessel must be able to be achieved with one 12 cylinder DG only at a maximum power of 85% MCR with Natural Gas having a MN = 80.

. All SFC figures are to be based on factory test bed results of the Vessels engines, corrected in accordance with ISO 3046-1.

The engines are to be tuned to achieve maximum efficiency at the following fuel mode:

- GAS mode 100% MCR
- MGO mode 85% MCR.

Each generator set will consist of a four stroke diesel engine driving the alternator through a flexible coupling.

The generating sets are to be arranged with the diesel engine located on resilient mountings and alternator rigidly mounted on the ship's structure, driven by "dry" rubber element coupling.

With this arrangement the engine oil drain tank is arranged in the double bottom such that no convention valves are required between the drain tank and the engine crankcase. The drain tanks are to be designed to the recommendations indicated by the Engine Manufacturer.

Flexible connections on all engine terminal points are to be of a type and make approved by the Engine Manufacturer.

The engine specification is to include the manufacturer's options for engine monitoring and maintenance.

Engines will be started by compressed air.

DGs are to be capable of emergency black-out self start without external electrical power. If electrical power is needed this is to be fed from the engine room UPS

The engines will be designed for continuous operation at all loads, stopping and starting with Marine Gas Oil to ISO 8217: 2017. Natural Gas starting according to Class requirements.

The engines are to be completed with all equipment according to the manufacturer's standard, including for each engine:

- Turbocharging equipment (turbo blowers and air coolers) including a turbocharger turbine cleaning system and intercooler and turbocharger compressor water washing system (if required by the turbocharger manufacturer)
- Flywheel with electric turning gear
- Torsional vibration damper, if required
- Exhaust gas manifold suitably lagged, with lagging capable of being removed and replaced without detriment to the insulation
- MGO, lube oil, cooling water and compressed air piping
- Engine driven lubricating oil pump
- Engine Driven LT cooling water pump
- Engine Driven HT cooling water pump
- Compressed air starting-up equipment, pressure 30 bar including slow turn facility
- Control safety and monitoring instrumentation
- Oil mist detector multipoint with failure localization and bearing temp monitoring system for crankshaft area
- Bearing temperature monitoring sensor for camshaft area
- Two (2) automatic independent over-speed trips linked to different speed sensors
- DG exhaust pressure drop including SCR, EGB and silencer is not to exceed engine manufactures' recommended maximum
- Automatic slow turning to be operator selected between 30 minutes and 12 hours. Timing to be agreed with the engine supplier. The final slow turning philosophy is to be defined during plan approval/trials process.
- Double wall flexible fuel hoses with leakage monitoring via IAMCS

Engine monitoring and safety system is to be to the latest engine manufacturer standard together with any interfacing cabinets which are required for integration with IAMCS.

Main components:

- Engine safety module for shut-down of engine according to Class requirements
- Main control module for internal engine control functions
- Input/output modules for handling of sensor data.

Main functions:

- Shut-downs (e.g. lubricating oil pressure, over-speed)
- Start blockings (e.g. lubricating oil pressure, turning gear)
- Measuring of engine and turbocharger speed
- Normal start and stop of the engine
- Engine speed control
- Other internal engine control functions as applicable
- Signal processing of engine monitoring and alarm sensors
- Data communication with ships alarm & monitoring system
- Hardwired interface with external systems for control functions such as remote start and stop.

The following indications are available on the LCP:

- Engine rpm
- Turbocharger rpm
- Running hours
- HT water temperature
- Lubricating oil pressure

The LCP is equipped with at least but not limited to the following control switches and pushbuttons:

- LOCAL/REMOTE control mode switch
- Local START/STOP
- Shut-down RESET
- Emergency stop pushbutton
- Manual slow turn function

Sensors

- Alarm, safety and measuring sensors according to engine maker and Class requirements.
- Connections for testing of pressure sensors except for turbine charger cooling pressure sensor, intake air pressure sensor at turbocharger, differential pressure switches lube oil/fuel oil, VVT load indication pressure sensors, rail pressure, charge air pressure, pressure switches start/stop air.

Main cabinet for Engine Automation/Control should be supplied loose and installed separated from the engine block.

For the A.C. generator characteristics, see Section 7.3.

For control and monitoring, see Section 11.4.

One complete set of tools to facilitate maintenance, including, but not limited to, fuel valve pneumatic for pilot and main nozzle testing rig and hydraulic tightening devices for tightening or loosening the cylinder head nuts and for other tie-bolt nuts, crankshaft deflection gauge, peak pressure indicator with spares for hydraulic tools according to Diesel Manufacturer Tools List.

For spares refer to Sect. 1.16 - Spare Parts and Special Tools

The following tools also to be supplied:

- One (1) special cylinder liner pneumatic honing
- One (1) cylinder head manipulators
- Two (2) dial indicator type cylinder liner gauging tools, with extended rods
- One (1) tool for HT water pressure test cylinder head

6.3 – Steam System

6.3.1 – Design concept

Steam will be usually produced by the exhaust gas economizers and will be supplemented, when and if required by the dual/fuel fired boilers.
The steam system design pressure is to be 9 bar G.

6.3.6 – Steam and condensate system

Steam system, designed as ring, will supply these main services but not limited to:

- Main engine fresh water heaters

6.4 – Fuel oil System

6.4.1 – Design concepts

The following FO systems are to be provided for the main generating set engines, boiler and incinerator services:

- FO service systems
- FO purifying systems
- FO transfer systems
- FO drains system
- Sludge system

The machinery and piping installation including FO transfer and purification system will be designed for operation on the following fuels:

- Marine distillate fuel to ISO 8217:2017 Fuel Standard type DMA with viscosity 2 cSt.

6.4.2 – Service system

Main diesel generator

The five (5) main engine fuel oil systems are to be divided into two groups, one designed to supply two 12V engines, one to supply two 9L0 and one 12V engines, .modules are arranged with dedicated pumps for each engine type.

The systems are to be designed to supply the maximum capacity of fuel for all connected engines at 100% capacity at a condition as indicated in the engine manufacturer's project data book.

Two (2) high pressure pumping system skids are to be provided.

One unit is to feed two (2) 12V diesel engines, one is to feed two (2) 9Land one (1) 12V diesel engines.

Each skid is to include the following:

- Two (2) supply pumps with magnetic coupling and with suction filter for each pump
- One (1) mass fuel meter interfaced with IAMCS at the supply pumps suction Simplex suction filter for each pump
- One (1) deareation tank
- One (1) high efficiency automatic back- flushing filter with manual back up filter
- One (1) dedicated circulating pump with magnetic coupling for each engine plus one stand-by circulating pump for each engine type. Circulating pumps to be fitted with VFD
- One (1) viscosity sensor
- One (1) cooler, double wall type AISI 316, fed by chilled water, installed on circulation side. The cooler is designed for the related engines running at 100% of the MCR in order to cool the MGO to guarantee the engine supplier's required viscosity at the engine inlet with a bunkered fuel of 2.0 cSt @ 40°C, if fed by chilled water.
- One (1) cooler, double wall type AISI 316 fed by LT system cooling water, installed on supply side
- Dedicated sample cocks at delivery line to the engines
- Emergency feed pump for black out operation

Consumption measurements of engines main fuel will be provided to the IAMCS from the SFOC cabinet.
One (1) pneumatic FO shut off valve to be installed at each engine fuel oil inlet and outlet for a total of ten (10) valves. Inlet and outlet valves are to be interlocked each other and are to be manually activated (closing) through push buttons located in ECR and engine room.

The engine fuel spills are to return to the appropriate buffer tank or service tank.

In the event of a black out a "quick recovery" fuel system is to be provided by emergency fuel supply by a pneumatic pump with dedicated air bottle sufficient for 5 minutes running of the pump or an electric pump with UPS also sufficient for 5 minutes running. Design and selection of system to be adopted to be agreed between Builder, Engine Supplier and Owner.

6.4.3 – Treatment system

Two (2) groups of two (2) MGO purifiers are to be provided, one (1) group for two (2) 12V diesel engines, one (1) group for two (2) 9Land one (1) 12V diesel engines.
Fuel oil settling and service tanks for each system to be arranged as follows:

- One (1) diesel oil service tank
- One (1) diesel oil settling tank

Two MGO clean engines leakage collecting double bottom tanks (one per the fwd engines and one for the aft engines). One (1) pump is to be installed to transfer the clean leakage from the DB tanks to one (1) of the settling tanks.

6.5 – Lubricating oil System

6.5.1 – Design concepts

Following lube oil systems are to be provided for the main generating sets engines and auxiliary machinery:

- Service system
- Purifying system
- Transfer system (including storage tanks)
- Vent system
- Drain system
- Sludge system

6.5.2 – Service system

The general lubrication of each main D/G engine is to be effected by means of one engine driven pump. Each engine system is to be independent. In addition to this, each engine is to be provided with an electrically driven priming pump, supplied via an automatic changeover switch from normal and emergency power supplies.

Five (5) in number generator engine-driven lubrication oil pump suction filters, one to each engine lubrication oil system.

Five (5) generator engine lubricating oil automatic filters to be installed one in each engine lubricating oil system.

The filters are to be of the continuous, automatic, back flush type, multi candle filters to comply with requirements of Engine Manufacturer and to have differential pressure indicator and alarm contact interfaced with IAMCS.
Back flushing is to be continuous by an electrically driven motor so that the back flush oil is returned to the lubricating oil sump.
Filter elements are to comprise a filter frame and filter screen.
The filter housing is to be made in Nodular cast iron or steel.
Filter sieve material to be of stainless steel with mesh size according to engine manufacturer recommendation.

Additional engine lubrication oil filtration to be provided only if required by the engine manufacturer.

Five (5) generator engine lubricating oil indicating filters (Duplex) are to be installed in each engine lubricating oil system separated from the Engines.
Filter is to be of full flow double filter type, equipped with remote differential pressure indicator and alarm contact on IAMCS.
Design arrangement and operational safety of the filter must comply with the requirements of the Classification Society.
Filter to be fitted with magnetic staves before filter element.

Sampling points are to be positioned before and after every filter and purifier. Sampling points are to be fitted with isolating cocks and needle valves.

Five (5) stainless steel plate type coolers, each with a capacity of 100% of the total required capacity of one engine, for the cooling of the main DG engines lubricating oil with 15% fouling factor in addition to the engine manufacturer's specification.

The temperature of lubricating oil at the main engine inlet is to be automatically controlled by the thermostatic control valves.

Dependent upon which engine is selected, the lube oil cooler may be engine manufacturer supplied and mounted separated from the Engines.

The cooling medium is to be low temperature fresh cooling water.

The cooler to be sized for the maximum LT water temperature at the cooler inlet with the relevant engine running at 100% MCR.

Alternators bearings are to be fitted with jacking pumps (each with dedicated suction line) complete with simplex filters and, if required by the bearing manufacturer, a cooling system served by the relevant engine LT FW system.

6.5.3 – Treatment system

Five (5) centrifugal, , self-cleaning total discharge electric motor driven purifiers disc type, suitable for continuous automatic service and of a type with in line monitoring and control of the water content of the lubricating oil are provided for lube oil purifying of the main D/G engines sump tank content.

The LO purifiers are to be connected in such a way as to allow LO purifying in a continuous way and to permit suction and delivery from the LO sump tanks, and renovating oil tanks and dirty oil tanks.

6.5.4 – Transfer system

Each main generator engine is to have a separate LO circulating system. The five (5) systems are to be replenished with clean oil from the DG LO Storage Tanks, from the LO Renovating Tank, and directly from shore via the bunker stations.

6.5.5 – Vent system

Provision is to be made for venting the engine crankcases and lubricating oil sump tanks. Each crankcase vent is to be led independently to atmosphere positioned as high as possible on the funnel "cat walk". The dirty LO tanks and the clean LO tanks are to be vented to separate collectors in the casing and then to atmosphere. The emergency diesel engines LO sump tanks and crankcases are to be vented independently.

Each oil vent is to be fitted with condensate traps and flame arresters.

Horizontal lines should be avoided. If not possible the lines to be inclined in such way to avoid vapour/condensation stagnation. Access hatches are to be provided on the horizontal lines to allow inspection & cleaning.

The drains are to be led to the leakage oil system.

The location and design of the vent terminations are to be arranged avoid pressurization of the systems by wind or exhaust ventilation pressures, access is to be provided for cleaning the flame arresters and avoidance of rain water ingress and staining of the funnel.

6.6 – QUICK CLOSING VALVES SYSTEM

In addition each main engine is to be provided with a quick closing valve at the fuel inlet and fuel outlet .

6.8 – Machinery cooling water systems

6.8.1 – Design concepts

Centralized fresh water cooling systems are to be installed for the main diesel generating sets, for auxiliary systems, for the Azimuthing Podded Propulsion (APP) units and for the thruster. The engine associated systems are to be designed in accordance with the engine manufacturer's project guidelines. The propulsion and auxiliary cooling systems are to be sized in accordance with data received from the individual associated equipment suppliers.

Each central cooling system will consist of one sea water circuit and a low temperature fresh water circuit.

High temperature fresh water circuits are to be provided for the main engine jackets.. The HT systems to be cooled by LT mixing with three way valve and to be provided with HT recovery heat exchanger. .

Nozzle cooling system is to be provided as per engine manufacturer recommendations.

6.8.2 – Cooling water pumps

- 2 sets of vertical motor driven centrifugal pumps. for the sea water circulation in the FW coolers of the main D/G sets of the aft and forward Engine Room,. Each pump is to be driven by a Variable Speed Drive (VSD) controlled by IAMCS. The sets to be composed by one working pump for each engine and one common stand by pump for each system, three (3) pumps for the engine room with two engines and four (4) pumps for the engine room with three engines. .

6.8.3 – Coolers

The following coolers are to be provided:

- 2 sets of three (3) main D/G LT FW cooler (two working and one in stand by) , each cooler sized for 50 % of the required cooling capacity of each group of DD/GG sets,.

Coolers are to be of the plate type with titanium plates for the main D/G sets, auxiliary systems propulsion motor system coolers and thrusters, designed for operation with sea water at 32°C, with 15% fouling factor (in heat exchange area).

6.8.4 – Header tanks

The following header tanks are to be provided:

- two (2) diesel generators LT FW system

Header tanks to be coated (coating to be agreed with Owner)

Two fresh cooling water drain tanks are to be arranged in the double bottom for draining fresh cooling water from the main engines, for maintenance purposes. Provisions are provided to drain all LT header tanks to the double bottom recovery tanks.

6.8.6 – Main generator system LT FW cooling system

Each DG LT FW cooling system is to be a closed circuit system which serves the following:

- Engine charge air cooler
- Alternator air coolers
- Alternator pedestal bearings
- DG LO coolers.
- Engines nozzle coolers, if required by Engine manufacturer
- HT coolers (Jacket and HT Charge Air Coolers) by LT water mixing
- LNG Glycol Heat Exchanger

Heat extracted by the system is to be transferred to sea water and overboard through the DG LT FW coolers.

The selected pumps will restart automatically on restoration of power supplies following a black-out.

The LT cooling water temperature at the inlet to the pumps is to be controlled at 36°C by temperature control valves located at the outlet from the coolers, one for each group of coolers.

The system is to be designed to automatically shut off cooling water to the above equipment following an operator set time delay and the cooling water is to be restored on a start-up command both locally and by IAMCS.

6.8.9 – Heat Recovery System

The waste heat of the HT system will be transferred via a separate circulation system to the following users:

- Absorption chillers
- preheating the HVAC reheating system
- preheating the the hot potable water system

One dedicated plate heat exchangers (5 heat exchangers in total) to be fitted for recovery of HT FW rejected heat of each engine.

One circulation pump for each engine (five pumps in total) will be provided.
Pumps capacity to be defined in the design stage.
Header tank to be fitted. Automatic Corrosion inhibitor to be provided
All plate heat exchangers for users in the heat recovery system are to be fitted with temperature control three way valves .

Temperature transmitters will be provided on:

- pump delivery,
- plate type heat exchangers (PHE) heaters outlet on heat recovery side
- Inlet of main HT recovery PHE
- Inlet /outlet of heated fluids
- Inlet / outlet of HT heating water

Pressure transmitters will be provided on:

- Inlet /outlet of both fluids of heat recovery system heaters

The three way valves will be controlled according to the temperature of heated fluid.
A pressure transmitter will be installed on pump delivery.

6.10 – Demineralized Water System

Demineralized water will be supplied from two reverse osmosis plant or from shore and collected in the distilled water tanks and in the boiler feed water tanks.

Supplies are to be also provided for various Engine Room systems including:

- DD.GG. FW HT Header Tanks
- DD.GG. /Propulsion FW LT Header Tanks

6.11 – Compressed air system

The compressed air system is to supply air for the starting of the generator diesel engines, for instrument/control and for general ship services.

6.11.1 – Air compressors

The following air compressors are to be provided:

- Two (2) starting air compressor of the reciprocating, two-stage, single-acting, water-cooled by the Auxiliary FW Central Cooling System, electrically driven type with a capacity and filling time as required by the Rules with a working pressure of 30 bar.

- Two (2) starting air compressor of the reciprocating, three -stage, single-acting, air-cooled, electrically driven type with a capacity and filling time as required by the Rules with a working pressure of 30 bar.

  Serving the engines as follows:

  - FWD engines group (1x12V + 2x9L): one water cooled compressor and one air-cooled compressor (connected to the emergency switchboard via manual changeover switch for the dead ship start duty.)
  - AFT engines group (2x12V): one water cooled compressor and one air-cooled compressor (connected to the emergency switchboard via manual changeover switch for the dead ship start duty.)

- Two (2) L.P. air compressors, screw type, water cooled, and equipped with suction air filter, after cooler, moisture separator with drain trap at 8 bar about 500 m^3/h for the "Instrument & Control" "Ship Services" and SCR air.

Automatic loading / unloading to be arranged to maintain Ship service air receiver pressure.

6.11.2 – Air receivers

- Two (2) main DG engines air receivers, cylindrical in shape, built of welded steel plates with dished ends, maximum working pressure 30 bar, capacity as required by the Rules fitted with manholes and fittings. The internal surface is to be coated with suitable paint to ensure long term internal protection against corrosion.
- Two (2) SCR air receivers, capacity to be defined by Engine Manufacturer, at 8 bar
- Two(2) air receivers for the emergency diesel generators, maximum working pressure 30 bar, capacity as required by the Rules.
- Two (2) general service air receivers of 5 m^3 at 8 bar
- Two (2) control air receivers of 1 m^3 at 8 bar fed through a running or stand-by air dryer having the following characteristics:

Flow:	189 m^3/h
Inlet Pressure:	8 bar
Dew point:	+3°C
Air inlet temperature:	+45°C
Air outlet temperature:	+35°C

Units to be fitted with hot gas by-pass to control refrigerant capacity between zero and 100% load.
Control panel running parameters in accordance with Sec. 11
Electric activated drains are controlled by a programmable logic control.
Unit to be supplied with copper heat exchanger coils.
Engine room ventilation system to be arranged such that refrigerated dryer unit is adequately ventilated and cooled.
Install two (2) high efficiency coalescing type oil removal filters.
Automatic condensate trap to be installed.

The filling of the "Instrument & Control" and "Ship service " air receivers is to be provided in emergency for the AFT Engine room by the main starting air receivers with a reduction valve from 30 bar to 8 bar (fitted with safety valve) and for the FWD Engine Room by the by the **main starting air** receivers **with a reduction valve (fitted with safety valve)**"

Valves arrangement will be designed to allow survey of class receivers isolating valves and receiver without compromising service and safe operation of the system.

6.12 – Exhaust gas System

6.12.1 – Exhaust pipes and silencers

The exhaust gases from the main and emergency diesel generator engines are to be led to atmosphere at funnel top through duct systems with welded joints except for those at the engine, one joint at the top and bottom of the economizers, silencers, SCR.

Flexible exhaust bellows are to be of the welded double skinned stainless steel type with internal sleeve.

Each main generator engine exhaust gas system is to include one (1) exhaust economizer for heat recovery.

Due to the LNG operation each Main generator Engine and each boiler, if required by the supplier, is to be fitted with an Exhaust gas ventilation unit with a fan for purging exhaust gas system with air, to be mounted as close to the engine as possible.

Gas ventilation unit fitted with following main components:

- Centrifugal fan
- Flow switch
- Shutoff valve, pneumatically actuated, with position feedback
- Flexible connections
- Counter flanges

Relief valves for gas engines

Relief valves to be installed in the exhaust gas system

Each emergency generator engine is to be provided with one (1) silencer with spark arrester, and a drain connected to the appropriate main DG drain system.

All silencers are to be fabricated in "Corten" steel and provided with inspection and cleaning doors. The silencers are to be executed with manholes, drains and spark arresters. The silencers shell plate thickness to be 6 mm and the top and bottom plates to be 10 mm.

The exhaust gas ducts and silencers for main generator engines and boilers up-takes are to be entirely in "Corten" steel.

The exhaust gas ducts for emergency generator engines and emergency diesel driven air compressor, are to be entirely in "Stainless steel".

Silencer attenuation to be sufficient to achieve the open deck noise limitations as laid down in section 1.10.2.

Exhaust ducting for all main generator engines, boilers and incinerators are to incorporate rain catchments (on the upper part of the exhaust) and associated drain piping.

D.G. exhaust ducts, as well as waste heat economizers and silencers are to be installed on resilient supports to minimize noise transmission through the structure.

Access holes with covers and separate heat insulation mat to be provided for cleaning and inspection of the main exhaust pipes at base of the funnel.

Exhausts are to be completely insulated along their entire length to the extreme end of the exhaust outlet , in accordance with Annex XIV Piping Specification, with the thickness of insulation for the final 10 m to be double the stated thickness..

Builder and Owner will agree final configuration of the arrangement of the system above in order to reduce the soot falling on decks and superstructures around the funnel.

6.12.4 – Exhaust Gas Cleaning system (EGCS)

In order to reduce the emission of NO_x at the IMO Tier III level when the engines are running on MGO, a reducer system will be installed on the exhaust gas duct of each main engine.
The operation of the reducer system is based on nitrogen oxide abatement by Selective Catalytic Reduction (SCR).

The NO_x abatement process works by injecting a solution of water and urea into the exhaust gas before it passes through a catalytic converter.

Urea storage tank to be dimensioned for 156 hours with three 12 cyl. engines at 85% MCR in navigation / manoeuvering plus 120 hours with one 12 cyl. engine at 85% MCR in port.

The selection of the SCR system will be done according to the recommendation of the main diesel engine manufacturer.

6.13 – Miscellaneous

6.13.1 – Floors, gratings and ladders

Generator foundations to be designed to allow access for inspection and maintenance under the machinery.

The required deck area for main engine service work is to be in accordance with the Manufacturer's Project Guide.

6.13.2 – Lifting gear

Gantry cranes of 2-speed electric type for overhauling the main generator engines to be arranged.

Single beam between the main engines to be provided for the transportation of the engines parts from the overhead crane to the platform to be the lowered to deck 1 level avoiding all the removable gratings around the engines

Lifting beams and trolleys to be arranged for overhauling alternators, engine turbocharger, charge air coolers, emergency alternator set, and furthermore, lifting

The largest pieces of equipment envisaged for the main engine are cylinder cover, cylinder liner, piston assembly and complete turbocharger assemblies

Predisposition is to be made for removing each generator engine crankshaft from the machinery spaces for transport ashore according GAP.

6.13.3 – Workshops & miscellaneous spaces

- One fuel valve injector test bench to include an injector test set with the appropriate air supply for the main engine injectors testing in accordance with the engine maker recommendations

7.2 – DISTRIBUTION

7.2.1 – DISTRIBUTION SYSTEMS

The distribution system is to be arranged as per the one-line diagram, Appendix XXIV. The ship's electric generating plant is to consist of five dual fuel engine driven synchronous generators capable of supplying the ship's electric load and the propulsion electric motors.

The generator sets are to be named DDG1, DDG2, DDG3,DDG4 and DDG5 and each will generate power up to their maximum continuous rating (MCR) at 11000 V, 60 Hz, 3-phase.

7.3 – POWER GENERATION

7.3.1 – MAIN DIESEL DRIVEN GENERATORS (DDGS)

The ship's electric generating plant is to consist of five dual fuel engine driven synchronous generators, star connected with the star point led out to an accessible terminal which is connected to earth by means of resistors.

The five generators shall be capable of supplying the ship's electric load and the propulsion electric motors (see Appendix XXXIV).

The generators sets will generate power at 11 kV, 60 Hz, 3-phase.

The generators are to be designed for continuous parallel running and suitable for converter load.

1) Main features

Type	Synchronous
Enclosure up to/above the shaft	IP 56 / IP 54
Cooling system	Water cooled with air/water heat exchanger
Rated outputs	IAW prime mover power rated voltage/No of phases 11000 V / 3-phase
Rated frequency	60 Hz
Rated power factor	0.85
Revolutions	IAW Prime mover
Service ratings	continuous
Efficiency	Not less than 97.5% at rated p.f. at 100% load for the large and medium ones Not less than 97.0% at rated p.f. at 100% load for the small ones
Exciting system	with voltage droop - brushless type
Insulation/over temperature	class F/F
Connection	star
No. of bearings	two
No. of sets	five
Prime mover	dual fuel engine

2) Construction

The stator frame is to be made of welded steel, plates and cross members; the pedestals for the bearings are to be of fabricated steel, split to facilitate disassembly.

One water drain hole and plug is to be provided at the lower part of the machine frame.

Alternators mounting arrangement shall be IM 7301 (in accordance with IEC Publication 34-7 with extended forged shaft, with coupling type cylindrical shaft end with key).

The machine is to be coupled to the dual fuel engine through a flexible coupling. Two pedestal sleeve self aligning bearings with self lubrication provided for running. A lube

oil pressure (jacking) pump is to be provided for each alternator bearing for each generating set slow turning and turning with the engine turning gear. The starters of the lubricating pumps are to be interlocked to prevent turning the generators without the pump running. Bearings are to be so designed such that stopping and starting can be achieved without damage in the event of jacking pump failure.

If necessary the oil is to be cooled by circulating fresh water through a cupro-nickel coil in the oil bath. Alternatively, if a lubrication system is required, each bearing is to be fitted with two pumps (one working and one in stand-by). The oil is to be circulated through an oil cooler (fresh water cooled by associated LT circuit). Oil flow switches (level switch type) are to be fitted in each oil delivery line.

One bearing is to be of the double thrust axial type sized to absorb the thrust produced when the vessel is pitching to the maximum allowed value, and the axial thrust produced by the flexible coupling.

The bearing sleeve is to be of split type so as to facilitate disassembly. The housings are to be made of cast iron.

The bearing type and Manufacturer are to be submitted to the Buyer for approval.

Insulation liners are to be provided to avoid damage to the bearing due to the shaft currents.

The stator windings are to be composed of copper bars globally impregnated (vacuum process).

The rotor is to be in accordance with Mfr standard and provided with a damper cage for correct operation under transient and unbalanced load conditions.

The rotor is to have removable poles (bolted poles). Removable covers are to be fully bolted with gaskets and earthing straps.

3) Excitation equipment

The rotary exciter is to be an AC generator of the stationary field and rotating armature type.

The automatic voltage regulator (AVR) is to be of the solid state type. The brushless exciter is to be fitted inside the generator frame.

The equipment is to be capable of over-exciting the alternator, under short circuit conditions, in order to maintain the short circuit current at least 3 times the rated current and to be cut-out automatically in case of short circuit upstream of the generator CB, by the differential protection device.

The exciter solid state equipment is to be fitted in separate cabinets one for FWD ER and one for AFT ER.

4) Excitation equipment performance

When the main generator is running at rated speed (frequency) and is giving its rated voltage, the system is to be capable of maintaining:

- In steady state conditions:

  The voltage within ± 1.5% or its rated value, for every balanced load between zero and rated load at rated power factor and for every frequency between ± 5% of its rated value.

- In transient conditions:

  The voltage within -15% and +20% of its rated value, when a balanced load (kVA) equal to 60% of the smaller generators' rated value with power factor between 0.4 and 0 lagging (starting from no load) is suddenly applied and/or taken off.

  The voltage within -15% of its rated value when a balanced load (kVA) corresponding to the starting current of the 11 kV motors is suddenly applied with a pre-load (kVA) equal to 75% of the generator's rated capacity with rated power factor.

The above performances are to be complied with for starting one HVAC compressor motor with one generator and one thruster motor with ~~either the FWD or the AFT~~ two medium main generators or three (any) running in parallel. Such performances may not be complied with for starting of a variable-speed HVAC chiller with a bypassed VFD as described in 7.10.2.6. In that case, greater connected generating capability may be needed.

The voltage is to be restored in the above cases within ± 3% of its rated value in less than 1.5 seconds.

During parallel operation the voltage droop of 3% between no load and full load ensures correct sharing of the reactive power.

5) Cooling system

Generators are to be self-ventilated in closed circuit with two fresh water coolers.

Heat exchangers are to be sized for 36°C inlet water temperature.

Reduced load operation up to 75% is to be possible, without the water cooling facility available, by removal of panels or similar measures. For this eventuality, mesh panels are to be provided for the opened sections of casing.

The cooler is to be of double tube type, with inner tube made of Copper/Nickel and external finned tube of copper or brass.

Inspection doors are to be provided.

6) Parallel operation

Main DDG sets are to be capable of automatic continuous parallel operation, with the active and reactive loads equally shared within the limits of ± 5% and ± 10% respectively.

7.9 – SWITCHBOARDS, SUBSTATIONS AND DISTRIBUTION BOARDS

7.9.1.6 – PREFERENTIAL TRIPPING (11000 V NETWORK PROTECTION)

With one or more DDGs in service, network protection is to be provided with a Preferential Tripping System, included in the MVSWB.

Non-essential circuits are to be arranged for preferential tripping in three stages.

Preferential circuits are to be fitted with adjustable electronic timers.

Automatic tripping to be arranged when the generator protection devices indicate an overload situation.

Alarms and indication of tripping to be provided.

Preferential tripping stages:

1) AC compressors (on the MV switchboard)
2) Galley substations (on the MV switchboard) and Laundry (on ER-SUB)
3) HVAC (AC stations CBs in Accommodation Substations)

Automatic tripping of all three steps with no delay will take place in case of underfrequency detection.

To improve the performance of the traditional PT, an additional fast preferential tripping (FPT) is to be included and based on:

- DDGG circuit breaker trip signals;
- PMS including a load monitoring functionality.

SECTION 11 – Integrated Alarm Monitoring and Control System (IAMCS)

11.1 – GENERAL

11.1.1 – OVERALL DESCRIPTION OF IAMCS

The following systems – but not limited to – are to be integrated or interfaced with the IAMCS as agreed with the Buyer:

- Power management system including mode selection system
- Main engines
- Thruster system
- Emergency diesel engine
- Medium voltage switchboards
- Low voltage switchboards
- Pumps and fans
- Remote control valves
- Temperature controllers
- Viscosity controllers
- Tank monitoring and remote level gauging
- Interface to the "Dynamic Trim Support System"
- Management of all auxiliary and electrical systems as listed within the ship specification

The following systems are to be interfaced with the IAMCS via serial lines (the serial lines are to be provided with back-up by hard-wired common alarm):

- Diesel Engines Safety and Control System (redundant serial link from each engine) for monitoring functions only, while Hardwired I/Os are to be used for control function and key monitoring functions.

11.2 – IAMCS DETAILED DESCRIPTION

11.2.2 – SYSTEM ARCHITECTURE

For each DDG, the main and reserve serial lines are to be connected to the main and reserve PMS-process control station, respectively.

11.2.3.9 GROUP ALARM AND WATCH RESPONSIBILITY SYSTEM (U.M.S.)

The engine alarm system has to be extended with a group alarm and watch responsibility system for unattended machinery spaces operation. The system to be composed of Unmanned Machinery Spaces (UMS) panels, according to Classification requirements.

An Extension Alarm System (EAS) shall be available through the UMS panels.

The responsibility system to have the following options:

11.3 – POWER MANAGEMENT SYSTEM

11.3.1 – GENERAL

A power management system is to be provided to carry out the following control functions:

- Automatic limitation of the power consumed by the propulsion system according to the power available from the network (included in PEM control system)
- Automatic control of the re-generation of the propulsion motors during reversing/slow down manoeuvres (included in PEM control system)
- Automatic starting, synchronizing and load sharing of stand-by generator set on failure of a running machine
- Automatic load dependent start/stop of generator sets, including sequence control
- Monitoring of automatic load shedding (preferential tripping) of consumers according to power demand from network (load shedding included in the MSWB logic, see Section 7)
- Interface with MSWB for selection of users to be disconnected by Fast Preferential Tripping (see also Section 7)
- Warning and pre-warning of abnormal load conditions at switchboard
- Status indication of electrical generating system and medium voltage distribution system
- Remote control of the medium voltage switchboard ACB's
- Measuring and monitoring of frequencies, powers, currents, voltages, power factors and insulation of medium voltage suppliers and consumers, within the limits indicated in Section 11
- Monitoring of both main switchboards and display of all MSWB measured values and alarms, within the limits indicated in Section 11
- Remote control of synchronizing and load sharing of main alternators from IAMCS terminals
- Operator fixed load control for one DDG at the time, for maintenance purposes
- Operator load limit control for one DDG at the time, for maintenance purposes
- Measuring and monitoring of electrical conditions for the propulsion converters, transformers, excitation system, DC link reactors and motors within the limits indicated later on (remote control in the PCS)
- Status reporting and event logging (i.e. stopping and starting machinery, alarm, and data logging).
- Control of the electrical power supply and distribution of the ship network consisting of two 11 kV main switchboards (MSWB), forward (FWD) and aft (AFT)
- Overall control of diesel driven generators

- Heavy Load Start Program for heavy consumers in the individual parts of the ships' electrical network according to the actual selected configuration on the MSWB for the:
  - Thrusters
  - AC compressors

  Once started according to limitations detailed in 7.3.1-4, and according to the relevant power reserve, one thruster is allowed to run when in port mode.
- 11kV shore connection automatic control, monitoring and indication
- Automatic restoration of the ship network after a black-out
- Automatic switching over between the four defined main switchboard configurations under the command of the operators (Port mode / Maneouvre mode / Sea mode / Anchor mode)
- Selection of minimum number of DDG connected, according to the selected operating mode
- DDG sets starting interlock for CO_2 release
- Automatic control of DDG auxiliaries, including pre-lubricating pumps, alternator jacking oil pumps, pre-heating, various PID control loops
- Other functions and signals as per reference ship.

11.3.2 – EQUIPMENT

The functions are to be performed by PMS process control stations except those related to the PEMs which are to be performed by the Propulsion control system.

The Propulsion control system and the IAMCS process control stations are to be connected via serial links for exchanging data.

11.3.3 – CONTROL FUNCTIONS

The DDG sets are to be able to be remotely started manually and automatically. They are to be able to be connected to the network manually and automatically.

Load sharing and frequency regulation are to be performed automatically.

One or more DDG sets are to be on stand-by and available for automatic starting in a pre-set sequence in the event of failure of a running machine.

When the load on the network reaches a maximum preset level, a stand-by DDG set is to be primed and started automatically and then connected and loaded automatically.

When the network load is reduced to a selected pre-settable level, a DDG set is to be disconnected and stopped automatically after a pre-settable time delay.

The maximum and minimum load limits used for starting/stopping of DDG's are to be calculated according to the number of DDG's in operation.

The PMS is to start a DDG for high current on one or more running DDG's as well.

The PCS is to monitor the number of DDG sets in service and thus control the power available for propulsion.

The overloading of DDG sets in service is always to be prevented if the operator requests a ship's speed which requires more power than is available through the network.

Thus the power increase of the propulsion motors is to be prevented by PCS until another DDG set is started, connected to network, and sharing load evenly with the other DDG sets.

The overloading of DDG sets in service is also to be prevented by PMS if the operator requests the starting of a large consumer (HVAC compressor motors, thruster motor). This is to be achieved using the heavy load start program.

One DDG at the time can be set at fixed power or load limitation with setpoint in IAMCS for maintenance purposes.

11.4 – DIESEL GENERATOR OPERATION AND CONTROL

11.4.1 – GENERAL

With one or more of the main diesel generators (DDGs) running, the others are normally on stand-by and ready to be automatically started in case of power demand from the network or in case of failure of a DDG in service, depending on the main switchboard's selected configuration.

The control system for the DDGs is to be designed to perform the following operating modes:

- Automatic remote control through IAMCS
- Manual remote control through the IAMCS operator stations
- Manual remote control from the ECR electric console
- Remote manual control (speed control/synchronization/loadsharing) at the MSWB
- Manual local control at the engine.

11.4.2 – DDG SAFETY, CONTROL AND MONITORING SYSTEM

Each main diesel engine is to be provided with an individual and independent safety, control, speed and load sharing governor and monitoring system. System is to be provided

based on microprocessor controllers or PLC. Main diesel engine safety, control speed and load sharing governor and monitoring system is to be part of the delivery of the main diesel engine manufacturer.

The electric over-speed device is to have a fail-safe operation as required by the Classification Societies.

Fail safe operation is to be provided in case of speed control electronic failure.

The racks and control panels for the safety, control, speed and load sharing governor and monitoring system of the DDGs are to be fitted in a position to be agreed with the Buyer according to the standard of the chosen Engine manufacturer. For each main diesel engine one individual local operator cubicle is to be provided.

Check-synchronizers are to be provided at the main 11 kV switchboards and at the emergency switchboard. Each check-synchronizer is to be able to be overridden only locally on the relevant switchboard via a switch (Section 7).

DDGs' Alarm, Monitoring and Safety System details

Safety system based on microprocessor controllers is to be provided for each individual main engine and is to consist at least of:

- Fuel oil pressure/temperature/leakage monitoring
- LNG injection and combustion monitoring
- Lubrication oil pressure/temperature/level monitoring
- Lubrication automatic oil filter failure
- Lubrication oil filter differential pressure high alarm
- Starting and control air pressure monitoring
- HT water pressure/temperature/level monitoring
- LT water pressure/temperature monitoring
- Nozzles cooling water pressure and temperature monitoring if required
- Charge air pressure/temperature monitoring
- Oil mist monitoring
- Bearing temperature monitoring
- Cylinder fuel injection pressure

- Exhaust gas temperature monitoring, including average temperature
- Exhaust gas temperature deviation monitoring
- Engine and turbocharger speed monitoring
- Turbocharger filter differential pressure
- Start blocking monitoring
- Load position monitoring
- Slow turning monitoring and control
- Sensor failure alarms
- Other signals and functions as per reference ship.

Vibration monitoring system for diesel engines' turbochargers (if available by the Diesel engine's Manufacturer), to be installed and relevant signals per each turbocharger to be connected to the IAMCS.

DDGs' Speed Control System details

DDGs' Speed control system providing droop, load control and isochronous loadsharing via electronic microprocessor based controller is to be provided for each individual main diesel engine. Speed control signals up/down are to be hardwired connected to each individual generator panel in the 11kV main switchboards.

DDGs' Alarm Processing System details

All alarm processing, loggings, settings, blockings etc. are to be done in the main diesel engine safety, control and monitoring system. All alarms are to be transferred via redundant (if supported by the chosen engine's Mfr.) serial line interface to the IAMCS for indication in the machinery automation system. Hardwired common alarm, shut-down, slow-down, blocking, reset signals etc. are to be connected to the IAMCS/PMS for back-up reasons.

DDGs' Interfaces details

Each main diesel engine safety, control and monitoring system is to be interfaced with:

- The IAMCS/PMS via hardwired signals for all essential signal control and monitoring functions
- The IAMCS machinery automation via redundant serial line for monitoring functions, alarms and status information.

11.4.3 – DDG SETS OPERATING MODES

See also Section 11.4.1.

At each main DDG there is to be local/remote selector switches fitted on the local control stands.

The EDDG is to have a manual/automatic test selector switch.

11.4.3.2 – OPERATION OF DDG SETS BY REMOTE CONTROL FROM IAMCS/MSWB'S

In this condition all local engine controls are to be interlocked and the DDG sets are to be remotely controlled from IAMCS.

When an engine is to be started, the slow turning sequence is to be followed prior to admitting full starting air to take the engine up to firing speed. If the engine performs cyclic slow turning sequences, it can be started directly without slow turning. If the slow turning fails the engine starting is to be blocked and an alarm is raised.

With the engine running and all safety systems in service, the DDG is to be connected to the network:

- Automatically via IAMCS (paralleling sequence initiated by IAMCS)
- Manually via IAMCS operator station (paralleling sequence initiated by the operator but carried out by synchronizing device)
- Manually, acting directly on the speed controller, and using synchronizing instruments and ACB controls available on MSWB's.

DDG sets are to be disconnected from the network and stopped through the IAMCS.

In case of serious fault conditions, the diesel engines are to be stopped automatically by their safety systems.

All necessary signals for remote control of DDGs from IAMCS/PMS are to be hardwired and monitored for wire faults if necessary. Remote control from IAMCS/PMS is to be independent of the serial line interface to IAMCS.

11.4.3.3 – OPERATION OF DDG SETS BY LOCAL MANUAL CONTROL

With all remote controls out of operation, the operator is to be able to start/stop the DDG sets by using the relevant mechanical controls and instruments provided on the engines.

The safety systems are to remain in service.

The paralleling operation for generators is to be carried out manually using the speed governor controls, check synchronizer, instruments and ACB controls at the main 11 kV switchboard.

One graphical indication/operation panel is to be provided for indication of all engine status information, engine speed, turbocharger speed, alarms, measuring values (including exhaust gas temperature in/out), shut-down and slow-down alarms, start blockings etc. The panel is to be installed close to each main diesel engine on the local operator cubicle. Local operation is to be totally independent of the remote control.

11.4.4 – CHANGE-OVER OF DDG SETS OPERATIONS WITH FAULT CONDITIONS

The following situations are anticipated which requires DDG sets to be started or changed over:

11.4.4.1 – POWER DEMAND BY NETWORK

With one or more generating set selected for stand-by and automatic starting, if the power demanded by the network increases to a level which requires another generating set, the first selected generating set is to be automatically started and connected to the network, and is to share load equally with the other generating sets.

If the load increases further than another generating set, if available, is to be automatically started and connected to the network and share load equally with the other generating sets.

The PCS is to limit the output of the propulsion motors to suit the power available from the network, as described in Section 11.3.

When the network load is reduced to a level which permits the stopping of one generating set, the IAMCS is to perform such operation with an adjustable hysteresis, according to the number and configuration of DDG's.

The rate at which the load is increased on an incoming machine is to be fixed, according to a pre-set ramp characteristic of load versus time.

Fast loading is to be available via the IAMCS.

11.4.4.2 – NON-CRITICAL FAULT CONDITIONS

The IAMCS is to start and connect a stand-by generating set, if available, then unload disconnect and stop the faulty set.

11.4.4.4 – BLACK-OUT CONDITIONS AND RECOVERY

During a black-out, the emergency lighting is to be maintained by means of the emergency transitional lighting system until an EDDG is started.

In order to recover from a black-out, the following operations are to be performed:

- Automatic starting and connection to the emergency switchboard of the EDDG's by means of its automatic starting system; this is to restore power to the emergency network
- Automatic starting of DDG set auxiliary services
- Automatic starting of one main DDG set and connection to the voltage-free 11 kV network. This is to provide power to the 11kV/690 VAC transformers and to the 690 VAC ER-SUB
- Manually instigated synchronizing and paralleling of the emergency switchboard with the ER-SUB from the IAMCS; when the two switchboards are connected, after a brief delay the EDDG circuit breaker opens automatically and the engine remains running until it is stopped locally, or remotely from the IAMCS (if accepted by Class, otherwise it is to be stopped only locally)
- Dedicated "Blackout mimic pages" are to be provided in order to assist the operator at recovery from blackout.

Automatic control of black-out M.G.O. valves or air operated pumps or electric pumps (see Section 13) is provided in order to allow automatic starting of main DDG set without the need of the EDDG to be running ("short black-out solving").

11.4.4.5 – DEAD SHIP CONDITION

The starting of the ship from dead conditions is performed as follows:

- Manual starting of the EDDG using compressed air or starting battery. This is to supply the emergency network and, by over-riding the relevant interlocks, one of the two 690 V ER substations.
- Starting of main air compressors and auxiliary services for the main DDG sets. Starting of the boilers, raising steam, heating engines and manual starting of a main DDG set.

11.11 – CONTROL STATIONS AND CONSOLES

11.11.1 – ECR AND HCR MAIN CONTROL CONSOLE

- Main engine mode selector alarm panel

11.11.2. – ECR ELECTRIC MIMIC SYSTEM

The ECR electric mimic is an independent system which displays on a Large Display Unit (LDU) the overview of the Electric Generating Plant via a customized set of soft mimics and allows remote control of Diesel Generators and relevant circuit breakers, MV transformer breakers and ESWB interconnection breakers.

The design of the system to comply with Safe Return to Port regulations; in particular total loss of the ECR is not to affect the DDG and MSWB local control and remote control from PMS. At least the following functions are to be provided:

- Synchronizing and connecting generators via request to DG synchronizing units ("synch & close").
- Manual load sharing and load control among generators by manually increase/decrease in droop mode.
- Manual recovery after black out (i.e. possibility to close the generators on dead bus).
- Selector soft switch to enable control from mimic with feedback "Control Here"
- Main DG set remote control functions (start, stop, shut down indication, various indications)
- Electrical interlocks logics to prevent unsafe breaker closing

Diesel engines features (5 DG's):

- Engine start/stop commands, black-out mode selection
- Engine remote, running/stopped (two colour), ready status indications
- Engine shutdown, start failure alarm indications

11.12 – PREPARATION OF SFOC CABINET (OWNER SUPPY) INSTALLATION

- Serial interface cable Modbus RTU between IAMCS and terminals in the ECR console (serial link will be used for SFOC cabinet at later time). The serial line interface between IAMCS and SFOC cabinet will be used also for Engine's Gas Valve Units (GVUs) gas flow meters indication.

13.1 – FLUID HANDLING SYSTEM

13.1.2 – PIPING DESIGN – FUNCTIONAL CRITERIA

All resiliently mounted equipment is to have flexible connections between the equipment and its associated piping.

Flexible metallic and rubber bellows are to be fitted strictly in accordance with the manufacturer's instructions in terms of alignment. Where no solid spool pieces of the same dimensions as the approved installation dimensions of the bellows is used to prove the accuracy of the installation of the interconnecting pipe work, the printed manufacturer's standard and tolerances is to be provided to the Buyers representative at the relevant call and inspection.

[illegible] piping to avoid electrolytic corrosion.

All nuts, bolts and washers used for pipe flanges and brackets/supports are to be galvanized.

Cast valve chests are not to be used. Arrangements are to be provided to permit Class survey of pressure vessels and attached valves without compromising the operation of the remainder of the system (Double isolation with the drain in between criteria to be followed) Heat exchangers, filters and control valves are to be provided with isolating valves, such that it is only necessary to drain a limited part of the system in order to carry out maintenance on the components within the system.

13.1.5.2 - PLATE HEAT EXCHANGERS AND MATERIAL

The design is to incorporate a feature which ensures correct plate spacing when the nuts, which hold the assembly together, are tightened.

Thermometers to be fitted at inlet as well as outlet sides of heat exchangers fitted in pocket.

All plate heat exchangers to be arranged with connections for in place chemical cleaning facilities.

Where possible, the tensioning, or back plates of all sea water cooled heat exchangers are to be provided, if feasible, with blank flanges in way of the sea water inlet and outlet passages to permit easy emergency cleaning to be carried out.

Port type filters are to be provided on all sea water plate coolers (with capability for cleaning or replacing).

Back flushing facility to be provided for sea water plate heat exchangers (only sea water side). Is possible that Heat exchangers, supplied by a particular supplier, are not fitted with back-flushing function. CIP connections have been foreseen for cleaning.

The minimum number of tightening bolts on which the plates are assembled is to be provided and they are to be of sufficient length to ensure that all the plates can be assembled by ship's personnel without requiring the use of any special tools different from the hydraulic tightening tool provided by Yard.

Pressure plates weighing more than 100 kg are to be provided with rollers.

Where drain cocks and the necessary connections for pressure testing and venting both the hot and cold sides of the plates cannot be accommodated on the heat exchanger, the Yard is to arrange provision of these cocks and connections in the associated piping.

In establishing the heat exchanger which is required to meet any particular duty the manufacturer is in addition to any other design margins to use a 15% of fouling factor

The materials of the heat exchangers to be as follows:

Plate type heat exchangers for lube oil:

- Frame Mild steel
- Plate Stainless steel 316L
- Others As per Manufacturer's standard

All heater inlet and outlet connections to be made with tap bolts or machine screws to ensure pipes or valves may be readily removed for cleaning, maintenance, etc.

All heat exchangers to be arranged with by-pass valves to enable work to be carried out on any heat exchanger sheet without shutting down the complete system.

Stainless steel covers to be provided to protect all heat exchanger plate stacks.

Such covers must be in place before coolers are installed in the ship.

Save all with drain to be fitted underneath each exchanger. Capabilities to divert the drain via isolating valve, to a portable collecting tank during washing/maintenance

13.1.6 – FILTERS AND STRAINERS

In the selection and design of filters, due attention is to be paid to:

- Maximum ratio of effective element area to container bulk.
- Robustness of element design.
- Effective and reliable jointing between the element and the filter bowl or strainer house to prevent bypassing of unfiltered fluids.
- Easy replacement of expendable filter elements by ship's staff.
- Manual cleaning capability by ship's staff for filter re-use (where allowed by the filter Supplier)
- Minimum cost and bulk of spare components required.

The direction of flow of liquid through filter elements is to be such that all sludge will be removed with the element when it is withdrawn for cleaning.

Strainer and filter elements are to be capable of withstanding, without mechanical failure, the maximum pressure difference which can be imposed upon them under any condition of operation specified for the units.

Where an integral automatic by-pass arrangement is incorporated it is to be so constructed that:

- Carry over of sludge does not occur when the by-pass is in operation.
- Leakage due to the presence of dirt between sealing faces is minimized.
- There is visual indication and alarm that the by-pass is in operation.

Strainers for sea water system are to be of flat plate or basket type of fabricated or cast construction and of suitable non-ferrous material.

Strainer plates/baskets are to have mesh size 20% less than apertures which are to be protected.

The open areas for suction strainers are to be as follows:

- 3.5 times the area of the pipe for pipes up to 50 mm.
- 3 times the area of the pipes of 65 to 100 mm.
- 2.5 times the area of the pipes of 125 mm and above.

An on/off ventilation cock or ball valve and ventilation pipe are to be provided on the high point of each strainer. For filters installed on skids of same particular supplier this functionality is not available.

The ventilation cock or valve is to be mounted directly on the strainer.

The strainer body is to have a drain plug at the bottom.

Strainers for fuel pump and lubricating pump suction pipes to be with 1 mm holes and with an area not less than 2.5 times the area of the suction pipes.

Final sizing of the hole diameters shall be decided taking into consideration the fluid and flow conditions and pump design.

Filters for fuel oil and lubricating oil are to be strictly in accordance with the engine Manufacturer's specification and the filter bowl to be provided with on/off ventilation and drain cocks.

The drain cocks to be placed readily accessible and connected with a drainpipe led to hopper so that flow from the drain is visible to the operator.

Fuel and lubricating oil filters are to be of the mechanical type and not of the disposable type.

Non-automatic filters to be arranged as Duplex filter units.

The main lubricating oil and fuel oil filters to be of automatic back flushing design.

Where necessary, filters are to be provided with heating arrangement

Filters and strainers not provided with an integral bypass system to be provided with a piped bypass complete with isolating and shut off valves. This does not apply to services and systems where redundancy is already foreseen.

Unless stated otherwise, all micron filtrations are stated in "ABSOLUTE" terms.

Save all with drain to be fitted underneath each filter and strainer associated with fuel and lube oil.

13.1.7 – PUMPS

Each pump is to be provided with a manometer or a compound manometer on the suction and a manometer on the discharge.

The pump revolutions to be constrained to within 1800 RPM, unless the following systems:

Vertically mounted centrifugal pumps to permit removal of the rotating elements without dismounting the electrically motors or pipe flanges. Pumps extending into tanks are not to be installed. For horizontally mounted pumps the pump casings to be either

- split on the horizontal centre line or
- provided with end cover to permit removal of the elements without dismantling the electrically motors.

Sufficient working space to be left around pumps for ease of maintenance.

All pumps to be supplied with renewable impeller wear rings.

A spacer shaft with flexible coupling is to be installed between the pump shaft and motor drive shaft.

The thrust forces are not allowed to be transferred from the pump rotor to the drive motor bearings.

Pumps used for pumping hot liquid to be manufactured from suitable materials.

Close coupled or mono block pumps can only be installed with Owners' approval and will not be considered for pumps with a capacity greater than 30 m3/hr.

Unless otherwise specified or approved, glands for pump shafts and spindles are to be mechanical seals.

Where mechanical seals are not employed, renewable sleeves in way of stuffing boxes are to be provided.

Mechanical seals to be of Crane Type 502 or suitable approved equivalent, with silicone carbide seal face and seat material

For electric motors driving rotary pumps, the rated motor power is to be adequate in providing the power required over the entire operating range of the pump.

Variables to be considered in this respect are to include:

- Specific gravity of the fluid.
- The viscosity of the fluid.
- The fluid pressure and temperature at suction.
- The fluid pressure and temperature at the discharge
- The influence of any relief valve or bypass rating.

Motors to be rated approximately 10% above maximum designed duty.

13.1.7.1 – PUMPS MATERIALS

– FRESH WATER PUMPS

Pump casing:	Cast iron
Impeller:	Al Bronze to DIN 1714 Cu AI 10 Ni ASTM B148C95800
Shaft:	Stainless steel AISI 316L, AISI 329
Wearing ring:	Phosphor bronze
Seal:	Mechanical "Crane" Type 502 or similar

Materials for the oil pumps to be as follows:

– SCREW TYPE PUMPS

Casing:	Cast iron
Screw:	Steel
Shaft:	Steel
Seal:	Mechanical of "Crane" Type 502 or similar

13.2 – AUXILIARY SYSTEMS

13.2.2.2 – FRESH WATER GENERATION

13.2.2.2.1 – REVERSE OSMOSIS UNITS

Five (5) disc-tube or spiral type membrane filtration sea water de-salination reverse osmosis plant, each capable of producing 1100 tons with TDS not more than 250 PPM (double pass) of fresh water per day at a sea water temperature of +25 deg. C and operating in a fully automatic mode, to be provided.
The units are to be able to produce water worldwide.
Two (2) units of five, arranged in two different SRtP areas are to be provided with a second outlet of demineralised water at 5 ppm for demineralised technical water users.

14.0 - SUBJECT

Aim of this document is to summarize the design principles adopted on this Vessel in order to accomplish the requirements of SOLAS Safe Return to Port.

14.1 - DESIGN ASSUMPTIONS

14.1.1 - MAIN REQUIREMENTS

The Ship's critical Systems as defined by MSC Circ. 1369 will be divided in two separate subsystems "A" and "B" with suffixes to identify the particular system involved.

In case any space ("A" or "B") is damaged due to fire or flooding, only the sub-system to which that space belongs will be affected by the casualty ("A" or "B"), while the other sub-system ("B" or "A") will remain operational.

Electrical load balances will be developed to assess the power requirements in SRtP in the worst case scenarios, for both active and reactive power, on the following cases:

- One Power Generation and Propulsion system ("Ap" or "Bp", see Par. 3.1) in service (one azimuth unit with shaft locked, the other running)
- One Power Generation and Propulsion system ("Ap" or "Bp") in service with any one generator out of service.
- One of the two alternative Safe Areas provided with all the required services (see Par. 14.3).

A fuel consumption balance will be provided to assess the capability of the vessel to reach the SRtP range, on the basis of the electrical load balance in SRtP (see Par. 2.1) and fuel consumption of 210 g/kW Hr.

14.2 - SHIP DESCRIPTION IN SAFE RETURN TO PORT (REG. 21 AND 8-1)

14.2.1 - POWER GENERATION, DISTRIBUTION AND PROPULSION

Base:

The adopted design criterion is the separation of the Propulsion and Power Generation systems, together with all their relevant ancillaries and the necessary electrical and mechanical circuits, in two sub-systems, named "Ap" and "Bp"

- System Ap: Fwd Engine/Generators, Fwd HV and LV Main Switchboard and relevant auxiliaries, Propulsion equipment and relevant auxiliaries
- System Bp: Aft Engine/Generators, Aft HV and LV Main Switchboard and relevant auxiliaries, Propulsion equipment and relevant auxiliaries

A third Emergency Generating System (System "E"), constituted by the Emergency D/Gs and Emergency Switchboard, will be available in case of loss of either System "Ap" or System "Bp":

- System E: Emergency Generator, Emergency Switchboard and relevant auxiliaries

Availability of users belonging to Propulsion and Power Generation System that are considered to be available when:

- not directly affected by fire or flooding in SRtP scenario

is obtained through power supply from its own Generating Systems (and from Emergency Generating System, when needed).

Propulsion and Generation cables belonging to Systems Ap and Bp are protected by separate routing, keeping essential cable trays all inside the area of the Subsystem to which the cable belongs.

5.6 - PAINTING

1st Treatment		2nd Treatment		3rd Treatment			
ALKYD PRIMER		ALKYD ENAMEL GLOSS		ALKYD ENAMEL GLOSS			
Coat thickness µ	No. Of Coats	Coat thickness µ	No. of coats	Coat thickness µ	No. of coats	**Total Coats**	**3**
50	1	50	1	30	1	**Total dry film thickness (µ)**	**130**
Colour		Colour		Colour			
				RAL 6017			

Note:

(1) To Maker account

(2) See paragraph Outfitting Items

(3) Supplier painting standard could be accepted

(4) Painting system below machinery and equipment to be completed before the installation; **RAL 6021**

(5) **RAL 6033** for electrical cabinets/panels

7 - ANNEXES

7.1 - TAB. A1 – SHIP CONDITIONS

Tab. A1

SHIP CONDITIONS

FLUID AVAILABILITY ONBOARD

DESCRIPTION	WORKING PRESSURE [barg]	NOMINAL PRESSURE [PN]	DESIGN PRESSURE [barg]	TEMPERATURE [°C]	F/C CODE
High Pressure Compressed Air	30	ANSI 300	33	40	***AR***
Low Pressure Compressed Air (dried)	8	16	9.35	40	***ARC***
Demineralized Water	abt 3	6	6	Max 50	***DD***
H.T. Cooling Water	5	6	6	96	***DRH***
L.T. Cooling Water	3.5	6	6	36	***DRL***
Aux Cooling Water	2-4	6	6	36	***DR***
Sea Water Cooling	1-3	6	1.5-4	32	***MR***
Steam	9	16	12	180	***VA***

THERMAL PARAMETERS

Engine Room Temperature [°C]	Max. 45
Maximum allowed surface temperature [°C]	Max. 60
Diesel engine Maximum allowed surface temperature [°C]	Max. 220

POWER SUPPLY

VOLTAGE [V]	FREQUENCY [Hz]	PHASES
690	60	3
220	60	3