GUIDELINE SPECIFICATIONS

FOR

174,000 M^3 LNG VESSEL

2014. 8

KOGAS
KOREA GAS CORPORATION

I N D E X

Guideline Specifications for 174,000cbm KOGAS LNG Project (2 Stroke Low Speed Diesel Engine)

1 General

1.1 Introduction

The vessel described in this outline performance specification is a Liquefied Natural Gas Carrier suitable for the international transportation of LNG at -163ºC.

All materials and workmanship including items not mentioned in this Guideline Specification, which fall within the latest state of the art of first class international shipbuilding practice, shall be incorporated by the Builder together with all Statutory and Classification requirements of relevant Authority for the design and construction of the Liquefied Natural Gas Carrier (LNGC).

The hull form, together with propulsion and power generation systems, shall be designed for maximum efficiency and fuel economy.

1.2 General Requirement

The vessel shall be designed for worldwide trading and is mainly scheduled to trade between loading facilities located in North Atlantic basin Sabin Pass LNG (USA) up to existing Korea unloading LNG facilities located in Incheon, Pyeongtaek, Tongyeong and Samcheok as well as planned LNG unloading facilities located in the East Pacific, through Panama Canal.

This vessel shall meet the requirements of the LNG terminals specified below.

Ship/Shore Compatibility

The vessel shall meet all the ship/shore compatibility of loading and discharge terminals.
The following items shall be considered in the design phase. Consideration should also be given to any air draught restrictions at these ports.

- Fender contact area and reaction force
- Mooring arrangement and mooring wire tension
- Gangway landing position & envelope
- Manifold arrangement and loading & discharging arm's envelope
- Ship/shore communication (Including Optical Fiber Data Link)
- ESD system
- Storage and crane, etc.
- Loading/Unloading Terminal

Country	Loading Terminal
USA	Sabine Pass
Australia	GLNG
Oman	Qalhat

Qatar	Ras Laffan
Yemen	Balhaf
Russia	*Sakhalin
Australia	Prelude FLNG
Australia	Darwin(Ichthys LNG)
Malaysia	Bintulu
Indonesia	Bontang LNG
Malaysia	PETRONAS FLNG 1
Indonesia	Abadi FLNG
Canada	Kitimat LNG

* Summer only

Country	Unloading Terminal
South Korea	Incheon
South Korea	Pyeongtaek
South Korea	Tongyeong
South Korea	Samcheok
Belgium	Zeebrugge
Brazil	Baia de Guanabara
Chile	Quintero LNG
France	Fos-Cavaou (Fos-sur-Mer II)
France	Montoir-de-Bretagne
Italy	Adriatic LNG
Japan	Futtsu
Japan	Niigata
Japan	Sakai LNG
Japan	Senboku II
Japan	Sodegaura
Japan	Chita I
Japan	Chita II
Japan	Joetsu LNG
Japan	Kawagoe
Japan	Ohgishima
Mexico	Manzanillo
Mexico	Altamira
Mexico	Costa Azul
Singapore	Singapore LNG

Spain	Barcelona
Spain	Bilbao

The Ship/Shore Compatibility booklet for above ports, which is the major standard format with ship's optimoor data, shall be provided.

The Builder at no extra cost to the Owner shall nevertheless supply all items necessary for the working of the vessel not mentioned in the Specification.

The representatives of the Owner, who shall reserve the right to reject any work or materials that does not reasonably meet with their approval shall inspect all work and materials.

The Builder shall inspect all equipment intended for the vessel before it is fitted. Proper storage and protection of equipment (Including Owner's supply items) before and after lifting on the vessel shall be provided by the Builder.

Special consideration shall be given to all equipment fitted being serviced and repaired in Korea, Singapore, Japan, Yemen, Qatar and Oman, USA and Australia, as far as practical.

All instruments and control systems shall be coordinated to assure a minimum of manufacturers and types and provided optimum design efficiency.

All drawings, specifications, purchase orders etc. shall be in the English language, and all values used throughout those documents shall be expressed, in principal, Metric system except S.I unit for cargo part.

1.3 Principal Dimensions and Capacities

The following principal dimensions shall not be exceeded:

Length Overall	Max 308.00 metres
Breadth (extreme)	Max 49.00 metres
Design Draught (extreme)	Max 12.50 metres

The design draught shall be based upon the loaded departure condition with 98.5% of full cargo capacity at cargo specific gravity 0.47 and bunker and consumables corresponding to 12,000 nautical miles without making use of boil off gas and with ballast water to achieve approximately even keel.

The scantling draught shall be design draught plus one metre. A cargo specific gravity of 0.5 shall

be used in determining the scantlings of the hull and cargo containment system.
Designs should also endeavor to maximize cargo carrying capacity by optimizing engine room length.

The length of parallel body at the ballast draught shall be not less than 90 metres; the objective being to ensure the required number of jetty fenders for each port are in contact with the flat of side when the manifold is aligned with the loading arms.

The total cargo tank volume shall be the maximum that can be safely achieved within the dimensional constraints set out approximately 174,000 m^3 when calculated at 100% volume and LNG temperature of –163ºC.

The Builder shall investigate and confirm the consequences in terms of cargo carrying.

Ballast capacity and distribution shall be sufficient to allow the vessel to achieve even keel arrival in ballast with the required amounts of heel in the cargo tanks and with consumables at 50% maximum capacity plus three days reserve. The designated ballast spaces shall exclude the peak tanks. The aft draft shall provide for the immersion of the propeller with an enough depth above the upper blade edge in order to maintain at least 110% propeller immersion ratio.

The ballast system shall be designed to allow concurrent de-ballasting during cargo loading or ballasting during discharge without at any time exceeding the maximum and minimum draught limits.

Total fuel and consumables capacity shall be sufficient for at least 12,000 nautical miles operation with engines burning oil fuel only, on the basis of the following conditions:

- Service speed 19.50 knots at NCR
- Fuel : ISO 8217 Fuel Standard; 2012 International Standard for Marine Distillate Fuels.
- Fuel tanks 98% full, 2% unpumpable and reserve for 3 days.

1.4 Speed

The propulsion plant and vessel's hull form shall be designed to provide a service speed is not less than 19.5 knots in the design draft, calm and deep sea condition at NCR with 20% sea margin.

1.5 Classification, Rules, Regulations and Standards

1.5.1 Classification Society

The vessel, including its machinery, equipment and outfitting shall be built in accordance with the

rules of double Classification Societies, Korean Register of Shipping (KR) and one(1) of the following Classification Society.

- Lloyd's Register of Shipping (LR)
- Det Norske Veritas (DNV)
- Bureau Veritas (BV)
- American Bureau of Shipping (ABS)

The class notation shall be equivalent to the following KR's notation:

+KRS 1 - Liquefied Gas Carrier 2G 3M(R)/0.25bar, -163℃, 0.5SG(IGC), SeaTrust(DSA2, FSA3,HCM), IWS ERS ENV(IAFS, IOPP, ISPP, IGPP, IAPP, IBWM, IEE, IIHM), CHA, LI

+KRM 1 - UMA3 STCM NBS2 IGS

The Vessel shall be classed as an ocean going liquefied gas carrier suitable for the transportation and handling of Liquefied Natural Gas (LNG) at -163℃ and specific gravity 0.5.

1.5.2 Rules and Regulation

The vessel shall be registered in a port of Panama. It shall satisfy the applicable maritime rules and regulations for international trade and for entry into the ports specified in section 1.2.

The latest version of the following Rules & Regulations and Recommendations incorporating all subsequent additions and amendments current and in force or agreed but awaiting ratification, enactment of implementation at the time of signing the Shipbuilding Contract shall be applied:

Notwithstanding the above paragraph, countermeasures for relevant rules and regulations, which are entered into force before the date of vessel's delivery and therefore be applied to the vessel, shall be taken appropriately by the builder.

- National Maritime Regulations of Country of Registry
- International Convention for the Safety of Life at Sea, 1974 with the Protocol of 1978/1988 and Amendments, including the New International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (new IGC Code) which is under consideration for adoption in IMO.
- The International Life-saving Appliances Code (LSA Code), and Amendments
- The International Code for the Security of Ships and Port Facilities (ISPS Code), and

Amendments.

- International Convention on Load Lines, 1966 with the Protocol of 1988 and Amendments.
- International Regulations for Preventing Collision at Sea, 1972 and Amendments.
- International Convention for the Prevention of Pollution from Ships (MARPOL), 1973 (Annexes I, IV, V & VI) with Protocol of 1978/1997 and Amendments including following:
  - IMO Resolution MEPC.212(63) "Guidelines on the Method of Calculation of Attained Energy Efficiency Design Index(EEDI) for New Ships" and Amendments;
  - IMO Resolution MEPC.213(63) "Guidelines for the Development of a Ship Energy Efficiency Management Plan (SEEMP)" and Amendments.;
  - IMO Resolution MEPC.214(63) "Guideline on Survey and Certification of the Energy Efficiency Design Index (EEDI)" and Amendments; and
  - IMO Resolution MEPC.215(63) "Guidelines for Calculation of Reference Lines for Use with the Energy Efficiency Design Index (EEDI)" and Amendments.
- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) and Amendments
- International Telecommunication Union (ITU) Radio Regulation, 2012.
- International Convention on Tonnage Measurement of Ships 1969 and Amendments
- International Conventions for the Control and Management of Ships' Ballast Water and sediments, 2004
- Maritime labor convention 2006 (Title 3)
- International Convention on the Control of Harmful Anti-Fouling systems on Ships, 2001
- International Code on Intact Stability, 2008 and Amendments
- International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code) and Amendments
- Suez Canal Navigation Regulation including Tonnage Measurement
- Existing and new Panama Canal Navigation Regulation including Tonnage Measurement

The Builder is to furnish a Letter of Compliance from the Classification Society with regard to the following requirements and recommendations of the USCG:

- USCG Rules CFR title 46-Shipping:
  Parts 154.22: Safety standard for LNG for Foreign flag vessel-Certificate of Compliance endorsement application;
  Part 32.56-15: CO2 Extinguishing Systems, details;
  Part 34.15-10: Control;
  Part 34.15-30: Alarms.
- USCG Rules CFR 33-Navigation and Navigable Waters
  Part 155: Oil or hazardous material pollution prevention regulations for vessels

Part 156: Oil and hazardous material transfer operations

Part 159: Marine sanitation devices

Part 164: Navitation safety regulations

- USCG Rules CFR title 29-Labor
- Part 1918: Safety and health regulations for longshoring
- Public law 95-474 Oct. 17, 1978 "Port and Tanker Safety Act of 1978"
- Guidelines of the National Oceanographic and Atmospheric Administration (NOAA) in relation to actions to avoid strikes in the water of the United States of America with protected species

Builder is also to furnish all certificates required to enable the vessel to trade, including appropriate entries in the Register of Lifting Appliances (or equivalent), Crew Accommodation Certificate etc.

The latest revision of the following recommendations and guidelines shall apply:

- OCIMF "Recommendations on Equipment for the Towing of Disabled Tankers", 1981
- OCIMF "Mooring Equipment Guidelines", 2008(3rd Edition)
- OCIMF "Guidelines and Recommendations for the Safe Mooring of Large Ships at Piers and Sea Islands", 1994
- OCIMF "Manifold Recommendations for Liquefied Gas Carrier", 2011
- OCIMF "Ship-to-Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases", 2013
- OCIMF HSE at New building and Repair Shipyards and During Factory Acceptance Testing July 2003.
- ICS "Guide to Helicopter/Ship Operations", 2008(4^{th} Edition) and IAMSAR manual, 2013
- SIGTTO "ESD Arrangements & Linked Ship/Shore Systems for Liquefied Gas Carriers", 2009
- SIGTTO "Guidelines for the Alleviation of Excessive Surge Pressures on ESD", 1987
- SIGTTO "Design and Maintenance of Cargo System Pressure Relief Valves on Board Gas Carriers", 1998
- International Electro-Technical Commission (IEC) Publication 60092
  "Electrical Installations in Ships"
- International Electro-Technical Commission (IEC) Publication 60533
  "Electrical and Electronic Installations in Ships – Electromagnetic Compatibility"
- ISO 4406:1999
  "Hydraulic Fluid Power – Fluids – Method for Coding the Level of Contamination by Solid Particles"
- ISO 10816 Parts 1, 3 & 6 "Evaluation of machine vibration by measurements"
- ISO 6954:2000 "Mechanical Vibration – Guidelines for the Measurement, Reporting and Evaluation of Vibration with Regard to Habitability on Passenger and Merchant Ships"

- ISO 8310:2012 "Refrigerated light hydrocarbon fluids-measurement of temperature in tank containing liquefied gases - resistance thermometers and thermocouples
- ISO 10976:2012 “Refrigerated light hydrocarbon fluids – Measurement of cargoes on board LNG Carriers”
- ISO 484-1:1981, “Manufacturing Tolerances for ship screw propellers > 2.5m diameter”.
- ISO 8573-1: 2010 “Compressed air – Part 1: Contaminants and purity classes”
- ISO 8861:1998 “Engine room ventilation in diesel engine ships”
- ILO “Guide to Safety and Health in Dock Work” 1976, as amended in 1979 with modifications 1998**.**
- IMO Resolution A.1021(26) “Code on Alerts and Indicators”, 2009
- IMO Resolution A.272(VIII) and A.330(IX) “Safe Access to and Working in Large Cargo Tanks and Ballast Tanks”
- IMO Resolution MSC.337(91) “ADOPTION OF THE CODE ON NOISE LEVELS ON BOARD SHIPS”
- IMO Publication No.978 "Performance Standards for Navigational Equipment (1997 Edition)".
- IMO Resolution MSC. 137(76) “Standards for ship manoeuvrability”
- IMO MSC/Circ. 854 “Guidelines for shipboard loading and stability computer Programs”.
- EPA’s 2013 Vessel General Permit part 2 “Effluent Limits and related Requirements”
- IACS UR M59 “Control and safety systems for Dual Fuel Diesel Engines”
- Exxon Mobile “Marine Environmental, Safety and Quality Assurance Criteria for Seagoing Vessels in Exxon Mobile Affiliate Service”

1.6 Stability and Trim

The vessel shall have positive stability in all conditions including the simultaneous handling of cargo and ballast during loading and discharging operations.
The vessel shall be capable of departure from the berth at any state of loading.

Statutory stability requirements shall be met over the full range of operating conditions, including partial cargo filling conditions, full cargo conditions, all load and discharge sequences, and exchange of ballast water while on passage.

The implications of complying with all requirements of ballast water exchange procedures for the range of conditions specified are to be fully investigated to comply with the requirements of Class notation IBWM. The healing angle shall not exceed 1.3 degrees and no bow trim when a tank is being pumped out. Propeller shall remain immersed during ballast water exchange and IMO visibility requirements shall be met at all times.

The vessel shall be fitted with an online loading computer capable of verifying loading cases, load/discharge sequences and damage stability.

A four(4) position, remote read-out draft gauge indication system shall be installed in wheelhouse and CCR.

1.7 Sloshing

Sloshing loads should be kept at an acceptable level for avoiding possible damage of the inside walls of the cargo tanks.

1.8 Hydrodynamic Design and Model Testing

The Builder shall carry out model testing to determine the vessel's hull form and hydrodynamic design. The tests, to be carried out at ballast, design and summer draught conditions, shall be carried out at an established model basin acceptable to the Owner to verify the design for resistance (in air and water) (resistance and wind tunnel tests), self-propulsion (in still water and in waves), flow-line, cavitations, wake, sea-keeping and manoeuvring (free sailing manoeuvring tests), pressure fluctuation measurement.

The objectives of the tests shall include:

- Determination of the after body hull form,
- Optimization of the length and line of bilge keels,
- Reduction of flow separation at the propeller aperture,
- Determination of final propeller design (including an open water test),
- Determination of steering and course keeping characteristics.
- Determination of sea-keeping characteristics.
- Determination of optimum funnel exhaust arrangement by means of a smoke visualization test.
- Determination of the suitability of the helicopter winching zone.
- Determination of EEDI

The analysis is to include oblique wind and wave environments to determine the worst combinations of environment and motions.
Theoretical studies shall be conducted on the excitation of propeller in the after-body hull form.

1.9 General Arrangement

Under-deck passageways immediately below the main deck level or within the trunk deck for membrane ships shall be fitted between the aft and forward areas on the port and starboard side.

These passageways shall be also used as pipe and cable passages where practical.
Double bottom shall be provided under cargo space and engine room.
Passageways shall be provided (mainly for the ballast pipe) in the double bottom.

F.O/D.O/F.W/D.W(Drinking & Distilled water) tanks shall not be incorporated in double bottom except F.O overflow and drain tank.
Double bottom shall be dry spaces, as far as practical, and cofferdam shall be dry spaces.

A cargo deckhouse shall be provided. The cargo deckhouse shall be contained a cargo machinery room and a motor room separated by a gas tight bulkhead.

The inert gas generator room shall be located in a separate compartment in the engine room, as far as practical.

The bridge wings should be designed to extend at deck level 600mm beyond the sides of the vessel port and starboard to enable ship's officers to view the side during berthing. The bridge wing under-deck structure is also to be closed and support structure is to be box section or similar closed sections with suitable drainage facilities for ease of maintenance.

Hull outfit design and selection of materials shall be such as to require minimum maintenance. This can be achieved by allowing adequate clearance between and beneath fittings to permit coating maintenance of all surfaces, use of suitable materials to avoid corrosion of fasteners, pipe clamps, supports and brackets.

As far as possible, pipelines, cables and fittings shall be installed below the deck, in underdeck pipe passages, inside deckhouses and similar protected spaces in order to minimize exposed steelwork. This requirement includes but is not limited to:

- Electric cables
- Cargo pump junction box / cable connections.
- Pneumatic pipework
- Fire lines
- Hydraulic pipelines
- Nitrogen distribution pipework
- Signal lines (except those carrying gas under high pressure)
- Sampling lines
- Control and Instrumentation
- Dry-powder houses and similar structures

Cables to bridge wing equipment shall be routed through the resulting void so far as practical. Where possible, open structures that have similar access problems should be avoided.

1.10 Tests and Trials

1.10.1 General

A comprehensive testing and commissioning program approved by the Owner and shall be undertaken by the Builder.

In addition to the requirements of the Classification Society and Regulatory Authorities, the program shall satisfy and confirm that the design requirements of the specification and approved drawings.

The Builder's schedule shall include the procedures to be followed and the standards to be achieved. The testing and trials shall be conducted in accordance with the requirements of the Classification Society, Regulatory Bodies and equivalent standards, e.g. SNAME and BSRA, etc.

The schedule shall cover shop trials, commissioning, dock trials, sea trial, gas trial and post sea & gas trial inspections.

The builder shall be provided to tender the procedures and Trial result reports for major tests and trials (LN_2 test, sea trial and gas trial, etc.).

1.10.2 Inclining Experiment

The light ship weight, longitudinal and vertical centers of gravity shall be determined by means of an inclining experiment that shall be carried out in the presence of representatives of the Owner and the appropriate regulatory authority when the vessel has reached a state of completion that satisfies those representatives.

1.10.3 Shop Trials, Commissioning and Dock Trials

Commissioning of all equipment shall be carried out to the Owner's satisfaction prior to sea trials, including a dock trial for the main propulsion plant developing at least 10% MCR. Shop trials should be carried out in accordance with the SNAME Technical & Research Bulletin 3-39 "Guide for Shop and Installation Tests".

1.10.4 Dry-dock

The vessel shall be dry-docked for cleaning the underwater hull and propeller etc. within 4 weeks before the commencement of sea trials in accordance with the Ship Building Contract.

At this time the final coat of anti-fouling is to be applied. Hull roughness measurement shall be

taken before sea trials, and steps taken to ensure that the hull and propeller are free from fouling on sea trials.

1.10.5 Sea Trials

The sea trials shall include speed runs as close as practical to the ballast draughts, and to those used in the model tests (for comparison). The number of reciprocal speed runs and specific power where the speed is to be measured shall be carried out in accordance with the IMO relevant requirement and under the agreement between the Owner and Builder.

In order to limit the effect of changing environmental conditions a maximum of about 1 hour is to be allowed between each leg of a pair of reciprocal runs.
The environmental wave and wind conditions together with current if practicable are to be continuously recorded during the trial and made available in real time for the Owner. The recorded environmental results are to be used in establishing the speed of the ship.

All speed trial parameter measurements (i.e. wave height/period/direction, wind speed/direction, current effects, shaft power and rpm, rudder angle, vessel motions) shall be agreed during the trial with the Owner representative. Independent properly calibrated physical means (i.e. wave rider buoy, wave radar) capable of measuring and recording wave heights, wave direction and wave period shall be used by the Builder.

The speed trial results shall be corrected in accordance with the IMO relevant requirement.

An endurance run of at least 24 hours shall be undertaken at NCR; which shall include at least six hours operation under unmanned engine room conditions, during which no adjustments shall be made. Fuel consumption rate shall also be measured over a 6-hour period, concurrent with the endurance test. Noise measurements shall be carried out of all living and working spaces during the endurance run. Noise measurements shall be taken under all sea and port operating conditions, e.g. cargo pumping, deck machinery running, etc., to establish the limits are not exceeded.

The fuel consumption rate is to be additionally measured in accordance with the IMO relevant requirement and under the agreement between the Owner and Builder.

A vibration test should be carried out during the trials, to establish resonant frequencies and ensure they lie outside the normal vessel operating conditions. During trials, seat vibration measurement of all rotating machinery above 15 kW shall be undertaken.

Maneuvering trials, including stopping trials, astern running at full astern power, turning circles,

Zig-Zag test, including the data required for the bridge display, shall be carried out at ballast draft condition.

Maneuvering trials should be carried out in accordance with the guidelines in IMO Resolution MSC.137(76) – Standards for Ship Maneuverability and MSC Circular.1053 – Explanatory Notes to the Standards for Ship Maneuverability.

Execution, data registration and presentation format of the manoeuvring, speed and fuel consumption tests shall be agreed with the Owner and all recorded data shall be provided to Owner. The speed trials shall not be carried out under weather conditions exceeding Beaufort Wind Scale No.4, but this could be adjusted under the mutual agreement between the Owner and Builder.

The conduct and procedures for all sea trials including analysis, reporting and correction methods shall be in accordance with agreed international codes, e.g. BSRA, SNAME.

Anchor and windlass test shall be carried out at the area of approx. 110m sea depth.

During sea trials, following measurements or calculation shall be performed:

- Noise level and vibration including hull vibration measurement, global vibration measurement including main deck and inside of No.4 cargo tank at intervals of 5 RPM, local vibration measurement at NCR and MCR load (during endurance trial), noise measurement at NCR and MCR load (during endurance trial), torsional vibration measurement of propeller shafting,
- Fuel oil consumption, under stable operating conditions in normal seagoing electric power conditions, at different machinery load,
- Shaft power shall be calculated from average torque and rpm of main shaft. Torque and rpm of main shaft shall be measured by means of calibrated and certified torsion and rpm meters, which shall be fitted temporarily on the intermediate shaft.
- Lubricant oil analysis shall be performed after sea trials for main gearing, if applicable, and main engine sump tank oil, dual fuel generator engine sump tank oil, stern tube, steering gear and fore/aft hydraulic deck machinery.

1.10.6 Post Sea Trials Inspection

The following items shall be subjected to post sea trial inspection;

- Main engine
- All filters and strainers to be inspected and where applicable, renewed
- Thrust block
- Dual fuel diesel generator engine

- Generator(s) to be inspected and overhauled, etc.
- Selected bearings, piston, rings, crankshaft, camshaft, rods, if any, lub-oil and hydraulic oil analysis

1.10.7 Gas Trial

The main purpose of the Gas Trial is to confirm correct functions and capacity of the cargo handling equipment using LNG. The function tests to comprise instrumentation, monitoring control and alarm systems as well as the cargo pumps, spray pumps, compressors, heaters, vaporizers etc. and valve operation. The endurance run of at least 6 hours shall be undertaken at NCR at the gas mode.

The cold tests of cargo handling equipments, cargo piping systems and one (1) cargo tank shall be carried out by use of liquid nitrogen (LN_2) or low temp. N_2 Gas before the Vessel's leaving to LNG terminal for the gas trials.

Prior to the gas trial, the followings shall be carried out.

- Cargo tanks and relevant piping shall be cleaned
- Internal T.V inspection for the cargo piping of all major liquid and vapor lines as far as applicable, agreed by Owner to ensure cleanliness.
- Cargo tanks and relevant piping systems shall be inerted with nitrogen (N_2) gas.

The Builder shall carry out full commissioning tests and load a suitable quantity of LNG at the builder's expense prior to the gas trials.

The Gas Trial for cargo part including fuel gas system using the boil off gas shall be performed as required by the Class and other regulatory bodies concerned.

The operation test of cargo handling equipment and associated instrumentation shall be carried out at a KOGAS terminal prior to the Vessel's delivery according to the Builder's test procedure approved by Owner.

Emergency cargo transfer test shall be carried out during gas trial. After Gas Trial, the vessel's all cargo tanks to be aerated for cargo pump and other equipments visually inspected.

The SNAME Technical Research Bulletin No.5-2 "Gas Trial Guide for LNG vessel" shall be considered as guidance in the Gas Trial.

The cold spot inspection shall be carried out at the Builder's expense after delivery.

1.11 Delivery

The completed vessel, ready for service, after completion of all tests and trials to the satisfaction of the Owner and issued with all certificates as described in the Specification shall be delivered to the Owner at the shipyard or agreed location in accordance with Shipbuilding Contract.

The delivery condition in the vessel's cargo tanks shall be decided by the requirement of the first Loading terminal.

1.12 Manning and Complement

The selection, configuration and lay-out of equipment shall facilitate efficient operation with minimum manning levels permitted by the registry authority.
Accommodation shall be provided for a complement of 40 persons excluding six(6) workers.

1.13 Vibration

Vibration levels in the accommodation and working spaces during normal operating conditions shall be within the range "Adverse Comments Not Probable" given by the lower limit in the ISO 6954:2000 "Guidelines for the measurement, reporting and evaluation of vibration with regard to habitability on passenger and merchant ship". Vibration level should be reported in accordance with ISO standard 20283-2:2008 "Code for the measurement and reporting of shipboard vibration data". Design peak vibration velocities in living spaces shall not exceed 1.5 mm/s over the frequency range 1-100 Hz. Noise and vibration calculations shall be carried out at an early stage of the design to verify compliance with the criteria. Noise and vibration trials shall be carried out as specified in Section 1.10.5

Hull vibration/accommodation analysis to be carried out before any structural design and details are finalized, results to be submitted to the Owner.

Resilient rubber mounting shall be provided for auxiliary & emergency diesel generators, blowers & fans for I.G.G. and air compressors except emergency air compressor, if necessary.
The builder shall prepare a schedule for recording the level of vibration and measurement shall be done in accordance with the builder's practice at MCR of the main engine during sea trial.

If vibration level exceeds the defined criteria, the builder shall make necessary improvement to a practical extent mutually agreed between the Owner and Builder.

The vibration levels for the following equipments shall not exceed "the fair zone (Max. 4 mm/sec)" in the IRD chart 305-1.

- Generator(s)
- Gas compressors
- IGG, etc.

A whole ship vibration analysis, independently assessed by a third party, is to be carried out to predict the vibration characteristics of the following main structural arrangements and interactions: hull, deck house and engine casing, bridge wings, radar masts and pump towers within cargo tanks. The analysis shall include local areas and local equipment including superstructures, local panels, radar mast, funnel, steering gear space, tanks in aft body and main hull. An independent investigation shall be carried out to identify possible resonance between machinery, propeller, pump tower and hull structure.

Particular attention shall be paid to reduce vibrations caused by the propeller (e.g. location of propeller in relation to the adjacent hull structure) or machinery (e.g. design of machinery foundation).

The vibration analysis is also to cover panels at the aft end and accommodation decks, this may be carried out as a separate study to the whole ship analysis. The results of the analysis are to be available to the Owner for use in main scantling plan approval.

1.14 Noise

Noise levels under normal seagoing conditions shall not exceed the following limits:

Cabins, hospital, public spaces, control rooms and offices	55 dB(A)
Galley and food preparation spaces	65 dB(A)
Workshops	75 dB(A)
Machinery control rooms	70 dB(A)
Machinery Spaces	110dB(A)

All other areas shall comply with IMO Resolution MSC.337(91).

Noise measurements shall be conducted in accordance with IMO Resolution MSC.337(91). If the measured noise levels exceed the recommended value, the Builder shall make necessary improvement mutually agreed between the Owner and Builder.

External noise levels shall not exceed 90 dB(A) at any location approximately one metre above the deck during pumping operations and with hydraulic machinery in use.

1.15 Drawings, Inspection Books, Operation Manuals

All drawings, specifications and other documents relating to the vessel shall be written in English, and all values used throughout these documents shall be expressed in SI units. Electronic versions of the drawings are to be provided on CD Rom and USB. Drawings to be AUTOCAD compatible and shall include the "Ship – Shore Interface Plan" to allow for future updates.

A drawings schedule shall be submitted to the Owner for agreement at an early stage showing:

- Builder's drawing for approval
- Supplier's Drawings for approval
- Reference Drawings

The proposed submission date for all documents shall be identified in the schedule.
An Owner approved specialist contractor who has experience of the containment system and machinery that is used, as required by the STCW and IGC Codes, shall write operating Manuals for Cargo and for Machinery. The first language of the technical author shall be English.

The Builder shall ensure the involvement and close co-operation of primary instrumentation contractors and cargo/machinery plant designers during the preparation of these manuals. Drafts shall be submitted to the Owner at least six months before contractual delivery. Electronic versions of the above manuals are to be provided on CD Rom and USB.

1.15.1 Plan for Approval

Four(4) copies of drawings shall be submitted to the Owner for approval before any material is ordered or work put in hand.

One(1) copy with the Owner's approved signature shall be returned to Builder.
The Owner shall be allowed four(4) weeks working days from receipt of the above drawings for reviewing and approval.
Plans for reference shall be sent to the Owner in three(3) copies.

One(1) copy of the Class's approved plan for the major key plans, the list of which shall be agreed by the Buyer, except functional drawings shall be submitted to the Owner for reference.

1.15.2 Finished Plan

A list finished plans including instruction books and tests and inspection reports shall be submitted to the Owner for approval.

Copies of the agreed drawings shall be supplied to the Owner at the time of the vessel's delivery as

follows:

Certificates	:	4 copies (total)
Tests and inspection reports	:	4 copies (total)
Drawings	:	4 copies (total)
Instruction books	:	4 copies (total)
Operation manuals	:	4 complete sets
Manufacturers equipment plans	:	4 sets
Reduced copy	:	2 copies
Electronic versions of the drawings on CD Rom and USB	:	1 set (total)

One (1) set of CD Rom and USB which shall contain the Shop & Onboard test results and certificates to be provided before delivery.
Drawings for SOPEP, ISPS, OPA-90 and etc. shall be provided.

1.15.3 Tender Document

The following five(5) drawings shall accompany with the specification of the vessel at the time of tender.

- Master Schedule
- General Arrangement
- Cargo Piping Diagram
- Heat Balance and Flow Diagram
- Speed-Power Curves (Loaded and Ballast)

And the following drawings shall be provided to Tender at the time of Shipbuilding Contract, also the Builder shall provide the final drawings to Tender at the time of vessel's delivery (including above mentioned five(5) drawings).

- Accommodation Arrangement
- Tank Plan with Capacity Table
- Trim and Stability book
- Light ship breakdown
- Hydrostatic/Curves
- Midship Section including Inner Hull Temperature
- Details of Containment System (for design B.O.R)
- Cargo Machinery arrangement
- Cargo handling Equipment Calculation
- Complete set of Cargo Operation Diagrams
- Manifold Arrangement
- Machinery Arrangement

- Machinery System On Line Diagram
- Electrical Load Analysis
- Electrical Distribution Plan
- As built Specification (only vessel's delivery time), etc.

1.15.4 Equipment List

The following drawings, lists and documents shall be provided by the Builder according to the form approved by the Owner.

- Component parts listed of hull, cargo, machinery, electrical and automation with dimensions and material.
- Particular list of hull, cargo, machinery, electrical and automation including accessories with name, type and maker.
- Valve and joint list of hull, cargo and machinery.

1.16 Material and Equipment

The Builder shall procure all materials and equipment from sources specified on the final mutually agreed "Makers List" which shall be an integral part of the Contract Specification. Their quality shall be in accordance with the relevant specifications, and the Builder shall not purchase materials whose production may be discontinued in the near future.

For those equipment, Tender may propose other Maker than those specified if the proposed selection is based on recognized components and equipment suitable for long service life of an Vessel, including Maker's ability to render world-wide spare supply and service within 24 hours for a twenty (20) year period after the Delivery Date of the Vessel.

For each component or equipment, the Maker shall be represented and shall have a technical assistance readily available in USA and Korea.

The Builder shall propose only those vendors who are properly equipped to meet the requirements of the Project Specification, which includes:

- Satisfactory performance records (current experience)
- Satisfactory operational maintenance records
- Quality assurance system
- International reputation
- Proven technical support
- Competent after sales service
- Anticipated spares availability for 20 years

- Proven worldwide service and spares network

The Builder's proposed Makers List shall be agreed with the Owner prior to Contract Award. If the Builder subsequently wishes to add to the agreed list, the Owner's written agreement shall be obtained before going out for enquiries.
The Builder shall not purchase Material of which the production may be discontinued in the foreseeable future.

For reasons of standardisation, the Builder shall select sources for materials in such a manner that the variety of types is restricted as far as possible. The Builder shall aim at selecting a single vendor for similar types of equipment, such as fire fighting equipment, groups of pumps, electrical motors, instruments, control valves, etc., with due regard to the vendor's capacity and extent of exposure, but without reducing the overall standard of equipment that could otherwise be provided from alternate suppliers. Design selections shall also attempt both to restrict the number of different sizes and types of pumps, electrical motors and other equipment, and to duplicate these for the various applications.

The Owner in accordance with the provisions of the Ship Building Contract shall approve selection of suppliers for the Makers List.
The finally agreed "Makers List" will be issued as part of the Shipbuilding Contract.

The Builder shall after verification complete all requisition, at a sufficient early date to ensure timely supply of materials and services.
Purchase order shall state which drawings, cross sectional drawings, fabrication drawings, calculation, certificates, data instruction books, operating/maintenance manuals, spare parts lists and other documents are required from vendor and the date by which they shall be sent to Builder, inspection agency and/or Owner.

In general all instrumentation, piping, fittings and lighting equipment on deck and open areas are to be of strong material with high resistance to sea water, ambient atmosphere, and preferably stainless steel 316 or copper alloys but not aluminum alloy.
The Builder shall carry out a material handling study, approved by the Owner, to ensure all materials, including spare parts, consumables stores, machinery valves and equipment requiring repair can be safely and efficiently moved around the vessel by provision of adequate shipping routes, fixed and portable lifting appliances, access hatches, etc.

1.17 Owner Furnished Equipment

All Owner furnished equipment, stores and spares required for the vessel to proceed to sea shall be installed and stored by the Builder. These include all mooring ropes and loose equipment, furnishings, galley equipment and utensils, bedding, boatswains stores, navigation equipment, radios, television, safety equipment and consumable stores, etc.

1.18 Spares and Tools

The Builder shall provide the spares and tools in accordance with the "Attachment" as a minimum.

1.19 Ship's Model

The Builder shall provide one (1) complete ship's model (1/150) to the Owner. For KC-1 type CCS it is of an opened type.

1.20 Aerial Photograph

One(1) copy of aerial photograph shall be provided to the Owner.

1.21 Ship's Name

The ship's name is to be decided, considering the characteristics of each LNG project, in accordance with Tender's advice.

1.22 Technical Change Control Management

The Builder shall be responsible for ensuring changes from the contract specification, changes in design and changes from agreed plans are correctly managed throughout construction period. The Builder shall document and demonstrate their policy for change control of machinery plant, navigation, cargo, instrumentation and control systems.

A formal documented Change Control procedure is to be agreed with the Owner prior to the commissioning phase of construction. The Builder is to submit his proposals for Owner's consideration and approval as part of the plan approval process. This proposal shall include, but not necessarily be limited to, the commissioning of machinery plant and resulting changes that may be needed within the IAS system.

2 Hull

2.1 Hull Structure

2.1.1 General

The vessel shall be of all welded construction with, principally, a longitudinal framing system and adequate scarping where transverse framing is used. Continuity of primary longitudinal structure shall be maintained as far aft and as far forward as practicable, into the main machinery space, the superstructure and the spaces forward of the cargo tanks.

Structural analyses calculations, using finite element analysis (FEA) methods, shall be carried out for the vessel's main hull structure incorporating requirements of the Classification Society. In general, the finite element modeling shall cover the whole cargo area. For membrane designs, this shall include the structural integration of the trunk deck. The results of the structural analyses, including output file in an agreed format, are to be forwarded to the Owner in support of main scantling plan approval. The Builder shall include a list of the local areas that will be analyzed through FEA methods.

The design fatigue life of all critical details in primary structure and all stiffener connections shall be sufficient for 40 years based on the requirement of Classification.

In general, the structural analyses calculations and fatigue analyses shall be submitted to the Classification Society for approval and Owner for reference.

All welding shall be double continuous except behind linings in dry spaces in the accommodation, which may be intermittent in accordance with Classification Rules.

The external bulkheads and decks of the superstructure and deckhouse shall be of steel flat plate construction.

The design of the superstructure shall consider the vertical alignment of internal structure bulkheads and girders with main hull structure to minimize vibration.

Steel bulwarks, of about 1.0m height, shall be fitted on forward mooring deck to protect machinery at the bow and around the bridge wings. Breakwaters shall be fitted where necessary.

Transverse watertight bulkheads dividing holds shall be of the flat plate type with stiffeners. So far as possible, structural profiles used in the water ballast spaces, especially on deckheads, shall be of bulb-plate or flat-bar section to facilitate correct application of the protective coatings. Plating and stiffeners in ballast tanks shall have a minimum thickness of 12mm.

Penetration connections of longitudinal frames and transverse webs shall be fitted with collar/lug plates or shall be of the slotless type with full double weld connection in way of concentrated loads, areas of high buckling or direct stress.

The hull structure in way of the bow area and shoulder regions in the fore body shall be treated similarly when designing against impact pressure loading. The bottom forward region is shall be reinforced against slamming for any loaded, part loaded or ballast condition.

The quality assurance documents and procedures that include details of hull structure tolerance and checking procedures (including alignment, welding etc.) shall be submitted to the owner.
Foundation seats for main and auxiliary machinery shall be of all welded, rigid construction, designed to minimize vibration.

2.1.2 Materials

The main hull structure shall be mild steel throughout. The use of high tensile steel shall be subject to the approval of the Owner.

All steel grades for hull structure are to meet the requirements of the IGC Code and USCG.
Ambient conditions around hull surface for determining material grade are;

- Air temperature (at a wind speed of 20m/sec) : -18℃
- Sea water temperature : -0℃

Materials of guaranteed through thickness qualities are to be used for all cases where significant out of plane forces arise. The areas to be investigated are to include but are not limited to the following:

- Bulkhead connections to the inner bottom.
- Stringer end connections.
- Knuckle arrangements.
- Foundation decks.

The quality of materials used for flanged knuckles is to be specially considered and subject to the Owner’s approval.

In order to enhance habitability the use of special materials such as sandwich plate systems may be considered for external plating of the accommodation or other superstructures in order to benefit from the thermal break characteristics. The material may also be used where it is expected that vibration attenuation would be beneficial.

2.1.3 Scantlings

No reduction in scantlings due to “corrosion control” allowance from the classification society shall be permitted.

Preliminary structural design scantling calculations and drawings shall be submitted to the Owner and approval prior to any steel ordering indicating factors of safety, rule/design module and bending moments and design stresses.

Determination of the hull and cargo containment system scantling shall be based on the cargo having a specific gravity of 0.50.

Ballast loading conditions involving partially filled peak and/or other ballast tanks at departure, arrival or during intermediate conditions shall not be permitted to be used as design conditions unless; design stress limits are satisfied for all filling levels between empty and full. In cargo loading conditions, this requirement shall be applied to the peak tanks only.

Hull scantlings shall be adequate to allow any combination of cargo tank or tanks to be empty with adjacent tank or tanks still full. Water ballast may be used to limit shear forces and bending moments in which case the tanks are to be 100% full or empty.

The vessel is to be designed to accommodate ballast exchange procedures at sea.
The peak tanks are not to be used for ballast.
Five areas of shell shall be reinforced on each side, from the light ballast docking draught to 2m above the scantling draught and marked, for tug pushing.
The LNG terminal fender contact area shall be specially reinforced.

2.1.4 Non Destructive Testing

Non-destructive examination is to be carried out to the satisfaction of the Classification Society and up to reasonable scope additional radiographic examinations of welding are to be taken in locations agreed with the Owner.
All manual welding joints, including block joints, on cargo hold inner hull shall be R.T or U.T tested.

2.2 Hull Appendages

2.2.1 Rudder

A streamlined, semi-balanced rudder shall be designed based on the speed at MCR in the summer draught condition and shall have a working angle of 35 degrees either side of the centreline. The

effective rudder area shall be about 2.5% of the product of the vessel's length and draught.

The rudderstock shall be of forged steel, the diameter of the stock shall be increased in way of the carrier.
It shall be possible to unship the rudderstock without unshipping the rudder.

Rudder and pintle bearing sleeves shall be of stainless steel and the bushes shall be fabricated from synthetic material ("Thordon" or "Orkot"), with easy access for inspection. Roller or ball type bearings will not be accepted for the rudder carrier.

2.2.2 Bilge Keels

Continuous bilge keels, correctly aligned with streamline flow, shall be fitted over 35% of the length amidships, as determined by the model tests stated in Section 1.8.

2.3 Corrosion Protection

2.3.1 Painting

2.3.1.1 General

A corrosion protection system of the highest standards shall be provided. The finish colors shall be to Owner's approval.

The following outline specification shall be regarded as being the minimum acceptable standard of surface preparation and application:

- For the application of these specifications the hull structure is categorized as follows:
  - Category 1: Water ballast spaces, submerged areas, and areas exposed to the weather.
  - Category 2: Void spaces, cofferdams naturally ventilated.
  - Category 3: All other spaces.
- All steel plate, profiles and sundry steel fitments shall be shot-blasted to give a finish equal to Sh2 of the Japanese Shipbuilding Research Association (SPSS-1975) "Standard for Preparation of Steel Surface Prior to Painting" (Grade Sa2.5 of the Swedish Standard SIS 05.59.00). Plates, profiles and fitments shall be primed with a compatible shop primer immediately after shot-blasting. No mill scale covered permanent component or fitment; either welded or bolted shall be fitted in any part of the vessel.
- For Category 1 spaces : All free edges of plating, structural openings and stiffening shall be provided with three pass edge grinding followed by paper disc treatment to a suitable profile and removal of burrs. All ballast tanks shall be coated in accordance with requirements of SOLAS RegII-1/3-2.

- For Category 2 spaces : All free edges of plating, structural openings and stiffening shall be provided with a one pass edge grinding followed by paper disc treatment to a suitable profile and removal of burrs.
- For Category 3 spaces : All free edges of plating, structural openings and stiffening shall be provided with a suitable edge treatment for the removal of burrs.
- After fabrication of block sections, all weld connections, damaged, chalk marked or rusted shop primer on areas to which a corrosion protection system will be applied, shall be re-blasted to Sh2 standard or equal. The remainder of intact surfaces sweep-blasted to achieve the following standard for removal of the original primer
    - At least 70% for category 1 spaces,
    - At least 40% for category 2 spaces.
    - Category 3 spaces are to be provided with a suitable secondary surface preparation and may use hand tooling.
- Expendable copper slag or mineral abrasives (but not sand) shall be used for blasting. Full moisture control and ventilation facilities shall be applied throughout the whole preparation and painting period. All surface contaminants such as salts and oil are also to be removed by the appropriate method before painting or over-coating.
- Areas where inorganic zinc silicate is specified such as exposed decks shall be blasted to Sa2.5 before application.
- Structure in way of all block erection joints in areas of external hull, decks shall be re-blasted to Sh2 standard or equal after completion of welding and grinding. Vacuum-blast, or similar techniques, shall be used to minimize the potential damage to surrounding areas of coating within the water ballast spaces when re-blasting these erection joints and any burn-damaged areas. Care should be taken to ensure existing paint is properly 'feathered' after blasting.
- When welding is to be carried out on steel that has already been coated, this shall be performed with a low heat input to avoid damage to the coating system (e.g. stud welding for the LNG containment system on the inner hull after coating of the opposite side). Qualification tests shall be performed to demonstrate the ability of the coating system to withstand the heat input from the welding process. The qualification tests are subject to approval by the Owner and the Paint/Coating manufacturer.
- Where primer remains as the only corrosion control coating e.g. within the hold spaces, the DFT. is to be suitable to prevent rusting of the steel throughout the fabrication and building period.
- For membrane systems where the method of securing the insulation to the inner hull uses adhesives, the surface must be prepared to the manufacturer's required standard. Suitable adhesion tests are to be carried out to confirm that during production the required standards are being maintained.

- The Builder shall ensure that all machinery and proprietary equipment is prepared and painted in accordance with the specification.
- In principal, paint to be applied by airless spray, but air spray, brush or roller may be applied where airless spraying is not applicable.
- Water ballast tank fittings, which are to be bolted or welded to the main structure, may be coated same as surrounding or equivalent paint system without holding primer.
- Galvanized and aluminized steel on exposed area shall be coated same as surrounding with holding primer, and generally, galvanizing to be applied for steel wire rope.
- Electric cables shall not be painted.
- Finish colors shall be to Owner's approval.

2.3.1.2 Inspection

All paints and coatings shall be applied strictly to the paint supplier's instructions and under his supervision. The Owner's representatives shall be fully integrated into all production and inspection procedures with the Builder and paint supplier, and shall inspect the quality of surface preparation and coating at all stages of application.

The dry film thickness (DFT) of the paint shall be checked after each coat application and on completion to ensure that at least 90%(except water ballast tanks: 100%) of the points measured shall have a thickness equal to that specified in the paint specification. The remaining 10% shall have a DFT more than 90% of that specified. Measuring points shall sample the thickness approximately every $20m^2$ on flat plate and more frequently on frames, stiffeners, etc.

2.3.1.3 Guarantee

Extended written guarantees relating to the performance of the corrosion protection system in accordance with the SBC shall be provided where appropriate, in particular, at least 3 years for the tin-free, self-polishing anti-fouling coating and at least 5 years for the water ballast tank coatings in accordance with the provisions of the Ship Building Contract.

2.3.1.4 Paint Specification

The following principal coating systems shall be applied:

Hull External:

Flat of Bottom	Two coats of a high solid content abrasion resistant epoxy a/c to 300μm total dry film thickness (D.F.T.) + tie-coat of vinyl tar and a tin-free self-polishing anti-fouling system, to provide 3 years protection against marine growth.
Side Shell (below scantling waterline)	As for flat of bottom plus one extra coat of tin-free self-polishing anti-fouling, to provide 3 years protection against marine growth.
Side Shell (above scantling waterline)	Two coats of a high solid content abrasion resistant epoxy, to 300μm total D.F.T plus one finish coat of polyurethane 100μm D.F.T

Apart from areas in way of supporting blocks, a final coat of the anti-fouling system and topside system shall be applied during final dock. Hull roughness of the underwater area shall not exceed 125μm. Fresh water cleaning and salt measurement shall be carried out at the final docking before applying the anti-fouling paint.

Superstructure and decks:

External structure vertical surfaces, bulkheads etc.	Two coats of pure epoxy primer, mist coat and a polyurethane finish coat to provide 400μm total D.F.T. minimum
Exposed decks, deck fittings & machinery	One coat of inorganic zinc silicate, mist coat and two full coats pure epoxy primer followed by pure epoxy finish coat to provide 350μm total D.F.T. minimum Finish coat on decks shall be non-slip.

Tank and spaces:

Water ballast tanks	Two coats of light-coloured high solid content abrasion resistant pure epoxy to 350μm total D.F.T
Void spaces, peak tanks, underdeck pipe passages & double bottom pipe passage	Two coats of light-coloured high solid content abrasion resistant pure epoxy to 250μm total D.F.T
Hold spaces (membrane)	Primer only.
Machinery spaces, including steering gear room and compressor room	Fire retardant paint system with white gloss finish Two coats of light-coloured epoxy mastic under engine room floor and on tank tops to 250μm total D.F.T
Store rooms	Light coloured paint system

F.O tanks (from ceiling to 3m below)	Two coats of light-coloured epoxy to 300μm total D.F.T
Lubricating oil tanks	Two coats of pure epoxy to 300μm total D.F.T.
Distilled and domestic water tanks	Two coats of solvent free epoxy to 300μm total D.F.T

Note : The coating system of the above areas shall include the stripe coating of all weld connections, free edges of plates, stiffeners and openings and scallops with one coat of the appropriate paint before the application of each full coat of the system. Stripe coating should also be carried out behind stiffeners and similar areas where access is difficult.

The epoxy system is to provide a high resistance to blistering and creep from mechanical damage. The coatings used on the hull external, superstructures and decks, water ballast, voids, lubricating tanks and distilled water tanks shall achieve a rating of B1 as classified according to ISO 4628/2 and ISO 4628/3 under the tests identified in Appendix 3 of the Tanker Structures Co-operative Forum book “Guidelines For Ballast Tank Coating Systems and Surface Preparation”. Alternative coating schemes that provide equivalent or superior performance will be considered.

Certified paint samples for each system to be provided to the Owner and composition checks on batches of paint to be made a regular intervals.

2.3.2 Cathodic Protection

2.3.2.1 Sacrificial Anodes

Sacrificial welded anodes’ material shall be the least toxic as practical, as magnesium or aluminum. Zinc shall be prohibited, in accordance with USCG requirements for VGP October 2013. Sacrificial welded anodes type shall be fitted in water ballast tanks including aft and fore peaks with a mean current density of 10mA/m² for expected lifetime of ten (10) years. A time immersion ratio of 50% shall be considered. At least, one anode shall be installed in each bay. Additional anodes shall be installed closed to the ballast suction bell mouth.

Additional “pitguard” type anodes shall be installed to protect those areas close to ballast suctions, the corrosion control coating system is to be compatible with the arrangement and anode density of the sacrificial anode system and its compatibility is to be confirmed by the paint coating supplier.

Bow thruster tunnel, sea chests and inlet grids are to be protected by sacrificial zinc or equivalent anodes for five (5) years life with a current density of 35.0 mA/m².

2.3.2.2 Impressed Current Cathodic Protection

The external hull and bow thruster tunnels shall be protected by an impressed current system, with platinum/ titanium or equivalent anodes, rated at 35 mA/m². Current density at the aft body shall be

at least 600 mA/m² over the propeller and 120 mA/m² over the rudder. A minimum of two active anodes per side for the aft hull part is to be fitted. The impressed current system performance is to be compatible with the external paint coating design.

2.3.2.3 Temporary Cathodic Protection

Cathodic protection of temporary sacrificial anodes shall be provided for the protection of under water hull, rudder and propeller during the outfitting and cargo containment system installation.

2.4 Anchoring and Mooring Equipment

2.4.1 General

All mooring equipment and fittings shall be designed, constructed and fitted in accordance with ISO standards, OCIMF recommendations for LNG Carriers and other relevant regulations such as Panama Canal regulation (considering Future expansion). The mooring system shall incorporate roller fairleads and split drum winches adequately sized for the moorings, mooring links and nylon tails. A system utilizing UHMWPE moorings is to be provided.

Mooring winch and windlass engines shall be of the totally enclosed electro-hydraulic driven or self-contained electro-hydraulic type or directly electrically driven and provided with ‘electronic’ variable speed control. Electric motor drives relying on pole change speed control are not acceptable.

As far as practicable, machinery shall be a single drum unit, with rendering but without self-tensioning capability. They shall be arranged for efficient manning during mooring operations, with both local and remote control from suitable locations at the ships side. Local controls are to be suitably arranged with safe access for personnel at the operating position. The local operating position is also to be arranged to allow the operator an unimpeded view of the wires to the fairleads. Remote stops shall be provided forward and aft to trip deck machinery in an emergency.

2.4.2 Anchors and Cables

Three(3) high holding power stockless anchors (Two working and One spare stowed on deck) shall be provided to classification society requirements with a weight of 75 % of the rule weight for a stockless bower anchor. Special quality steel chain cables shall be made up in interchangeable lengths of 27.5m, each exclusively composed of identical stud links with Kenter joining shackles. The anchor cables are to be Grade U3 special steel.

2.4.3 Anchor windlass

Each windlass shall have two motors and be capable of lifting the anchor and four lengths of cable at an average speed of not less than 12metres per minute using one motor only. Using two motors,

it shall be capable of lifting the anchor and maximum length of cable fully suspended. A cable counter and fail-safe payout speed limiting devices shall be fitted, with the hydraulically operated brakes able to be remotely controlled from the ship's side. A scale model of the anchor deployment and stowage system shall be built to demonstrate anchor storage and lead of chain.

Brake drums for windlass and winches shall be stainless steel or stainless steel lined (SUS 316L). All winch brakes shall be fitted with spring packs to facilitate consistent tightening of the brakes and shall incorporate suitable means of testing their holding power by the use of portable hydraulic test equipment. The deck should be suitably reinforced in the area where the test equipment is placed.

2.4.4 Mooring wires and ropes

Full calculations of the mooring arrangement for each of the berths shall be submitted for Owner's approval. The mooring arrangement shall comprised to use at least twenty(20) for mooring lines(p/s). The mooring arrangement shall generally consist of: Three head lines, Three stern lines, Ten breast lines and four spring lines. Moorings lines shall be 275 metres long, not more than 44mm diameter and shall be fitted with mooring (spelter) sockets. 11 metres long soft rope tails are to be supplied. Brake holding capacity of mooring winch shall be 80% of MBL at first layer.

Total number of mooring winch shall be nine (9) sets and total numbers of mooring drums shall be twenty-two (22) including combined windlass. The layout shall also make provision for "ship to ship transfer" operations.
Details of the mooring system are to be submitted for approval.

The mooring layout shall also make special provision for ship-to-ship transfer operations, as well as the safe handling and securing of tug lines, by fitting approximately eighteen(18) sunken bitts at suitable heights and positions on the side shell. These fittings shall be capable of handling an 80mm diameter towing hawser and a snatch load of 150 tones.

Two (2) Fire-wires driven by fixed air motor, stowed on suitable drums, shall be fitted below the mooring decks forward and aft. A spare mooring wire rope shall be provided forward and aft, also stowed on drums below deck.

2.4.5 Mooring winches

The safe working load of all mooring equipment and fittings shall be based upon the minimum breaking load of the mooring ropes and shall be marked on all items of equipment. Winch shall be split drum type with a brake holding capacity of at least 80% of the minimum-braking load (MBL) of the wires.

Brake holding test tool shall be fitted with tested position marking on the stud of handle.

2.4.6 Emergency Towing

Arrangements of emergency towing and strength of all components shall comply with requirements of SOLAS RegII-1/3-4 and IMO Res MSC.256(84).

2.4.7 Hydraulic system

For hydraulic systems initial flushing shall be in accordance with manufacturer's requirements or, if not stipulated, to ISO 4406 Code 17/14. Cleanliness is to be confirmed by electronic particle counting. Deck coaming(s) are to be provided to contain any oil leakage around mooring winches, windlass positions and all other associated hydraulic equipment

The hydraulic system of low-pressure type shall consist of two (2) independent groups, one fore part and the other for aft part. These units shall not be interconnected.

2.5 Hull Machinery

2.5.1 Steering gear

An electro-hydraulic (two (2) ram four (4) cylinder type) steering gear shall be provided. The two independent and completely separate hydraulic circuits shall each have a 100% electric motor driven hydraulic pump.

Each circuit shall be capable of meeting the classification society's requirements of moving the rudder from 35° one side to 30° on the opposite side in 28 seconds with the vessel at maximum speed.

Suitable arrangements shall be provided to ensure working access to the steering machinery and controls within the steering compartment. These arrangements shall include raised walkways with handrails and open gratings.

The hydraulic system shall be commissioned to ISO 4406 code 17/14, as per the other hydraulic systems. The hydraulic pipe material shall be to the manufacturer's standard. The recharging system shall be gravity based and not require the use of a transfer pump.

For harbour maneuvering condition, it shall be possible to operate the rudder up to 45° each side. Steering gear hydraulic system shall be air ventilated. A hydraulic oil storage tank having capacity of two (2) times service oil shall be provided in immediate steering gear vicinity with hand make-up pump and permanent piping connection.

2.5.2 Cranes

2.5.2.1 Manifold handling

Two (2) 10 tons one-man-control hydraulic slewing and luffing cranes, with enclosed, heated cabs, with window demisting, shall be fitted in way of the amidships manifolds. The cranes shall be able to achieve its safe working load when plumbing any point within the area of the manifold and up to 2m from the ship's side, over the full length of the cargo, bunkering and service manifolds.

2.5.2.2 Provision / Machinery handling

Two (2) electric hydraulic cranes of minimum ten (10) tons, shall be fitted aft. They shall be able to plumb the provision stores hatch, the machinery maintenance hatch and a point 5 meters beyond the line of the ship's parallel body.

Additional crane of at least 5 tonnes capacity may be installed if necessary. The cranes shall be fitted with hydraulic luffing, with stainless steel non-rotating wires and shall be capable of "inching" control. A remote operating facility is to be provided.

2.5.2.3 Davits

Sufficient fixed davits are also to be provided for easy storing and handling of equipment on board, such as emergency cargo pumps, manholes and the Suez Canal searchlight. The locations shall include, but not be limited to, the deck store, steering gear room, cargo tank domes and forecastle.

All lifting and mechanical handling equipment shall be load tested in accordance with the requirement of Classification Society and furnished with a test certificate provided by the Classification Society.

2.5.3 Bow thruster

One(1) set of electric motor driven type bow thruster based on the maximum continuous rating for one(1) hour with two(2) hydraulic for pitch control for port-maneuvering and unberthing with an adverse transverse wind of 25 knots shall be provided.

A remote control and monitoring station shall be fitted for the bow thruster in the wheelhouse and both bridge wings.

Certified lifting points shall be fitted to facilitate the overhaul and moving of heavy equipment and spare parts.

2.6 Hull Outfitting

2.6.1 General

All fuel tanks and consumable tanks shall preferably be located above the engine room double bottom level, and should not overhang any machinery. Fuel tanks, including storage tanks, settling tanks, distillate fuel storage tanks, lubricating oil storage tanks and other tanks that may contain oily residues are to be separated from the shell plating by a cofferdam or similar arrangement. The arrangements are also to allow safe inspection of the hull structure in way and external boundaries of the tanks. Cofferdams and the engine room double bottom should be dry spaces.

Forward fuel transfer facilities for forward bunker tank(s) shall include two fuel oil transfer pumps generally in accordance with the requirements for the aft transfer pumps.

Each ballast and fuel oil tank shall be provided with a hinged and/or bolted access manholes.

Deck coaming(s) with drain cocks are to be provided to contain flood water & any LNG leakage around each liquid dome area and all other associated hydraulic equipment.

Manhole(s) for ballast tank(s) were situated adjoining to fuel oil tanks shall be provided inspection window to check oil contamination of the aforementioned ballast tanks before each de-ballasting operation.

Arrangement of walkways (GRP grating) and stringers in ballast tanks and void spaces shall facilitate adequate close up inspection and maintenance of the structure.
Fittings shall generally be made of corrosion resistant materials, designed for long life. External nuts and bolts shall be of SUS 316L stainless steel or non-ferrous material, dependent on the application. Toggles and hinges for doors and hatches shall be of stainless steel or brass.

Handrails of approx. 1.0 m height shall be fitted to all walkways and openings in horizontal structure in ballast, void, peak and hold spaces. All large openings and the free edges of stringers shall be protected by guardrails or rungs, as appropriate, to ensure safe access for inspections. All ladders shall have handrails on both sides.

Fore and aft access shall be provided by a walkway arranged at the level of the trunk deck and running from the accommodation deckhouse to forward. All secondary steelwork exposed to the outside environment shall be fabricated of the box girder type to facilitate maintenance. Use of angle bar is to be minimized in the construction.

Once the layout of the walkways, piping and cabling has been established the arrangements of the supporting structures are to be reviewed with the Owner and rationalized as far as practicable in order to reduce the number of structural components and support attachments. Cable trays shall be of a non-corroding material and care given to minimize the effects of corrosion.

Suitable access shall be provided to all pipe and cable runs, to all valves and to bridge and accommodation windows.
The access arrangements within tanks shall be such as to facilitate easy access for the removal of any injured personnel from any bay in accordance with IMO guidelines.

Two self-contained rope pilot ladders shall be fitted. These shall be stored on power-driven drums, long enough to meet the lower level of the accommodation ladder in all draught conditions with 15º heel. The pilot ladder drums and the accommodation ladder shall utilize the same power source, i.e. all-hydraulic or all-pneumatic.

One(1) aluminum alloy wharf ladder approved by Classification Society is to be fitted.

Walkways, platforms and steps for ladders on the weather decks shall be grating type with non-slip surfaces. As far as practicable and acceptable to classification, these shall be of GRP construction. Access platforms around all deck equipment and working areas shall be of GRP construction, as far as practicable. The supports shall be of box girder or tube type, to facilitate maintenance.

2.6.2 Hatches and manholes

As far as practicable, at least two hatches or manholes shall be fitted for each tank (ballast or fuel), void spaces, cofferdam, double bottom passage, trunk deck passage, steering gear room and other compartments. Wherever practicable, one hatch / manhole should be provided with an inclined ladder access arrangement, the other with a vertical ladder access arrangement.

Maintenance hatches shall be provided for the cargo machinery room, cargo motor room, engine room and other machinery spaces. Machinery and motor rooms shall be fitted with certified lifting points to facilitate the overhaul and moving of heavy equipment and spare parts. All lifting equipment, beams, trolleys and eyes are to be tested and provided with test certification. ‘Construction’ lifting eyes are to be removed.

2.6.3 Ladders, Gangways and Walkways

Two aluminum accommodation ladders of self-stowing approved by Class Society in accordance with MSC.1/Cir.1331, fixed rail type with lower platform, shall be fitted within the parallel mid-body, leading aft. The handling mechanism shall be power-driven and capable of one-man

operation. The length of each ladder shall be sufficient to reach the lightest ballast waterline at a maximum inclination angle of 55 degrees.

The main steel ladders in the water ballast spaces shall be of the inclined type, giving access to all intermediate stringers or platforms and leading down to a continuous walkway running fore and aft through the bilge section with access to each bottom bay. Walkways and platforms fitted in the water ballast spaces shall utilize GRP gratings in a steel frame. All fastenings and fixings shall be selected to minimize corrosion in service.

Exposed vertical ladders (only to be used where inclined ladders with handrails are impractical) shall have safety hoops or, if over 3 metres high, protective cages.

One (1) weather shelter with steam heater for two (2) persons shall be installed on each side of manifold area agreed with the owner.

2.6.4 Handrails and stanchions

Handrails complying with requirements of ICLL Annex I/Reg.25 shall be provided on all exposed decks.

External storm rails shall be fitted on the outside of all deckhouses. Safe access to bows is to be provided. Stairways within spaces or wells are to be provided with handrails on both sides.

It is to be ensured that the transition of handrails from deck railings onto hand rails of inclined ladders are to be maintained as continuous as practicable sudden changes of hand rail height at these locations is un-acceptable.

2.6.5 Masts and Posts

Masts and posts, for navigation equipment and lights, deck floodlights and communications equipment, shall be self-supporting and constructed of steel, without stays.

2.6.6 Hull marking

External hull markings shall be provided as follows:

- The vessel's name, IMO number, port of registry, draught and freeboard marks, and funnel emblem shall be cut from steel plate, welded in position and painted.
- Tank or compartment names, vapour manifold location mark, tug push marks, and bulbous bow symbols shall be bead welded and painted.
- The designation letters 'LNG' are to be applied to the vessel's hull. 'NO SMOKING' marking are to be applied on the accommodation block

- Side mark (LNG), No smoking marks on the front of deck house and cargo compressor room

2.6.7 Eyes

All the machinery motor rooms shall be fitted with eyes in order to carry and transport the heavy spare part. All machinery and electric rooms to carry and transport heavy equipment of 50 kg and above in weight shall be fitted with certified lifting eyes to facilitate the overhaul and moving of all heavy equipments and spares.

2.6.8 Helicopter Winching Zone

A winching zone shall be provided, suitable for both day and night operations, to meet the latest ICS “Guide to Helicopter/Ship Operations” and IAMSAR manual.

2.6.9 Ballast Tank Pressurization System

Provision is to be made for temporary air connection to ballast tanks and means of blanking air vents, so that tanks can be pressurized using salvage air compressors in the event of grounding or collision. It is not necessary to provide special hoses or air compressors.

2.6.10 Ballast Exchange System

Ballast Exchange procedure under the seagoing condition shall be provided with suitable facility if required as rule requirement.

The ballast system shall be designed to enable the ballast water to be completely changed at sea, automatically under the control of the IAS to comply with the BWMP notation. Ballast Water Management Plan shall ensure sequential exchange rather than by dilution method.

2.6.11 Security

The cameras with passive night vision system shall be installed for security purposes covering the main and poop decks. The system shall monitor the main and poop deck areas and have a minimum range of 120metres.

The system shall comprise:-

- Cameras with pan, swivel and zoom facility
- 1 flat screen monitor and control panel situated on the wheelhouse
- Infrared illuminators as dictated by the system design.

The system may be combined with the CCTV system.

The Accommodation and control space security shall be considered and shall be in compliance with

IMO.

The following locations are to be designated as restricted areas:

- Bridge,
- Engine Room,
- Crew Accommodation areas
- Steering Gear Room,
- Control rooms for fire fighting equipment,
- Emergency Generator Rooms,
- Cargo Hydraulic and machinery Rooms,
- Cargo control Room,
- Engine Control Room,
- Ventilation and A/C Machinery spaces,
- Spaces containing Dangerous goods and Hazardous Substances (this includes battery room, paint stores, chemical stores, Pyrotechnic lockers, Oxygen & Acetylene stores, Oil stores, Foam room, CO2 Rooms),
- Spaces Containing Ships stores (this includes Provisions stores, decks stores, Engine stores, Safety lockers, bonded stores).
- Emergency escapes,
- Lift shaft access and machinery space.

All external doors to the restricted areas shall be provided with a locking arrangement to prevent unauthorized access. 'Restricted Area' signs shall be posted at their main access points. The locking arrangements shall be easily removable from inside the space if the space is accessible internally.

Accommodation access doors shall be capable of being locked from the inside without the use of a key. A single master key shall be capable of unlocking all doors. All doors must be capable of being opened from the outside using this master key i.e., internally applied locking arrangements are not acceptable. This is to ensure that the accommodation can be entered in the event of a fire.

An enclosed security guard house shall be provided on the main-deck in way of the aftermost shore gangway landing area. The guard house shall have windows overlooking the shore gangway landing area and be provided with, heating, lighting and seating for two persons. Natural ventilation is to be provided.

The Builder shall provide anti-piracy systems in accordance with the latest edition of the Best Management Practices for Protection against Somalia Based Piracy (BMP). The Anti-Piracy systems shall be approved by the Ship’s flag Administration with GSPS for Communication of

2.7 Life Saving

Two totally enclosed, fire-protected lifeboats, with self-contained air support systems powered by fresh water cooled, electrically started diesel engine shall be installed in gravity davits. Each engine shall have an alternative starting mechanism of the stored-energy type. Each lifeboat shall have sufficient capacity to accommodate a maximum complement of 50 persons, including supernumeraries and Suez Canal workers. The falls shall comprise non-rotating galvanized wire rope, with bushes of synthetic material and all pins and sliding surfaces that are subject to corrosion shall be stainless steel.

Recovery time for rescue boats from the water to the stowed position shall be less than 5 minutes. Provisions shall be provided for testing the release hook and mechanism while the boat remains secured by alternative means.

Lifeboats shall be provided with heavy weather recovery arrangements.

A dedicated and permanently installed charging system shall be installed to enable the lifeboat air cylinders to be re-charged in-situ using the SCBA charging compressor. Where the lifeboat air cylinders working pressure differs from that of the SCBA sets, each system is to be protected from over pressure by means of dedicated pressure relief valves, interlocked to prevent incorrect usage on the wrong system.

2.8 Fire Fighting Equipment

2.8.1 General

The arrangement of structural fire protection shall be complied with the SOLAS Chap. II-2 and the requirements of Classification Society.

2.8.2 Fire Hydrant System

A seawater fire fighting system of ring main type shall be provided for all fire hydrants in machinery spaces, accommodation and cargo areas.

Branch lines from the fire main shall be led to as follows:

- Fire hydrants
- Water curtains at cargo manifold
- Bilge eductor
- Anchor chain washing nozzles

Each branch line shall be able to be individually drained by an isolating valve at the connection with the fire ring main and suitable drain valves.

2.8.3 Water Spray System

A fixed water spray system shall be supplied to protect the cargo tank domes, cargo manifolds, compressor room, lifeboat embarkation areas, satcom dome and all front and side bulkheads of the accommodation block.

As for fire main, each branch line shall be able to individually dried by an isolating valve at the connection with the fire ring main and suitable drain valves.

2.8.4 Fixed CO2 Fire Extinguishing System

A fixed CO_2 fire extinguishing system shall be complied with the SOLAS and International Code for Fire Safety Systems.

The fixed CO_2 fire extinguishing system shall be installed in the following spaces:

- Engine rooms
- Propulsion converters and transformer room
- Main switch board room
- Cargo switch board rooms (if the rooms are not in accommodation area)
- Inert gas generator room
- GVU(Gas valve unit) rooms
- Cargo compressor and motor room
- Incinerator room
- Emergency generator room, etc.

CO_2 bottles shall be stowed in a separate room which shall be arranged at safe and readily accessible.

The CO_2 room shall have a mechanical ventilation system.

The CO_2 system shall be activated from the fire control station and the CO_2 room.

For galley, a stand-alone CO_2 fire fighting system for hoods and air ducts shall be installed.

2.8.5 Fixed Local Application Fire Fighting System

In addition to the fixed CO_2 fire extinguishing system, a fixed local application fire fighting system shall be installed in the spaces required by the SOLAS and Regulatory bodies.

2.8.6 Dry Powder System

A dry powder system shall be fitted to protect the cargo area deck including the cargo manifolds. The dry power system shall be complied with the IGC code.

2.8.7 Fire Control Plan

All machinery spaces where pressurized fuel, hydraulic or lubricating oil are present shall be monitored by an oil mist detection system, comprising point detectors directly connected to the IAS. Detectors shall be fitted in way of pump seals, fuel injectors, pipes, joints and other potential sources of leakage. The system shall initiate an alarm when 0.2 ppm of oil is detected in the atmosphere.

A fire control station shall be provided on the main deck level at readily accessible from the deck and the accommodation. The following system shall be controlled or stored in the fire control station.

- CO_2 system release
- Dry chemical powder release box for cargo tank area
- Oil tanks valve shut
- Fire alarm repeater panel
- Remote start/stop of fire pumps
- Remote start/stop of emergency fire pump
- Remote start/stop of fire & general service pump
- Fireman's outfits and breathing apparatus
- Safety equipment
- Personnel protection equipment
- International shore connection
- Other fire fighting system/equipment which may be required by the Regulatory bodies
- ESD push buttons
- Fire main pressure gauge
- Portable breathing air refill compressor
- Remote stop commands for engine room ventilation and flap closing, oil supply/transfer pumps, etc.

2.8.8 Fire Detection

A ship-wide fire detection and alarm system approved by the Classification Society shall be fitted to cover all machinery spaces including hydraulic rooms, steering gear room, inert gas room, bow thruster room, emergency generator room, GVU(Gas valve unit) room, N_2 generator room,

switchboard room, control room, service area, cargo machinery room, incinerator room, the entire accommodation area including cabins, paint store, bosun store and forward spaces and hydraulic power pack areas.

The main control station shall be arranged in the wheelhouse with repeater panels located in the cargo control room, engine control room and the fire control station.

In hazardous areas, intrinsically safe loops shall be provided. (i.e. cargo machinery room, cargo motor room, etc)

Fire doors shall be arranged with automatic magnetic release.

2.9 Hull Piping System

2.9.1 General

Materials for piping systems and equipment shall be selected with a view to minimizing in-service maintenance. Unless stated otherwise in this specification, these should be in accordance with Table 1 or better. Equivalents may be proposed, but acceptance will be subject to the owner's approval on a case-by-case basis.

System	Pipeline	Valves
Cargo lines on Deck	Stainless steel 316L or equivalent	Cast stainless steel
Cargo lines in tank	Stainless steel 304L or Al 5084 dependent on containment system design	Cast stainless steel
Inert gas lines	Stainless Steel 316L on deck and galvanised mild steel under deck.	Rubber Lined cast steel
Water ballast lines	Glass Reinforced Plastic (GRP) (In pipe duct & passing through W.B.T) Galvanized steel or equivalent (In engine room)	Rubber Lined cast steel with Ni-Al bronze disc
Hydraulic lines Control lines	Duplex stainless steel or 90/10 Cu-Ni (except for engine room) 90/10 Cu-Ni with polyethylene external coating (except for engine room) or outer sheath tube SUS316L	Ni-Al bronze (not more than 50A) or compatible grade of stainless steel for duplex as option
Fire main	Galvanized steel or equivalent	Steel cast with Al bronze disc

System	Pipeline	Valves
Water spray system	Stainless steel 316L or equivalent	Steel cast with Al bronze disc or equivalent
All sea water systems of continuous or intermittent duty	GRE or polyethylene lined steel. Connections to main condenser shall be steel with internal neoprene lining Alternative for sea water systems if GRE not allowed <100 mm 90/10 Cu-Ni	Cast steel with rubber lining with Ni-Al bronze disc (bronze body <200 mm)
Bilge systems	Schedule 80 hot-dip galvanised mild steel	Cast steel with Ni-Al bronze disc & stainless steel spindle
Hypochlorite injection system	Braided nylon or vinyl ester resin GRP and titanium injection pipes.	Titanium or FEP coated ductile iron
Domestic water system	Copper or stainless steel	Bronze
Pipes less than 25 mm diameter for non flammable liquids (fresh water, compressed air)	Copper	Bronze
Scupper pipes	GRE or extra heavy gauge galvanised steel. Accommodation external scuppers, to be synthetic material construction with colour compatibility with ships paint scheme. Only to be applied in areas not subject to sea loading	Heavy gauge bronze
Steam pipes	To Class requirements.	To Class requirements.

Cast iron valves shall be used at the minimum extent and be limited to non-essential lines (fresh water, drainage or etc.) in compliance with the Class Rules.

In general, all instrumentation and lighting equipment on deck and open areas shall be of strong material with high resistance to seawater and ambient atmosphere. The preferred material shall be stainless steel 316 or copper alloys where permitted but aluminum alloy shall not be allowed.

All screws, bolts and U bolts/band on the exposed deck shall be made of stainless steel(316) or

non-ferrous material.

Non metallic sliding pad shall be provided for all pipe support on exposed deck.
Non ferrous piping shall not directly connect with steel pipe.

2.9.2 Sea Water System

2.9.2.1 Sea Water Fire and Wash Deck System

A pressurized fire main system shall be provided for the hydrants.

Two(2) equally sized electric motor driven fire pumps shall be provided in the engine room.
All fire pumps shall be capable of supplying the water to the fire main.

One(1) emergency fire pump shall be provided.

2.9.2.2 Water Curtain System

Water curtain pipes shall be provided at ship side in way of each loading station to protect the loading station and the side shell during loading/unloading. Sea water for the water curtain shall be supplied by branch line(s) from the fire and wash deck system, with isolating valves.

2.9.3 Sounding and Air Pipes

The arrangement and construction of sounding pipes and air pipes shall be complied with the requirements of Classification Society.

2.9.4 Bilge System

Bilge system for cargo areas such as cofferdams, void spaces, forward pump room, bow thruster room, under deck passage way, double bottom passageway, bosun store, chain cocker, store room and emergency fire pump room (if not located at E/R aft.), etc. shall be provided with stripping eductors.

A separate bilge system with an eductor shall be provided for cofferdams.

The fire main shall supply driving water for bilge eductor(s). Bilge for a steering gear room may be led to an engine room bilge-well by foot valves.

2.9.5 Steam System

Steam shall be provided for the following services:

- Heaters and vaporizers for the cargo system

- Heating and humidification of air conditioning system
- Domestic use in living quarters
- Glycol heater for cofferdams
- On deck service for multipurpose, etc.

2.9.6 Compressed Air

General Service compressed air be supplied for:

- Weather deck (and flying passage, if any)
- Accommodation
- Other necessary area

2.9.7 Fuel Oil Piping On Deck

Fuel oil filling and transfer lines shall be provided as well as diesel/gas oil filling and transfer lines.

Four(4) shore connections shall be provided for filling fuel oil, two on each side at the forward and aft of cargo manifold. Two(2) shore connections shall be provided for filling diesel/gas oil tanks one on each side of ship at the aft of cargo manifold.

Independent L.O. filling pipe shall be provided on port and starboard of deckhouse.

Each tank filling connection shall be fitted with a butterfly valve operable locally and remotely from the CCR. Fuel oil transfer pumps and valves could be operated locally and remotely from CCR.

Bunker manifold reducers shall comply with the recommendations of SIGTTO & OCIMF.

Volume & Level monitoring system with alarm (High Level, Independent High-High Level) shall be provided.

2.9.8 Hydraulic Oil System For Valve Control

The hydraulic control system for the ballast and fuel oil system shall be independent from the cargo systems. All cargo, ballast, designated shipside valves and fuel transfer valves shall be remotely controlled and operated from the CCR. Local manual control with manual override shall be also provided.

Each power shall consist of two(2) x 100% cross connected pumps units having sufficient capacity to close or open two (2) largest valves of ballast system simultaneously within thirty (30) seconds

at an ambient temperature. One (1) small pressurizing pump shall be provided for local operation.

Separate tanks for holding a full, clean and dirty charge of hydraulic oil shall be provided for each system.

Two (2) accumulators shall be of the separated nitrogen gas loaded type having a sufficient capacity to compensate for oil leakage through the direction control valves for at least 15 minutes.

One (1) set of N_2 bottle shall be provided as a spare.

2.9.9 Water Service System

Water service system consisting of fresh water system, drinking water system and hot water system for all persons onboard shall be provided.

The fresh water service main line is to supply the following locations:

- Private toilets
- Catering spaces
- Sanitary spaces
- Wheelhouse window washers
- Upper deck in front of accommodation house
- Under deck passage
- Poop deck
- Cargo compressor room
- Cargo manifolds (P&S)
- Emergency fire pump room
- Flying passageway
- All other points throughout the vessel

Hot and cold fresh water system for washbasin, shower, bath, laundries, galley and pantries, etc. shall be provided.

Shut-off valves shall be provided for isolating sections of the system for repair and arranged so that remainder of the system can be available.

Fresh water filling connections comprising of a manually operated valve and blank flange shall be provided at manifolds and sides of accommodation house.

A hot water circulating system shall be provided to the accommodation. Approved temperature control mixing valves shall be fitted to showers if permitted by a Flag State.

2.9.10 Scuppers and Drains

Sufficient numbers of scuppers and drains shall be provided. The arrangement and construction of scuppers and drains shall be complied with the International Convention of Load Lines and the requirements of Classification Society.

2.9.11 Garbage Disposal

A garbage compactor of sufficient capacity shall be provided to compress solid waste garbage from galley and machinery spaces.

An incinerator (IMO type) shall be provided and located in a separate compartment within engine casing and with easy access from the open deck.

3 Accommodation

3.1 General

To minimize the transmission of vibration, the machinery casing shall not be integrated into the accommodation deckhouse.

Accommodation shall be provided for 40 persons, excluding 6 Suez Canal workers, with necessary facilities for both male and female crew.

3.2 List of Rooms

Accommodation shall be provided to the higher marine standard as per the following basis:-

- 3 'Captain class' cabins with bedroom, dayroom, lobby and shower/WC (1 owner A)
- 5 Senior officer cabins with bedroom, dayroom, lobby and shower/WC (1 owner B)
- 11 Junior officer cabins with combined dayroom/bedroom and shower/WC.
- 1 Pilot cabin with combined dayroom/bedroom and shower/WC considerately situated for access to the wheelhouse.
- 3 Petty officer cabins with shower/WC
- 17 Crew cabins with shower/WC
- 1 Suez Canal Workers cabin with six berths and shower/WC.

The Captain class & senior officer cabins shall be fitted with double beds of 1600mm width, junior class officer & petty officer cabins shall be fitted with double beds of 1400mm width, crew cabins shall be fitted with double beds of 1200mm width.

Captain and senior officer class accommodation shall be provided with TV, VCR, DVD and music systems. All cabins are to be provided with a refrigerator.

	<u>Public & Service spaces</u>
Living Spaces	Cabins
Public Spaces	Officer & Crew mess room
	Duty mess room, officer & crew recreation room (Lounge) & dedicated smoke rooms with separated ventilation system.
	Hospital, Dispensary, Library, Ship's office, Cargo office, Conference room, Gymnasium, Health center with sauna
Control spaces	Wheelhouse & Chart space, Radio space, CCR, MSBD, CSBD, PIO room, ECR, Computer room, Electric equipment room, Fire control room
Passage space	Stairway, Corridor
Catering spaces	Galley, Pantry
Provision spaces	Provision stores, Refrigerated provision chamber,

	Bonded store
Sanitary spaces	Private toilet, Hospital lavatory, Common lavatory
	Officer & crew and hotel laundry, Drying room,
	Deck and engine change room
Sundry spaces	Battery room, Paint & Lamp store, Gas bottle room
	Converter room, Swimming pool, Cable trunk
	Pipe & Duct trunk, Carpenter store,
	Electric distribution panel room
	Electric worker shop, other store & locker
Machinery spaces	Air conditioning room, Em'cy generator room
	CO2 room, Hydraulic pumps room,
	Cargo machinery & motor room, Lift machine room

3.3 Accommodation Arrangement

A hospital with two single 'stabilized' beds and basin/bathtub/shower/WC shall be provided. The hospital shall have access from within the accommodation and direct access from an external deck. A dispensary with stocked medical locker shall be situated adjacent to the hospital. Both dispensary and hospital shall be provided with telephones.

A fully equipped galley shall be provided. A public toilet and a cleaning equipment locker shall be arranged on each deck.

The galley, provisions stores, garbage disposal area and mess rooms shall be arranged on the same deck level, as far as this is practicable. The galley and laundries shall not be arranged above electrical switchgear rooms.

A swimming pool shall be provided.

An Officers' laundry and a crews' laundry shall be arranged within the accommodation, each provided with a drying room and wash trough, with 2 sets of washing machines, tumble dryers, irons and ironing boards. A separate laundry shall be equipped with sufficient industrial standard washing, drying and ironing machines to handle all the ship's linen and a separate washing machine and tumble dryer for working clothing.

Machinery control provisions shall be preferably of a conventional design with engine control room situated within the machinery spaces and the cargo control room situated within the accommodation.

A Cargo Control Room (CCR) shall be provided with large windows overlooking the cargo deck. They shall also have easy access to the main deck and cargo areas.

There shall be at least two means of access to each control room. For the machinery control room at least one means of access should be provided that does not pass through the open engine room. Large 'deck to deckhead' viewing windows should be provided and, if practicable, they should provide a clear line of sight to boiler water gauge glass and smoke indicators.

The location of the CCR shall give a free uninterrupted view of the cargo deck. There shall be direct access to the deck from the CCR while access to the main stairwell and lift shall be as direct as possible.

Wheelhouse, main control and equipment rooms are to be arranged with raised modular decks so as to provide a cable and services void of not less than 750mm in depth. Modular deck design and materials are to be carefully selected to provide a smooth non-slip surface. An appropriate number of easily removable access panels should be provided in way of cables and other such equipment installed in the void space.

The final deck height is to be maintained at the same level throughout the deck house or flat at that level.

Administration and conference spaces shall be provided adjacent to the CCR. Within these spaces shall be segregated offices for the Master and the Chief Engineer as well as a separate study area for two cadets.
As far as practicable, working and living spaces within the accommodation shall be segregated. Accommodation for Petty Officers and crew shall be on different decks from that for Officers.

3.4 Deck covering/insulation/Lining and Ceiling in accommodation

3.4.1 Deck covering

A latex under layer shall be provided on steel decks for all the spaces here below except galley for which a thick reinforced concrete under layer shall be provided on steel deck.
The internal deck finishing shall be as follow :

Carpet or equivalent	Captain and senior class cabins, recreation room
Polyvinyl/Chloride sheet	All cabins except captain and senior class cabins, Control & Public space, stairway, alley way (Luckstrong or Equivalent)
Ceramic Tiles	Sanitary spaces and Commissary spaces except galley

	and Provision rooms
Anti- skid Ceramic tiles	Galley
Rubber Carpet	Bridge wings
GRP Grating	Provision rooms

3.4.2 Insulation

Asbestos shall not be used for any purpose.

Thermal insulation(min. thickness 75mm, with good quality) shall be provided on all external bulkheads, on deckheads in way of open weather decks, galley, between air conditioned spaces and non air conditioned spaces in addition of the lining(if any).
An efficient thermal insulation shall be provided between living and working spaces and excessively heated spaces such as machinery, generator room, etc.

Sound insulation shall be provided between machinery spaces, public rooms, service spaces and private spaces. Sound insulation between cabins shall be incorporated in the partition walls.

The airborne sound insulation properties for bulkheads(including the doors) and decks within the accommodation shall comply at least with the following weighted sound index Rw according to ISO standard 717-1;as amended(1:2006), part 1;

Cabin to cabin	Rw = 35
Messrooms, recreation room, public spaces and entertainment areas to cabins and hospitals	Rw = 45
Corridor to cabin	Rw=30
Cabin to cabin with communicating door	Rw=30

Sound insulation of the rooms with very high noise level shall be designed depending on noise spectrum. Insulation not behind a ceiling or lining shall be covered by a protection.

The fire insulation shall be provided in accordance with the Rule/Regulation

3.4.3 Lining and Ceiling

All divisional bulkheads, linings and ceilings shall be made of modular panel system in order to keep maintenance at minimum. Colors shall be selected by owner.

The electric cables by duct, piping shall be concealed behind linings and ceiling.

Panels or sections of lining or ceiling in way of valves, junction boxes of wiring, dampers, etc. shall be arranged for removal by means of hinged type.

All ceiling shall be made of a core of mineral wool board covered with steel sheet.
Ceiling coated with baked enamel shall be provided for private spaces, public spaces, control spaces, linens, pantries, hospitals and passage spaces.
All subdivision bulkhead shall be made of a core of mineral wool board covered with steel sheet(sandwich panel/minimum 50mm thick). All lining shall be same as subdivision bulkhead (minimum 25mm thick)
Subdivision bulkhead and lining coated with PVC film on both sides shall be provided for private spaces, public spaces, control spaces, linens, pantries, hospital and passage spaces. Stainless steel lining shall be provided for galley.

3.4.4 Furniture, Fittings and Equipment

The furniture and fittings as well as the equipment shall be of high quality marine standard throughout.
Furniture shall be made of wood for private space and public spaces.

3.5 Ventilation

3.5.1 General

All living, public, sanitary, working spaces, galley, changing rooms, dry provision stores, wheel house, electrical equipment spaces, control rooms and all other spaces in the accommodation shall be air conditioned.

The accommodation ventilation system shall be designed to operate at constant pressure irrespective of the operation of individual ventilation controls. Special attention shall be paid to minimizing noise from vent outlets.

ISO 7547 “Air conditioning and ventilation of accommodation spaces on board ships” (including the annex) shall be applied.

- Assuming windows shall not be fitted with interior shading (for calculation only)
- Assuming heat gain from lighting shall not be ignored even for the spaces with daylight.
- Assuming the vertical and horizontal surfaces are dark
- Assuming the design conditions stated article 3.6.1

All electrical motors for the fans shall have a speed not more than 1800 rpm and fitted with grease nipples.

All ventilators in accommodation and store room spaces through the vessel shall have stainless steel mosquito screen fitted.

All fresh air inlets shall be provided with sand filters and shall be installed on 2nd tier deckhouse and above. Metallic construction filters shall be stainless steel.

3.5.2 Air Change Rates

The following air change rate (time per hour) may be increased after detailed heat load calculation and mutual agreement with the owner and builder.

Space	AC Supply	Ventilation	
		Supply	Exhaust/Recir.
Private spaces	8	-	-
Private & Public toilet	-	-	15
Public spaces & Control spaces	12	-	*
Office and Hospital	12	-	*
Galley	20	20	40
Change room	6	-	6
Paint store	-	-	10
Work shops	*	-	6

* : Size will be fixed according to the calculation and mutual agreement.

Mechanical ventilation fan shall be provided for smoking area such as two(2) recreation rooms, conference room and ship's office.

3.6 Heating and Air Conditioning

3.6.1 Design Condition

The air conditioning system shall consist of two(2) central units each of 100% capacity and a refrigeration plant of refrigerant R-407C incorporating two(2) rotary or reciprocating type compressors each of 70% capacity. It shall be capable of maintaining a temperature of 27ºC dry bulb, at an average relative humidity of 50%, when the outside conditions are of 45ºC dry bulb and 80% relative humidity. This performance shall be achieved without re-circulation. As an alternative, a system based on chilled / heated water circulation with fan coil units for each room may be proposed.

3.6.2 Air Conditioning System

A common refrigerant shall be used throughout the vessel including all air conditioning plants, package units and the cooler of the inert gas plant. The refrigerant shall be selected on the basis of

low environmental impact and future availability.

Refrigerant leakage detection systems shall be provided to monitor the compressors for the main air-conditioning and inert gas systems, with remote alarms in the IAS.
The heating system (steam and electric type) shall be capable of maintaining a temperature of 22ºC and 50% relative humidity with an outside air temperature -15ºC. Consideration will be given to systems that incorporate local heating/cooling in lieu of centralized heating/cooling units.

Fail-safe automatic dampers shall be fitted to each fan that shall close when the fan stops. Remote control for all dampers shall be located adjacent to the fire smothering controls at the fire control station and shall be of the self-contained pneumatic type.
All intake and exhaust louvers shall be of GRP or a similar non-metallic material, with means to prevent snow blockage or icing.

Electric heating or steam heating is also to be provided for the following spaces to maintain temperature of 15℃ with outside temperature of -15℃ and sea water temperature of 5℃ : dry store rooms, wheelhouse, laundries, emergency generator room.

Two(2) 100% independent air conditioning shall be provided for CCR, ECR, electronic equipment rooms, switchboard rooms/spaces.

Two(2) 100% independent air conditioning and heating system shall be provided for galley in accordance with Rule requirement.

Two(2) package type air conditioning units shall be provided for wheelhouse, work shop and engine store.

3.7 Refrigerated Provisions stores

3.7.1 General

The following cold rooms shall be provided, capable of holding 4 months provisions for a full complement:

Chamber	Temperature (℃)
Meat Room	-25
Fish Room	-25
Vegetable Room	+1
Dairy Room	+1

Chamber	Temperature (℃)
Kimchi room	-1
Lobby	+3
Dry provision store	Spot air conditioned

Temperatures shall be automatically maintained and recorded as part of the main machinery control and alarm system, using one compressor running not more than 16 hours per day in tropical conditions, with one additional compressor as a stand-by.

A refrigerating plant shall be designed to maintain the above temperature at cooling water temperature of 36℃ and at the outside temperature of 45℃.

High temperature and personnel alarms for the cold stores shall be incorporated in the machinery system IAS.

Cold rooms and dry provision stores shall be arranged with easy access from the galley and the loading area, on the same level as the latter.

A bonded Goods store of volume not less than $20m^3$ shall be provided.

3.7.2 Insulation and Fitting

The refrigerated provisions stores shall be insulated and lined(ceiling, floor and bulkhead) with prefabricated insulation panels which shall be made of polyurethane foam(thickness not less than 100mm) and covered stainless steel.
Sufficient shelves made of stainless steel and fitted with front rolling bars shall be provided.
A stainless steel bar with hook shall be provided in the meat room.
An ozone(O_3) generator shall be provided in the vegetable room & kimch room. Doors shall be fitted with electric defrosting heaters. Man calls system shall be fitted.
Wooden batten grating shall be installed in each room. Each refrigerated provisions store shall be fitted with air coolers(fan/motor/cooling coil/drip pan).

Deck store, rice store, paint store and linen store are to be arranged with good access.

Air cooler for negative rooms shall be fitted with electric defrosting heater and drain pipe heater automatically operated by timer switch.

The following general stores shall be provided:

- A central general store shall be arranged at the upper levels of the engine room with good access from deck for loading stores and spare parts.
- A chemical locker shall be provided at main deck level with fixed firefighting / flooding provision, save-all and emergency shower to be installed directly outside the store.
- Paint store shall be provided at main deck level and fitted with dedicated fixed fire fighting system.
- Lubricating Oil / Grease store shall be provided at main deck level and fitted with a dedicated fixed fire fighting system.
- Deck store shall be provided at main deck level.
- Safety equipment store shall be provided at main deck level with internal and external access.
- Pyrotechnics Locker on bridge deck with dedicated firefighting / deluge system.

3.7.3 Refrigeration Machinery

The refrigerated provisions stores shall be cooled by two(2) sets of refrigeration plant of refrigerant R-407C direct expansion refrigerating units (one in service and one as stand by).

Each unit shall have a capacity to keep the refrigerated room at the temperature stated in 3.7.1 under ambient temperature stated in 3.6.1 based on an 16 hours daily running time and to cool down food from ambient temperature to temperature stated in 3.7.1.

Each unit shall include one reciprocating type compressor, one electric motor (max. speed 1800 rpm), one condenser (horizontal shell and tube type) and one instrumentation and control system.

3.7.4 Fresh water and Drinking water

Domestic fresh water shall be produced by evaporators with connections to at least two(2) storage tanks. The sanitary system is to be supplied from the fresh water system.

The drinking water is to be treated by U.V sterilization and mineral dosing system.

The drinking water fountains containing refrigeration unit for water cooling to be provided.

3.8 Personnel lift

One(1) set of electric motor driven, counterweight type personnel elevator (Capacity : 500 kg) shall be provided from engine room floor deck up to below navigation bridge deck with enclosed steel trunk.

4 Cargo

4.1 General

4.1.1 General Description

The vessel shall have thermally insulated cargo tanks and shall be fitted with cargo handling system, control system and measuring system in order to transport a LNG (Liquefied Natural Gas, -163℃) of 174,000 m^3 at the normal cargo tank filling ratio.

The CCR(Cargo Control Room) shall be provided to enable the centralized control of loading, discharging, ballasting, etc. and continuous monitoring of cargo system.

Manifolds for the cargo shall be complied with the latest edition of OCIMF Recommendations for Manifolds of Refrigerated Liquefied Gas Carriers and SIGTTO ship shore compatibility documentation.

Cargo discharge shall be performed by two(2) submerged electric cargo pumps in each cargo tank. Gas compressors, heaters and vaporizers, etc. shall be installed in a cargo compressor room.

If cofferdam heating is required by the design of the cargo containment system, the system shall employ a glycol/water mixture circulating system.

An inert gas generator and two equally sized nitrogen generators shall be installed in the engine room.

A custody transfer system shall be installed in the vessel and it shall meet the needs of the buyers and sellers of LNG as well as the fiscal authorities of the countries exporting and importing the cargo.

The amount of cargo shall be calibrated /calculated by the custody transfer system according to the conditions of cargo tanks, i.e. level, temperature and pressure, etc. and the system shall be approved by an independent measurer nominated by the owner and approved by the appropriate customs and excise authorities.

As far as possible, all instrumentation lines, hydraulic lines and electric cables shall be run below the trunk deck. Where this is not practical, they shall be run in GRP ducts above the deck. Mild steel cable trays and conduits shall be fitted in exposed locations.

4.1.2 Design and Construction

The design of the cargo containment system shall be in accordance with the latest designs of the

following containment systems:

- KC-1
- GTT No. 96
- GTT Mark-III

Test reports, calculation sheets and reports on experience shall be submitted to the owner proving the ability of the respective system in the event that the proposed containment system is significantly different from the licensor's current design.

The vessel is to be designed to allow any one tank, which can be empty, aerated, accessible and safe, with remaining tanks full in seagoing conditions. Consideration shall be given to a design enabling any combination of cargo tanks full or empty. All cargo tanks shall be so designed as to withstand dynamic forces in the sea going conditions. Filling restrictions due to sloshing effects shall be minimized and indicated at the tender stage.

4.1.3 Cargo Composition

Composition	Range(Mole %)	Standard(Mole %)
Methane	84.0 % min	89.49 %
Ethane	8.0 % max	6.33 %
Propane	3.0 % max	2.49 %
Butane	2.0 % max	1.26 %
Pentanes and Heavier	0.1 % max	0.08 %
Nitrogen	1.0 % max	0.34 %
Impurities		
CO_2	100 PPM max	
H_2S	5 PPM max	
Total Sulfur	30.0 mg/Nm^3 max	

* Note: Standard composition shall be used for designing equipment. The equipment shall be suitable for any composition complying with the range shown in the above table.

4.1.4 Main Design Conditions

4.1.4.1 Cargo Temperature

The minimum service cargo temperature considered as the design of the cargo part is - 163°C.

4.1.4.2 Pressure in Cargo tank

The design normal absolute operating pressure of cargo tanks should be 106 kPa. This pressure should be adjustable between 105 kPa and 110 kPa.

The maximum pressure of gas in the tanks shall be 25 kPa M.A.R.V.S.(Maximum Allowable Relief Valve Setting) above atmospheric pressure.

The minimum permissible pressure(vacuum condition) shall be 1 kPa below atmospheric pressure.

4.1.4.3 Cargo Specific Density

In determining the design draft, trim, stability criteria and cargo handling system(except pumps), the cargo specific gravity of 0.47 shall be used. However, the hull scantling, the cargo containment system and pump design, the cargo specific gravity of 0.5 shall be used.

4.1.4.4 Ambient Conditions

The cargo containment and handling system shall be capable of operating in the following ambient conditions for service:

- Sea water temperature maximum 35℃
- Sea water temperature minimum 0℃
- Air temperature maximum 50℃
- Air temperature minimum -18℃
  (for cargo containment system and contiguous hull structure)
- Air temperature minimum for other system: -15℃

4.1.4.5 Boil-Off Rate

The cargo tank containment system shall be designed with the maximum cargo boil off rate (B.O.R) which is less than 0.12% per day of gross cargo volume under the following specified conditions:

- Air temperature 45°C
- Sea water temperature 32°C
- Cofferdam temperature +5°C (Membrane)
- Temperature of cargo -161.5°C
- Cargo pure methane
- Cargo tank pressure 106 kPa absolute (Stable)
- Sea condition calm
- Cargo tank condition 100 % wetted surface

Note: In the membrane system design, the natural boil-off rate mentioned above shall be achieved without the use of vacuum conditions in the insulation spaces.

The properties of pure methane at –161.5 °C shall be taken as:

- Specific density : 425 kg/m^3
- Latent Heat : 511 KJ/kg

The builder shall be required to provide a guarantee for the boil-off rate(BOR). The builder shall provide heat flow calculations to substantiate the guaranteed maximum nature boil-off rate. Detailed conditions and formulae for determining the actual boil-off rate shall be in accordance with the shipbuilding contract.

4.1.4.6 Insulation

Insulation shall be of a good quality and type specified by the licensors to meet the boil-off rate(BOR) stated in section 4.1.4.5.

4.1.4.7 Calibration

Each cargo tank shall be volumetrically calibrated and the tank tables of each cargo tank shall be prepared by an independent surveyor approved by the buyer and seller.

The tank tables shall be correlated with the volume of cargo tanks using 0.001 cubic meter as the smallest unit and with the depth of cargo tanks using 1 millimeter as the smallest unit.

The tank tables shall include the correction tables required for accurate gauging and especially shall have corrections provided for trim & list and float gauge offsets due to the shrinkage and specific gravity.

4.2 Cargo Handling Operation

4.2.1 General

This section describes the cargo handling operation which includes the loading, discharging, laden voyage, ballast voyage, cool down, warming up, gas freeing and emergency discharging, etc.

The operation manual(including diagrams), which describes on cargo handling operation in detail, shall be prepared by the builder and approved by the owner.

During each cargo operation, the conditions of cargo containment system and cargo handling

system shall be controlled automatically/remotely and monitored from the CCR, and various safety protections shall be provided for the system.

The cargo handling equipment shall be designed to fulfill with the following conditions:

- The vessel shall be able to load the total bulk cargo within 14 hours with a back pressure not exceeding 2.3 barg at the manifold, employing two(2) liquid manifolds and including the use of 20/60 mesh strainers.
- The vessel shall be able to discharge the total bulk cargo with 20/60 mesh strainers installed through three(3) liquid manifolds within 14 hours against a back pressure of 4.2 barg at the shore manifold.
- Inerting shall be performed in 20 hours or less.
- Aerating shall be performed in 20 hours or less.
- Evaporation of unpumpable cargo and warming-up shall be performed in less than 55 hours
- Gassing up shall be performed in less than 20 hours.
- Initial cooling down shall be performed in less than 12 hours.

The following calculations shall be performed by the shipyard to verify the safety of the system:

- Thermal stress analysis for each cargo containment system including the cargo piping system, taking into account expansion, contraction and vessel flexing, and such analysis to include transient conditions.
- Dynamic cargo pressure calculations based on hull accelerations at sea, indicating local maximum forces.
- Fatigue stress analysis due to thermal stress and forces created by the dynamic cargo pressure and induced forces from the hull.
- Sloshing pressure calculations based on the impact forces born by the cargo containment system due to the cargo free surface movement at sea.
- Transverse, longitudinal, torsional and local hull deflection analysis indicating stress levels.
- Local stress analysis for tank domes and their pipe penetrations as well as pipe supports inside the tank and on the deck.
- Calculation data of the max. allowable temperature for cargo loading.

Builder shall submit the calculation data on machinery’s capacity decision to the owner.

4.2.2 Normal Transport Cycle

The normal transport cycle consists of LNG loading, laden voyage, LNG discharging and ballast voyage. Before loading, the lines shall be cooled by LNG with one of the spray/stripping pumps.

During loading, the vapor is returned to the shore by high duty compressor(s). After completion of loading, liquid cargo in headers and pipes is drained to cargo tanks and blown with nitrogen gas from the shore or from the vessel via temporary connection(s).

Cargo tank's pressure and temperature shall be maintained at all times within their design range by either one or a combination of the following methods:

1) Re-liquefaction of cargo vapors
2) Gas combustion unit or equivalent, etc.

A forcing vaporizer may be used for producing additional fuel gas during laden voyage in case of the insufficient of natural BOG.

Before discharging, the lines shall be cooled down by LNG with spray/stripping pumps. During discharging, vapor is sent from the shore to each cargo tank to maintain pressure. After completion of discharging, liquid cargo in headers and pipes is drained to cargo tanks and blown with nitrogen gas from the shore or from the vessel via temporary connection(s).

During ballast voyage, cargo tanks may be maintained at low temperature conditions by spraying LNG with spray/stripping pumps. The boil-off gas generated during the ballast voyage shall be used as fuel for duel fuel diesel engines.

LNG may remained in one or two tanks if the operator in the vessel decides to burn fuel gas rather than fuel oil, and this case the forcing vaporizer may be used.

4.2.3 Preparation of Loading after Dry-Docking

The preparation of loading after the dry-docking consists of inerting cargo tank, natural gas filling and cargo cooling down.

During the voyage after dry-docking, inerting cargo tanks is carried out with the IGG in the vessel.

During purging cargo tanks, it is carried out by sending warm LNG vapor from the LNG vaporizer. In this case, LNG used in purging cargo tanks is received from the shore.

During the cool down of cargo tanks, LNG is supplied from the shore and sprayed in tanks. Also, vapor in cargo tanks is returned to the shore by the H/D compressor(s).

4.2.4 Preparation for Dry-Docking

The preparation of dry-docking consists of cargo tank warming up, inerting, and aeration.

Cargo remained on cargo tanks after stripping is vaporized by the circulation of hot cargo vapor through high duty compressor(s) and high duty heater(s), and then cargo tanks are warmed up finally.

And then, inerting is carried out with inert gas from an inert gas generator. After that, dry air is supplied from an inert gas generator/dry system during aeration.

4.2.5 Other Cargo Operation

4.2.5.1 Boil-Off Gas Utilization/Disposal During Cargo Loading

The minimum fuel oil and the maximum BOG gas may be burnt in the dual fuel diesel generator engines and/or managed with appropriate means mentioned in 4.2.2 during cargo loading by the suitable control system according to the buyer and seller agreement.

4.2.5.2 Gas Freeing Operation During Voyage

Gas free of cargo tanks in normal seagoing shall be possible. The builder shall submit the owner's procedure for carrying out the gas freeing operation at sea including safe access into the cargo tanks.

4.2.5.3 Ship To Ship Transfer

The ship shall be able to transfer cargo to, or receive cargo from, another ship according to the latest edition of OCIMF/SIGTTO "Ship to Ship Transfer Guide".

4.3 Cargo Piping and Valves

4.3.1 General

General cargo piping diagrams shall include cargo piping, nitrogen piping, safety valve system, purging & sampling piping and control instruments, etc.

The piping system shall be designed to carry out the warm-up, inerting, purging and cool-down, etc. in a single cargo tank with the remaining cargo tanks containing cargo or cargo vapor and without interrupting gas burning. Adequate separation between tanks in this condition shall be demonstrated. The separation shall be carried out with two positive means of isolation such as two valves or a valve with a spectacle blank; however, a swing check valve is not acceptable.

Bolts, nuts and all fittings inside tanks shall be secured in order to prevent bolts, nuts and all fittings from loosening. Electric bonding system shall be provided throughout to ensure that

potential differences shall be avoided.

4.3.1.1 Lines

In each cargo tank, the necessary piping for liquid, spray and vapor lines shall be installed, and the necessary lines for drying, venting and inerting shall be installed.

The main longitudinal headers shall apply to LNG liquid, LNG vapor, spray and N_2 bleeding. Drain lines shall be arranged to enable remaining liquid in lines to flow into cargo tanks or to the shore connection.

Sampling points fitted with double shut-off valves and test connections for pressure gauges shall be provided on the liquid and vapor lines. The whole piping system shall be continuously earth connected.

Means of efficient drainage of the loading arms and manifolds are to be provided. The main liquid lines are to be designed to encourage self-draining.

All sections of pipes where liquid can be trapped are to be fitted with relief valves which discharge to cargo tanks with an arrangement to allow safe entry to any one tank. This requirement is also applied to the sections of line outboard of the ship's liquid manifold valves.

Pipe stress analysis shall be carried out according to the requirements of the Classification Society.

All safety valves in the cargo pipeline system shall be supplied by one manufacturer and shall be provided with means of manual operation.

4.3.1.2 Piping Joint

As far as possible the cargo piping system shall be butt-welded throughout, except control valves and cargo handling equipment.

The flanged connections are kept to be minimum for weld neck & raised face type, but slip-on flanges may be used for open ended piping on deck as far as applicable.

4.3.1.3 Thermal Stresses

Adequate expansion loops or expansion bellows shall be provided in the liquid and vapor piping system to allow the thermal expansion & contraction of pipes and the flexing of the vessel. Any bellows used in the cargo system shall be of the multi-wall type with 'Inconel 825' flexible elements or equivalent in the outer layer.

4.3.1.4 Pipe Supports

Pipe anchors shall be designed to take thermal and dynamic loading including pressure surges that may be induced in ship's piping system.

Fixed pipeline anchors shall be designed to avoid point loading. Suitably shaped sections of pipelines with increased wall thickness may be employed. Pipe anchors are not to be directly welded to pipe "U" bolts and shall be of stainless steel (SUS 316).

In general, all pipelines on deck and in the compressor room shall be installed such that metal-to-metal contact between pipes and the ship's structure is avoided by the insertion of suitable pads, chocks or sleeves of PTFE (Polytetrafluoroethylene) or similar materials. The supports should be designed to allow the maintenance of pads in service without hot work.

Pipes on deck exposed to low temperature are to be supported by anchoring pieces of stainless steel and by clamps to avoid vibration.

Calculations shall be submitted which demonstrate the suitability of the design with respect to the strength of supports and the stresses in the pipelines under all conditions of operation including transient loads during cool-down. Details of each type and size of pipeline supports shall be subject to approval.

4.3.1.5 Fluid Velocity

Fluid velocity in the pipelines in normal service shall not exceed 7 m/s for liquid and 40 m/s for vapor with the exception of warming up, inerting, aerating, cooling down, gassing up and vapor flow to shore in which cases a maximum velocity of 45 m/s for the vapor lines can be accepted.

4.3.1.6 Piping Material

The cryogenic cargo piping system shall be constructed of austenitic stainless steel (SUS 316L).

-	Low temperature pipes	SUS 316L or equivalent
-	Low temperature pipes (in tank)	SUS 304L or equivalent
-	Other pipes (weather part)	SUS 316L or steel covered by anti-corrosive tape and coated with decadex or equivalent
-	Inert gas line	SUS 316L on deck and Hot-dip galvanized mild steel under deck

Bolts, nuts and U-bands for piping on exposed weather decks shall be of stainless steel (SUS 316L).

Expansion bellows shall be made of SUS 316L.

4.3.1.7 Piping Insulation

System pipelines operating at temperature below 0 °C shall be insulated and covered with a water and vapor tight barrier. Flanges, valves and expansion bellows are not to be insulated.

The cryogenic piping system outside cargo tanks shall be insulated with rigid, self-extinguishing polyurethane foam or equivalent suitable for temperatures up to +80 °C. The insulation shall be covered with a tough water and vapor tight barrier. Particular attention shall be given to thermal expansion and contraction arrangements to prevent ingress of moisture.

In general, the pipe insulation is to be of two(2) layers construction except small pipes (25mm) which can be smoothly slided between each layer. The thickness(mm) of the insulation shall be as follows:

Nominal pipe size	Liquid	Vapour
Ø ≤ 25	30	30
25 < Ø <100	50	40
Ø > 100	80	60

4.3.1.8 Pipe Testing

All pipe welds shall be 100 % radiographic inspection or tested by an equivalent method approved by the owner. The pressure test of pipes shall be conducted by air or water in the shop and by nitrogen on the ship.

After fabrication and testing, pipes shall be internally dried, cleaned and sealed before installation on the vessel. After pipelines have been installed, all liquid, vapor, nitrogen, distribution and inert gas pipelines shall be blown through with dry air and the main system shall be internally inspected by a remote controlled TV camera or owner's acceptable methods.

4.3.2 Cargo Manifold

4.3.2.1 Cargo Manifold arrangement

The cargo manifolds shall be complied with the latest edition of SIGTTO & OCIMF recommendation "Recommendations for Manifolds for Refrigerated Liquefied Gas Carriers" and the SIGTTO ship shore compatibility documentation. The connections on each side shall be arranged in the order L-L-V-L-L.

Two(2) liquid crossovers and one(1) vapor crossover are to be located on the main deck closed to

amidships. Each liquid cross-over is to be equipped with two(2) shore connections at each end.

The spacing between liquid lines and vapor lines shall be in accordance with the loading & discharging terminals' arm location. And, the distance between ship manifold flange and ship side shall be not less than 3.5 m or greater than 4.0 m. The pipe grade of cargo manifolds is to be sch. 40.

The distance between the bottom edge of the manifold flange and the top of the deck or working platform shall be a minimum of 900 mm. The distance may be increased but, in any case, should not exceed 1,400 mm.

Water curtain pipes (SUS316L or 90/10 Cu-Ni) shall be provided at ship side in way of each loading station to protect the side shell during loading and discharging (No spraying type but film type). Sea water for water curtain shall be supplied from fire and wash deck lines near the loading station.

The vertical center of cargo manifolds shall be between 14 meter and 24 meter above the water line at all ballast or loading conditions and the longitudinal center of the cargo manifold shall not be greater than 5 meter forward or 5 meter afterward of amidships.

The minimum distance flat side forward of manifold is 32.4 m and minimum distance flat side after of manifold is 58.0 m.

4.3.2.2 Manifold Connections

Manifold flanges shall be 16 inches and 12 inches/16 inches with RF(Raised face) type for both liquid and vapor manifolds respectively. Blank flanges of liquid and vapor line shall be hinged types. Eight(8) 20 inches/16 inches reduction pieces shall be supplied.

Connections for loading marine diesel/gas oil (8 inches) and heavy fuel oil (8 inches) shall be adjacent to the cargo manifolds. Also, a set of reducers, spool pieces and distance pieces should be provided in accordance with 'Bunker Connections Table.9' in the latest edition of SIGTTO and OCIMF recommendation "Recommendations for Manifolds for Refrigerated Liquefied Gas Carriers"

Connections for fresh water (3 inches) shall be adjacent to the cargo manifolds.

One(1) pneumatic hose & one(1) electric ESD connection for emergency shut down system shall be provided near each loading station (P/S).

One(1) fiber optical connection for ship/shore communication and tension monitoring system shall be provided near each loading station (P/S).

Separately, one(1) tension monitoring connection of electric type for discharging terminals shall be provided near each loading station(P/S).

Electric bonding system shall be provided throughout to ensure that potential differences shall be avoided.

4.3.2.3 Loading Platform

A loading platform made of steel for low temperature service shall be provided, and stainless steel or GRP gratings shall be provided.

A drain pan made of stainless steel shall be provided under each shore connection of low temperature liquid lines.

The means shall be provided to defect a spill of LNG overboard to facilitate the rapid escape and evaporation of the liquids in accordance with the OCIMF standard.

4.3.2.4 Strainers, Distance Pieces and Reducers

Strainers, distance pieces and reducers shall be designed in accordance with SIGTTO & OCIMF recommendations. Manifold strainers shall be of double flow type as far as practical.

Builder shall supply the total eight (8) manifold strainers. The distance pieces and reducers which are needed for each loading and discharging terminals shall be provided and stored on the loading platform for each ship side (P/S).

4.3.2.5 Nozzle for Cargo Jettison

A portable nozzle for emergency cargo jettisoning shall be supplied and stored in way of the manifolds. The nozzle shall be capable of mounting on any liquid manifold, projecting 3 m over the ship's side and providing an outlet velocity of 40 m/s when supplied by two cargo pumps at rated capacity.

4.3.3 Valves

Valves for cargo liquid shall be designed so as to prevent liquid trapping and all valves for cryogenic service are to have extended bonnets and to be of stem type as far as practicable to avoid freezing of moving parts. All sealing materials shall be suitable for a temperature range from -

163℃ to +80℃. Valves shall be “fire-safe” in compliance with a recognized standard. Non-throttling valves shall be suitable for bi-directional flow. All valves shall be designed to permit overhaul in situ.

In general, the type of valve shall be as follows:

- Globe valve nominal diameter: 100 mm and below
- Butterfly valve nominal diameter: 125 mm and above

The materials of valves shall be of stainless steel (Same quality as adjacent pipe). The joints of valves for liquid cargo shall be welded type. Valve seals shall be metallic or soft seals and be designed for bi-directional flow. The manifold ESD valves are to be “fire-safe” with metallic sealing.

For large diameter valves, special attention shall be given to the design of top flanges. Special tightness testing under transient cooling conditions shall be carried out.

All valves related to normal operation shall be remotely operated from the CCR. Each manifold liquid line shall be provided with two(2) remotely controlled valves (P/S).

All remotely operated valves shall be hydraulically actuated. Constant accurate and reliable valve position indicators of cargo system shall be provided. All remotely operated valves shall have flag indicators. Also, all valves shall be capable of being operated locally.

Valve manufacturers shall be responsible for providing a properly matched powered or manual actuator and for testing the whole assembly before dispatch from the factory.

Sampling, vent and drain lines on all liquid and vapor lines, which are open to atmosphere, shall be fitted with double isolating valves.

Materials for hand-wheels, levers and fittings for all valves and actuators shall be selected with a view to their resistance to corrosion.

4.3.4 Cargo Valve Hydraulic System

Cargo valve control system shall be installed to allow all normal cargo handling operations to be performed from the cargo control room (CCR). Valves shall be provided with hydraulic actuators powered from centralized power packs and controlled by electro-hydraulic control system.

All remote control valves shall be operable from the Integrated Automation System (IAS) and valves shall be also capable of manual operation with a hydraulic hand pump in general.

The hydraulic power packs, which consist of two electric motor-driven main pumps, one small pump, accumulators with filters, gauges etc., shall be installed in suitable protected locations. The small pump shall be designed to maintain system pressure under low demand conditions.

Each main pump shall be capable of operating either the two(2) largest valves in the cargo system or all manifold valves on one side within thirty(30) seconds, whichever is greater.

Suitable connections shall be provided for cleaning the hydraulic system without the removal of sections of pipelines.

All valve actuators shall be directly mounted on the valves.

Accumulators shall be able to close the manifold ESD valves and the fuel gas master valve in the event of a loss of hydraulic power.

Emergency shut down capability for the manifold valves shall be provided according to the IGC code.

Hydraulic control valves shall be located in groups in protected spaces such as under deck pipe passage(s). Where this is impractical, control valves shall be grouped in watertight boxes on decks. The lines to the actuators shall be run below the deck as far as possible.

All critical hydraulic operated valves shall be capable of local manual operation. This requirement shall include: ballast sea valves, cargo manifold valves, cargo tank loading valves and cargo pump and spray pump discharge valves. And solenoid valves shall be intrinsically safe type.

Actuators and hydraulic control system for the cargo tank filling valves, cargo pump discharge valves and manifold valves shall contain automatic pressure and temperature compensated flow control to ensure consistent speed of operation. The designated hydraulic control valves shall have a linear flow reduction characteristic.

During installation and commissioning, the hydraulic system shall be flushed to ensure cleanliness to ISO 4406 code 17/14.

4.3.5 Cargo Tank Relief Valves

Each tank and barrier space shall be equipped with two(2) diaphragm relief valves of the pilot-operated type. Each relief valve shall be provided with a means of manual operation.

Relief valves for cargo tanks and hold spaces or insulation spaces shall be pilot-operated type and relief valves for piping shall be spring-loaded type.

One(1) spare relief valve for the cargo tank and barrier space shall be provided.

4.3.6 Vent Masts

A stainless steel (SUS 316L) vent mast including all fittings shall be provided for each cargo tank and fitted with a nitrogen purging connection. The cargo vapor header shall be led into the forward vent mast, which shall be fitted with a pressure control valve and shut down device operated from the CCR & W/H with manual overriding function.

Vent masts for relief valves on each cargo tank are to be equipped with wire mesh flame screens and cowl materials made of stainless steel.

Drain connection(s) with a small drip tray shall be provided at the bottom of each vent mast. Also. ladders shall be fitted on the vent masts for access to the head of each mast top.

4.4 Cargo Handling Equipment

The cargo machinery and equipment shall be tested at the manufacturer’s shop according to the test procedures approved by the owner.

Performance curves for pumps and compressors and the shop test results for all equipment shall be incorporated in the relevant drawings.

All equipment used in loading, discharging and other cargo operations as well as some gas burning operations shall be automatically and remotely controlled from the CCR and locally controlled with manual operation.

The calculation sheets of design capacity of all cargo handling equipment shall be submitted to the owner for approval and reference, and the calculations of cargo handling equipment shall be based on the conditions of either pure methane or the standard LNG composition, whichever is the most severe.

4.4.1 Cargo Pump

Two(2) equally sized submerged electric cargo pumps are to be provided in each cargo tank. The pumps shall be designed to meet the performance requirements. Pumps in all cargo tanks shall be identical in manufacturer, model and capacity.

The pumps shall be designed with inducers and bell mouths to give the minimum NPSH (Net positive suction head) requirements and shall be designed to be fully hydraulic thrust balanced in normal service over a wide capacity range.

A large mesh strainer shall be provided for the suction bell mouth of each pump. Each pump is to be driven with soft starters systems and designed to meet 3,000 hours in operation and 600 start/stop between two dry-docking each 5 year.

Cooling of electric motors & bearing and lubrication of bearings are performed by cargo (LNG).

The speed of pumps shall not exceed 1,800 rpm. Cargo pumps and spray/stripping pumps shall be designed to operate continuously from 40 % to 120 % of the design capacity.

Cargo pumps, piping system and starters shall be designed to minimize liquid hammering during starting. In this regard, the non-return valves of cargo pumps shall be installed immediately above the pump in cargo tanks.

All pumps shall be run for test at duty point and establish NPSH in liquefied gas before delivery.
For the first pump of the batch, full performance tests shall be conducted with LNG of similar composition in actual service. If the results are satisfactory, this performance test needs not to be repeated for subsequent identical pumps for the ship or series of ships.

Casings, inducers and impellers shall be made of aluminum alloy and shafts shall be made of stainless steel or equivalent. Cargo pumps shall be capable of remote start/stop operation and pressure/temperature/motor current monitoring in the CCR. An emergency stop button for each cargo pump shall be fitted near each dome.

Vibration measurement of cargo piping shall be carried out at gas trial to confirm that the vibration levels are acceptable when starting pumps.

Each pump shall be provided with a low current trip device (or low power) to protect against dry running – NOT a low level trip.

4.4.2 Spray/Stripping Pump

4.4.2.1 Use

Spray/striping pumps are used:

- To supply necessary LNG for forcing boil-off at the maximum capacity of the forcing vaporizer with one pump
- To spray LNG in the cargo tank during the ballast voyage to cool down all cargo tanks with one(1) pump
- To strip LNG in the cargo tank (Un-pumpable by main cargo pumps)
- For the pre-cooling of liquid lines (if appropriate)

4.4.2.2 Description

One spray pump shall be installed in each cargo tank and shall be installed as low as possible so that it may be used for stripping. Spray pumps and cargo pumps shall be manufactured by the same manufacturer, and the design and materials of spray pumps shall be generally similar to those of the cargo pumps.

Each pump shall be fitted with inducers and bell mouths to achieve the minimum NPSH and shall be fitted at the lowest point of the tanks or wells, if applicable.

A large mesh strainer shall be provided for the suction bell mouth or each pump. All pumps shall be the identical size.

The speed of pumps shall not exceed 3,600 rpm. All pumps shall be fully tested with LNG or equivalent at makers' shop, and the performance curves shall be drawn up showing discharge head, NPSH, Ampere/kW versus LNG flow rate.

Spray/stripping pumps shall be capable of remote start/stop operation and pressure/temperature/ motor current monitoring in the CCR.

An emergency stop button for each cargo pump shall be fitted near each dome.

One(1) set of spare emergency cargo pump and relevant fittings shall be provided.

Necessary equipment like davit and trolley to carry the emergency cargo pump shall be provided by the builder. Direct on line starting method is applied for emergency cargo pump. The pump shall have start/stop operation, discharge pressure and motor current monitoring in the IAS.

4.4.3 Fuel Gas Pump

One(1) fixed electric motor driven pump of the submerged type shall be installed in a cargo tank in order to supply necessary LNG for forcing boil-off at the maximum engine demand. Additional one(1) set fitted in other cargo tank shall be provided as redundancy purpose.

The materials of major parts shall be equivalent to cargo pumps, and the fuel gas pumps shall have the function of remote and sequential start/stop operation and that of discharging pressure/motor current monitoring in the CCR.

Fuel gas pump in cargo tank shall be of a type verified for 15,000 hrs in operation and 1,000 start/stop.

4.4.4 Alternative Discharge System

In event of failure of both cargo pumps in a tank, alternative means, i.e. emergency cargo pump, shall be provided to discharge cargo. The pump shall have the same discharge head as the main cargo pumps.

4.4.5 High Duty Compressor

4.4.5.1 Use

High duty compressors are used:

- To transfer generated vapor to the shore during loading
- To transfer generated vapor to the shore during initial cooling down
- To re-circulate hot cargo vapor (maximum 80 °C) to warm-up cargo tank(s) to + abt. 5°C
- For the aeration of cargo tanks

The compressors shall be suitable for vapor return and for warming up and be able to handle cargo vapor, inert gas or mixtures of both.

4.4.5.2 Description

Two(2) equal sized constant speed, electric driven high duty compressors shall be installed in the cargo machinery room.

Motors shall be installed in the motor room and drive the compressors via an intermediate shaft which penetrates the bulkhead through a gas tight seal. The motor, gearbox and compressor shall be mounted on a common bedplate incorporating the gas-tight gland and partial bulkhead. The whole installation shall be designed to minimize vibration.

Each compressor shall handle 60% of the maximum vapor generated during loading under design loading condition with suction piping balanced for parallel operation.

Heat loss on shore facilities of loading terminals shall be considered for the calculation of final capacity design.

Compressors shall be capable of remote start/stop operation and pressure/temperature/motor current monitoring in the CCR.

Automatic capacity control device(s) shall be provided to maintain the constant absolute cargo tanks' pressure by means of an inlet guide vane.

Each compressor shall be equipped with an independent automatic, anti-surge control system and be capable of handling LNG vapor, inert gas or nitrogen, air and the mixtures of these gasses.

Both compressors shall be operated independently or parallel and the minimum discharge pressure shall be abt. 1.96 barg.

The shafts' sealing shall be carried out by nitrogen gas from nitrogen generator(s). A control panel shall be provided for each compressor.

Casings/shafts shall be made of stainless steel and impellers shall be made of aluminum alloy. Shaft vibration and shaft position-monitoring device(s) shall be fitted.

The first compressor of each size shall be tested with air before delivery and performance curves shall be established and then corrected for methane at the design condition.

Each compressor is to be spin-tested at cryogenic temperatures to verify performance and then dismantled for examination.

4.4.6 Low Duty Compressor(if fitted)

Low duty compressor(s) are designed to meet the requirement in accordance with the concept of the fuel gas system, if fitted.

4.4.6.1 Use

One(1) or two(2) compressors shall have sufficient capacity to transfer boil-off gas from cargo tanks to the dual fuel diesel generator engine(s) in engine room to maintain constant cargo tank pressure.

Compressor(s) shall have sufficient capacity to handle the quantity of gas compatible with 100% gas burning at MCR of engine consumer(s) at suction temperature of manufacturer's standard.

In order to maintain the required inlet temperature during the ballast voyages or laden voyages, an LNG spray cooler with mist separator is to be provided at compressor inlet, if necessary.

4.4.6.2 Description

One(1) or two(2) electric driven low duty compressors shall be installed in the cargo machinery room and motors shall be located in the motor room in principle.

The compressors shall be capable of remote start/stop operation and pressure/temperature/motor current monitoring in the CCR.

Compressor(s) shall be fitted with a DGV (diffuser guide vane). Compressor(s) shall be equipped with an independent automatic anti-surge control system and be capable of handling LNG vapor, inert gas or nitrogen, air and the mixture of these gasses normally.

Both compressors shall be operated independently. The shaft sealing shall be carried out by nitrogen gas from nitrogen generator. A skid control panel shall be provided for each compressor.

4.4.7 High Pressure Compressor (if fitted)

High pressure compressor(s) are designed to meet the requirement in accordance with the concept of the fuel gas system.

4.4.7.1 Use

One(1) or two(2) equally sized reciprocating high compressors shall have sufficient capacity to transfer boil-off gas from cargo tanks to the dual fuel diesel engines in the engine room to maintain constant cargo tank pressure.

4.4.7.2 Description

One(1) or two(2) electric driven reciprocating high pressure compressor with motor shall be installed in the cargo machinery room and/or motors shall be located in the motor room in principle.

A Butter tank/ accumulator, if any, is to be provided to smoothing of minor gas pressure fluctuations in the fuel supply as per maker's recommendation.

Compressor(s) shall be capable of remote start/stop operation and pressure/temperature/motor current monitoring in the CCR. Compressors shall be operated independently. The shaft sealing shall be carried out by nitrogen gas from nitrogen generator, if any. A skid control panel shall be provided for each compressor.

The compressor system shall be also able to operate in a stable manner at minimum delivery condition.

4.4.8 Low Duty Heater

4.4.8.1 Use

Low duty heater(s) is used to heat the quantity of gas compatible with maximum possible fuel gas demand of the propulsion plant.

4.4.8.2 Description

Direct steam heating shell(s) and tube(s) shall be installed in the cargo machinery room. The gas outlet temperature shall be automatically controlled and monitored in the IAS.

Heaters shall be provided with the automatic protection against the freezing of steam side. The drain level shall be automatically controlled and alarmed & monitored in the IAS.

The low duty heater(s) including fuel gas heater is to be in accordance with the proposed concept of fuel gas supply system.

4.4.9 High Duty Heater

4.4.9.1 Use

One(1) high duty heater is used to heat LNG vapor sent by high duty compressors in order to warm-up cargo tanks from -163°C to +5℃ within the specified time mentioned in 4.2.1.

4.4.9.2 Description

One(1) direct steam heating shell(s) and tube(s) shall be installed in the cargo machinery room. The gas outlet temperature shall be automatically controlled and monitored in the IAS.

Heaters shall be provided with the automatic protection against the freezing of steam side. The drain level shall be automatically controlled and alarmed & monitored in the IAS.

4.4.10 LNG Vaporizer

4.4.10.1 Use

An LNG vaporizer is used:

- To supply cargo vapor to cargo tanks when cargo pumps are discharging at the design flow rate without the availability of vapor supply from shore (Cargo tank assumed to be kept at -130℃)
- To purge inert gas from cargo tanks with cargo vapor at +20℃ within the specified time

mentioned in 4.2.1.

- To supply nitrogen gas to cargo tanks and insulation space (by receiving nitrogen liquid from the shore to inert cargo tanks)

In addition, in the event of forcing vaporizer failure, the LNG vaporizer could be possible to use.

4.4.10.2 Description

One(1) direct steam heating shell and tube vaporizer shall be installed in the cargo machinery room. The vaporizer shall be designed to avoid excessive thermal stresses.

The outlet gas temperature shall be automatically controlled by spraying a small amount of LNG into outlet vapor and monitored in the CCR. Suitable means shall be provided to ensure accurate outlet temperature, pressure and flow measurement.

LNG flow shall be automatically stopped in the event of high condensate level or low condensate temperature. Also, a high temperature alarm shall be installed.

Shells and tubes shall be made of SUS 316L or SUS304L.

4.4.11 Forcing Vaporizer

Forcing Vaporizer(s) are designed to meet the requirement in accordance with the concept of the fuel gas system.

4.4.11.1 Use

Forcing vaporizer(s) is used to supply gas in order to supplement natural boil-off gas during 100% gas burning of the main engine(s) or dual fuel generator engines in accordance with the proposed concept of fuel gas supply system.

4.4.11.2 Description

Direct steam heating shell and tube vaporizer(s) shall be installed in the cargo machinery room. LNG shall be supplied from stripping/spray pumps and fuel gas pump in accordance with the proposed concept of fuel gas supply system.

Liquid flow is controlled by an automatic inlet feed valve and it is also managed with re-circulation lines of each stripping/spray pump and fuel gas pump to cargo tanks in accordance with the proposed concept of fuel gas supply system.

The forcing vaporizer shall be designed to avoid excessive thermal stresses. The outlet gas

temperature shall be automatically controlled by spraying a small amount of LNG into outlet vapor and monitored in the CCR. Suitable means shall be provided to ensure accurate outlet temperature, pressure and flow measurement.

A mist separator shall be provided downstream of the forcing vaporizer

Shells and tubes shall be made of stainless steel (316L or 304L).

LNG flow shall be automatically stopped in the event of high condensate level or low condensate temperature. Also, a high temperature alarm shall be installed.

4.4.12 Drainage Pumps/Heating System

4.4.12.1 GTT No. 96, Mark III & KC-1 system

Water drainage from the secondary insulation spaces shall be complied with the licenser's standards. Two(2) water detectors with a test device shall be installed by the licensor's standards at each cargo tank drainage well.

The heating of cofferdams shall be performed by circulating glycol water in pipes or heaters. Cofferdam spaces shall be kept at +5℃ with temperature stated in 4.1.4.5. The freezing point of glycol water mixture shall be lower than -30℃.

Each cofferdam shall be provided with two(2) separate heating system, one(1) in service and one(1) spare of 100% capacity. Inside cofferdams, connections shall be welded type. The storage capacity for pure glycol shall be sufficient to replace the full amount of mixture glycol/water in the system.

Cofferdams shall be equipped with water detecting device(s).

One(1) electric heater shall be used for normal sea going and two(2) steam heaters shall be used in case of high demands such as during loading or in winter season(one stand-by).

4.4.13 Cargo Machinery Room and Motor Room

A separate cargo machinery room and motor room shall be provided for the installation of cargo handling equipment.

The motor room shall be separated from the cargo machinery room by a certified gas tight steel bulkhead.

All electric motors for cargo handling machinery shall be installed in the motor room. The

vibration and temperature monitoring device(s) of seals shall be provided. Special consideration shall be given to escape ways in case of emergency for both cargo machinery room and motor room.

A fresh water outlet with portable hose shall be provided in the space to assist defrosting of equipment.

As of Membrane, if applicable design (NO.96 CCS Type)

- Two(2) vacuum pump shall be provided for insulation spaces. The pump capacity shall be capable of vacuuming (800 mbar in all insulation spaces within 8 hours).

4.5 Gas Free and Ventilation Equipment

4.5.1 Inert Gas Generator/Dry System

4.5.1.1 Use

Inert gas generator/dryer system shall have capacities:

- To supply inert gas into cargo tanks during gas purging within 20 hours.
- To supply inert gas into cargo tanks during air purging within 20 hours.
- To supply dry air into cargo tanks during aeration within 20 hours.
- To supply dry air for drying cargo tanks, hold spaces, double bottom pipe passages and under deck passages.
- To supply inert gas for inerting cargo piping, cargo machinery and cargo hold spaces.

4.5.1.2 Description

An inert gas generator/dry air production unit shall be provided for inerting and aeration of the cargo system within the specified times. Special arrangements shall be made to prevent any return of cargo gas to the space having an inert gas generator.

The plant shall supply inert gas according to the following specification:

- CO_2 : max. 14%
- O_2 : max. 0.5%
- CO : max. 100 ppm
- SOx : max. 2 ppm
- NOx : max. 65 ppm
- Soot : 0 (Bacharach scale)
- Remainder : N_2

The dew point of the inert gas and that of the dry air shall not be more than -45℃. (Discharge

pressure: max. 0.25 barg).

The plant shall consist of:

- One(1) inert gas generator with a sea water washing tower
- Two(2) air blowers (Electrically driven)
- One(1) cooling unit
- One(1) dryer unit
- One(1) control panel set

Sea water for the inert gas generator shall be provided by ballast pumps. The plant shall be arranged for local start/stop by push buttons located on the control panel of the plant. Also, it shall be capable of fully automatic operation with remote start/stop and monitoring equipment in the CCR.

The combustion chamber of the inert gas generator shall be horizontal or near horizontal so as to avoid potential pollution during start up and in the event of flame failure. Materials in contact with humid inert gas or sea water shall be corrosion resistant stainless steel or special materials.

Blowers shall be suitably protected to prevent corrosion.

Dew point shall be monitored and recorded at the outlet of the inert gas generator. The O_2 content, dew point, flow, pressure and temperature shall be monitored and recorded in the CCR.

In case that O_2 content is above 3% per volume, inert gas shall be automatically vented and a visual/audible alarm shall be given locally and in the CCR.

4.5.2 Nitrogen Generator

4.5.2.1 Use

Nitrogen generators shall produce nitrogen gas:

- To supply insulation spaces
- To purge boil-off gas lines in the engine room
- To purge cargo liquid lines, vapor lines and vent masts
- To seal the shafts of high duty and low duty compressors, etc.

4.5.2.2 Description

Two(2) equal sized low pressure type nitrogen generation plants based on the membrane principle

of gas separation of air at ambient temperature shall be provided. The plant shall be fully automatically operated and be arranged for remote control and monitoring in the CCR.

Produced nitrogen shall be the following specifications:

- Purity (N_2): Not less than 97% vol. at 100% rated capacity
- Dew point: Not less than -70℃. Significant condensate shall not form when in contact with surface at -160℃
- Discharge pressure: 5 barg

The supply air and produced nitrogen shall be dust and oil free.

Each generator shall have at least 150% capacity to supply the maximum demands during normal service(e.g. loading operation). Both generators combined shall be sufficient to supply at least 150% maximum demands during in initial cool-down.

The plant shall be provided with a buffer tank of sufficient capacity to ensure that it shall not be started more than once per two(2) hours in normal operation at sea. Feed air compressor(s) shall automatically start and stop according to the pressure in the N_2 buffer tank.

Each nitrogen generator shall be designed for automatic operation and shall be provided with monitoring device(s) for oxygen and moisture.

The builder shall provide the adequate measures to reduce the noise of feed air compressors during operation.

A nitrogen analyzer shall be provided at the outlet of the plant, and O_2 content & dew point shall be monitored in the CCR with visual/audible alarm.

N_2 lines for the purging of cargo pipes shall be provided with connection(s) at each loading station, and a means shall be provided for purging loading arms in case that the shore purging facility could not be used.

4.5.3 Ventilation System for Cargo Work

The following spaces of the cargo area shall be provided with the following dedicated mechanical ventilation system.

- Cargo machinery room (2 sets (one stand-by), not less than 30 air changes/hour)

- Cargo motor room (2 sets (one stand-by), not less than 30 air changes/hour)
- Ducts for fuel gas line to engine (2 sets (one stand-by), not less than 30 air changes/hour)
- Under deck passages (not less than 5 air changes/hour)
- Double bottom passages (not less than 5 air changes/hour)

Fans shall be of a non-sparking type and electric motors shall be complied with the requirements of the Classification Society.

Dampers for cargo machinery room and motor room fans shall be operated at the entrance of the cargo machinery room.

Two(2) sets of explosion proof type water driven fan shall be supplied.

4.6 Water Ballast System

4.6.1 Ballast System

Water ballast system shall consist of a ring main with spurs to each tank with surge protection devices fitted to prevent rupture in the event of transient overpressure. The surge protection system shall consist of water detection probes installed in the ballast ring, forward and aft, port and starboard that will inhibit ballast operations until the ring main is completely flooded.

In case that pressure drop exceeds the pre-set value at delivery side(s) due to empty operation or air suction to ballast pumps, they shall be automatically stopped by means of indication of sensing from a pressure switch.

Two (2) sets of eductor and independent stripping line shall be provided.

Three (3) equal sized electrically driven ballast pumps shall be provided and any two (2) pumps of them shall be operated in parallel. Ballasting and de-ballasting shall be carried out at a rate commensurate with the cargo rate plus 10 % margin and sufficient for maintaining trim and stability within limits.

A water driven eductor with a non-ferrous body shall be installed for the stripping of ballast tanks via the ballast main lines without a separate stripping main line.

The structure of ballast tanks shall be designed to minimize the retention of sediment and water flushing system shall be provided to assist in the dispersion of mud.

The materials of ballast lines shall be GRP (Glass-fire Reinforced Plastic) in pipe ducts and passing

through water ballast tanks. GRP system shall employ double ring bell and socket joints. Where bell and socket joints cannot be used (because of physical constraints), GRP couplings shall be employed.

Each ballast tank shall have an independent high & low level alarm.

Special attention shall be taken to ensure efficient drainage of ballast tanks. Sea chests for ballast water shall be provided for both Port and Stbd side.

Ballast system ring main and branch line valves to each ballast tank shall be located in the bottom pipe passage. Valves shall be of a butterfly type, fitted with direct-coupled hydraulic actuators. It shall be possible to check the valve's opening position externally.

Hydraulic operated valves in the pipe duct and engine room shall be remotely controlled in the CCR. The ballast pumps shall be capable of remote start/stop operation and pressure/motor current monitoring in the CCR.

Ballast system shall have sequential control function and local manual control with overriding shall be also provided.

Each ballast tank shall be fitted with an approved type level gauge giving remote reading of ballast tank level (volume & height) in the CCR.

In an emergency, such as the failure of power, valves shall be operated by a local manual operation device.

4.6.2 Ballast Water Management System

A ballast water management system approved by USCG shall be provided. Such system shall be controlled and monitored from the IAS system with appropriate safety devices (level and pressure switches) in each tank.

4.7 Cargo Control and Instrumentation

4.7.1 General

4.7.1.1 Control, Monitoring and Alarm Concept

The control, monitoring and alarm system shall be arranged to enable unattended operation except during loading and discharging of cargo and ballast.

The control, monitoring and alarm system shall be arranged to enable one man to control the

system during loading and discharging of cargo and ballast.

The valves and equipment necessary for cargo loading, cargo unloading, ballasting and bunkering operations shall be remotely controlled from VDUs(Visual display unit) with keyboards in the IAS system.

All remotely controlled valves shall be provided with local and remote indicators. Cargo monitoring and alarm groups shall be repeated to the wheelhouse, selected officer cabins and all public spaces by extension VDUs.

The design standards of cargo instrumentation shall be the same as those of the machinery except the Custody Transfer System.

The following control system shall be provided:

- Loading/Unloading control system
- Forcing vaporizer control system
- Cargo tank pressure control system
- L/D compressor control system, if fitted
- H/D compressor control system
- Spray header pressure control system
- Spray/stripping pump load control system
- Cargo pump load control system
- Fuel gas pump load control system
- Spray line control system
- Spray control system
- Low and high duty heater control system
- High pressure compressor control system, if fitted
- High pressure pump control system, if fitted, etc.

4.7.1.2 Cargo Control System

A cargo control room (CCR) shall be provided within the accommodation and shall control and/or monitor the cargo, ballast and bunkering system.

One(1) extension color display unit (above 50”) for cargo system shall be provided in the CCR for monitoring all remotely controlled valves, pressure, temperature, flow and level.

In case of signal fault, failure of power supply or system malfunction, the system shall maintain the

current operating point, i.e. safe condition.

In addition, the design shall allow all operations from local positions in the event of failure of the remote control system.

Essential alarms shall be illuminated by individual lamp(s) at the cargo control console.

The following equipment (concerning cargo/ballast/bunker control, monitoring and alarm system) shall be provided (as a minimum) in the CCR:

- Four(4) color VDUs
- One(1) data logger
- One(1) alarm printer
- One(1) color hard copy
- One(1) gas detection panel
- One(1) custody transfer system with two(2) color VDUs (1 set back-up) and two(2) printers (1 set spare) and digital level gauge of cargo tanks.
- One(1) or two(2) mooring tension monitoring and alarm system
- One(1) loading computer
- One(1) multi-point pressure recorder (Membrane)
- One(1) remote draft indication system, etc.

4.7.1.3 Boil-Off Gas

4.7.1.3.1 Measurement of Boil-Off Gas Flow Rate

The means of instant integral flow of boil off, compensated for pressure and temperature, shall be measured, displayed and recorded as follows:

- Boil-off gas to engine room
- Forcing boil-off gas
- Vapor to GCU
- Vapor from shore
- Vapor to shore
- Vent to atmosphere
- Outlet of vaporizer
- N_2 flow meter, etc.

The accuracy of the total system including measurement shall be not more than ±3%.
The accuracy test shall be carried out by concerned specialists or certified companies.

4.7.1.3.2 Boil-Off Gas Burning Control

Detailed scheme of the boil-off gas burning control (dual mode and gas mode) shall be submitted to the owner.

4.7.2 Custody Transfer System (CTS)

The custody transfer system (CTS) shall be complied with all the requirements of the buyer and seller' "LNG Sales and Purchase Contract ".

The system shall provide online display of:

- Level, temperature, vapor pressure in each cargo tank
- Compensated cargo volume for each cargo tank and total volume
- Trim and list

The system shall include a data logging facility to provide a printed record on demand. All level, temperature, pressure gauges & sensors and trim & list gauges shall be calibrated and certified by the independent surveyor approved by the buyer and seller.

The CTS shall take signals from the level gauge system and shall automatically and continuously calculate cargo volumes corrected automatically for trim and list based on the certified tank tables.

4.7.2.1 Level Measurement System

Two(2) independent level measuring system shall be installed in each tank. The primary system shall use radar gauges for level measurement.

The primary level gauging system shall provide alarm level signals for low level and normal filling level, and the latter also shall provide a signal to close the filling valve(s).

The secondary level gauging system may be of the float type with local manual readings and remote level indication in the CCR. The float level gauge's lifting strip shall be made of stainless steel or invar.

The accuracy of the primary and secondary level gauges shall be or less than ±7.5 mm. The separate digital level indicator panel of each cargo tank shall be provided in the CCR. The digital level display system shall be able to read out in 1 mm increments.

Each cargo tank shall be fitted with two(2) independent high level sensors, and alarms shall be

initiated from the level measurement system. The alarm accuracy shall be less than ±10 mm.

4.7.2.2 Temperature Measurement System

A minimum of six(6) pairs of temperature sensors shall be fitted at each tank (6 main, 6 back-up).

The temperature sensors shall be fitted that there are one pair of sensors in the liquid phase (near bottom of the cargo tank) and one pair in the vapor phase (at the top of the cargo tank) at all times, with the remaining four pairs distributed at regular and appropriate intervals from the top to the bottom of tanks subject to owner's approval. A pair of sensors installed at each level, one working and one back up, shall be separately cabled to the control cabinet.

The temperature measuring elements shall be platinum resistance type capable of determining liquid and vapor temperature with an overall system. The accuracy of elements in this service shall be equal to or less than ±0.2˚c over the ranges from -165˚c to -140˚c and ±1.5˚c over the ranges from -140˚c to +40˚c. The temperature display system shall be able to read out in 0.01˚c.

4.7.2.3 Pressure Measurement System

Absolute pressure gauges shall be fitted at each cargo tank. The accuracy of the pressure gauging system shall be or less than ±1% of the measuring range and shall be capable of read out in 0.1 kPa increments.

4.7.2.4 Data Logger

A data logger with graphical capability shall be provided to supply automatic scanning and printing of cargo measurements. The system shall produce outputs on demand and at pre-set time and shall provide the "snap-shot" function.

The CTS reports shall be printed by a laser printer or equivalent and alarms shall be printed by a printer. The printer shall be also capable of printing the CTS reports as a back-up. One (1) back-up display and back-up printer shall be provided.

4.7.2.5 Trim and List Gauge

A list and trim gauge shall be fitted in the CCR and shall have an accuracy of less than ±0.5% for full span. And it shall be interfaced with the custody transfer system. The measurement of list and trim shall be conducted to the nearest zero decimal zero one(0.01) degree.

4.7.3 Cargo Containment System

In addition to the above system, the following system shall be fitted.

4.7.3.1 Level

An independent very high level alarm system shall be provided for each cargo tank. The system shall operate the emergency shut-down (ESD) to prevent the overflow of LNG.

4.7.3.2 Pressure

An independent pressure alarm and indicating system for the cargo tanks shall be fitted in the CCR.

4.7.3.3 Temperature

A temperature alarm and indicating system shall be provided to monitor cargo system, void spaces, insulation barriers and inner hull steel's temperature in the CCR.

4.7.3.4 Void and Insulation Space Instrumentation

Each insulation space shall be fitted with two (2) liquid sensors of different type in order to detect the leakage from cargo or ballast tanks.

4.7.3.5 Emergency Shut Down System

The ship/shore connections shall be compatible with all the system provided by the loading and discharging terminals.

Three(3) different types of ESDs shall be provided, namely an optical fibre system, intrinsically safe electrical system and a pneumatic system.

Actuators for emergency shut-down valves shall be of a single acting type with its own accumulators (reserve chamber) for constant closing time characteristic. The closing time of the ESD valves shall not exceed 30 seconds.

The emergency shutdown system shall be completely independent of the IAS control and alarm system. Each component of the emergency shut-down system shall be designed that any fault will result in a "fail-safe" condition for the whole system on the vessel. The system shall be complied with the IGC code and the latest SIGTTO recommendations.

The ESD system shall be fed from a UPS.

4.7.3.6 Tank Protection system

A tank protection system suitable for the containment system shall be provided.

4.7.4 Gas Detection System

4.7.4.1 General

A gas detection and alarm system shall be provided to detect cargo gas leakage. Regarding the gas detection, three areas shall be considered:

- Cargo area
- Engine room
- Accommodation space

The gas detection indication panel for the above-mentioned points shall be provided in the CCR and each repeater panel shall be provided at wheelhouse & ECR and also interfaced with the IAS.

Sampling points shall be provided as per chapter 13 of the IGC code. The sampling system shall be fitted with filters and moisture traps to protect the analyzer. The analyzer shall be the infrared type.

In addition to the above, a catalytic combustion type system shall be installed to monitor the following locations in principle (the final number and location shall be subject to owner's approval):

- Entrance lobbies port and st'bd on cargo control room deck
- Entrance lobbies port and st'bd on the upper deck
- Gas analyzer cabinet
- Ventilation intakes to the accommodation and machinery spaces, etc.

4.7.4.2 Cargo Area

The locations of sampling points shall be as follows:

- Under deck passages
- Double bottom passages
- Cargo machinery room
- Cargo motor room
- Air locks
- Vent masts
- Degassing tank with steam separator
- Primary insulation spaces
- Secondary insulation spaces
- Liquid dome void space etc.

Detection type: Infrared gas detection

The final numbers and locations of sampling points shall be subject to mutual agreement between the owner and the builder.

4.7.4.3 Engine Room

The locations of the sampling points shall be as follows:

- Fuel gas pipe to main engine(s) and dual fuel diesel generator engines
- Gas valve unit room including valve unit for gas combustion unit
- Gas combustion unit, if fitted
- Inert gas line after dryer, etc.

Detection type: Infrared gas detection

In addition to the above, several points shall be provided in the engine room (catalytic combustion type gas detection).

When flammable gas concentration in fuel gas main pipe ducts and a gas valve unit room exceeds a predetermined limit, fuel gas supply to the engine room shall be automatically shut down.

The final numbers and locations of sampling point shall be subject to mutual agreement between the owner and the builder.

4.7.4.4 Accommodation space

The locations of sampling points shall be as follows:

- Public space
- Control space
- Passage space
- Catering space
- Fresh air intake for air condition unit and E/R fan unit
- Emergency generator room
- Accommodation entrance, etc.

4.7.5 Mooring Tension Monitoring and Alarm System

One(1) or two(2) complete tension monitoring and alarm system shall be provided for all mooring wires to meet the loading and discharging terminals. The system shall be compatible with the fiber

optical communication system. The monitor(s) shall be installed in the CCR.

4.7.6 Loading Computer

Approved one(1) on-line loading computer and printer, which gives accurate information at any selected distribution of cargo, ballast, bunkers, etc., on longitudinal bending moment and shear forces at multiple points of trim, weight and GM values, shall be provided. The loading computer and printer shall be interfaced with the IAS.

4.7.7 Draft Gauges

The four(4) position remote draft gauges, which consist of magnetic or electric resistance type sensors, shall be fitted with digital display in the CCR and wheelhouse.

The following drafts shall be read:

- Extreme aftward
- Midship port
- Midship starboard
- Extreme forward

Indicators shall have an accuracy of ±25 mm and shall be calibrated in the same units as the draft makers.

4.7.8 Measurement of BOR

After delivery of the vessel, the builder shall calculate the actual BOG rate in the specified condition and then its results shall be calibrated in order to meet the design condition. The results of BOR calculation shall be submitted to the owner under the shipbuilding contract.

4.7.9 Portable Instrument

The following portable instruments shall be supplied to the vessel as follows (as a minimum):

- Two (2) CO_2 Analyzers
- Two (2) CO Detectors
- Three (3) Oxygen Analyzers
- Three (3) Combustible gas detectors
- Three (3) Dew point meters
- Three (3) CH_4 detectors
- Two (2) H_2S detectors, etc.

5 Machinery System

5.1 General

The vessel shall be diesel mechanical powered ship with a single or twin screws, which shall achieve high fuel efficiency at all loads and under all operating conditions.

The service speed at the design fully loaded condition with 20% sea margin shall not be less than 19.5 knots at NCR.

The required fuel gas shall be supplied to fulfill the power demand by main engine(s) and dual fuel generator engines at 100 % MCR.

The plant and machinery shall be designed to handle and efficiently operate with the following grades of fuels unless special requirements of main engine(s) and dual fuel diesel generator engine makers:

- ISO 8217 Fuel Standard; 2012 International Standard for Marine Distillate Fuels

5.2 Propulsion Unit

5.2.1 Main Engine

Fuel gas shall be always injected under the combustion condition of the pilot fuel oil. For this reason, a fuel valve for pilot combustion and a gas injection valve for gas combustion shall be provided on the cylinder cover. The gas shall be led to the gas injection with the gas pressure raised to 250-300 bar by a high pressure compressor or high pressure pump including high pressure vaporizer, etc.

For fuel oil, the opening/closing of valve is to be controlled according to the injection pressure of the fuel oil, but the opening/closing of the gas injection valve is to be controlled by the hydraulic oil.

To prevent gas at high pressure from mixing with the control oil during the time when the valve is closed, sealing oil is to be filled in the clearance of the spindle, and the pressure is to be set to higher by about 25-50 bar than the gas pressure.

A sealing with good durability against high temperature and gases shall be provided between the gas injection valve and the cylinder cover to prevent gas leakage from the mounting part of the valve.

One(1) or two(2) main engines shall be capable of running on variable quantities of cargo boil off gas(BOG) with minimum pilot fuel oil consumption. The pilot fuel shall be H.F.O or M.D.O or M.G.O, and the engines shall be capable of running at full rated power while consuming BOG. The engine must be capable of achieving a bumpless transfer from gas to fuel oil in the event of the gas supply failure.

Main engine(s) and dual fuel diesel generator engines are to be fully compliant with MARPOL Annex VI Reg. 13, Reg. 14 and the NO_x Technical Code. Also, attention should be given to any Flag State requirements, i.e USCG 46 CFR, Regulation 154.705(C).

5.3 Shafting and Propeller

The entire rotating system including main engine(s), shafting(s) and propeller(s) shall be designed so as to avoid serious torsional vibration and other undue vibration throughout the operating range except critical range.

Each one (1) spare propeller and one (1) spare propeller shaft are to be provided.

5.3.1 Shafting

Shafting shall be designed to enable propeller shaft(s) to be withdrawn inboard.

An earthing device with indicators for current and voltage shall be fitted to the shaft. The shafting shall comply with the requirements of Classification Society that permits ten (10) years operation without the necessity of withdrawing the stern shaft.

The flanges of shaft(s) are to be connected with reamer bolts & nuts or hydraulically tensioned coupling bolts. Propeller shaft(s) shall be withdrawn inboard by removing intermediate shafts. A lifting beam, geared trolley, etc. for withdrawing shaft(s) shall be provided.

Thrust block(s) shall be provided with a sight glass on the lubrication oil outlet flow.

Bearings of intermediate shafts shall be a lubricated white metal, tilting pad type. They are cooled by the central fresh water-cooling system, if cooling is required. The shaft bearing seating should be designed to have weighing devices for measuring the bearing loads.

5.3.2 Stern Tube

A stern tube bearing shall consist of two (2) cast iron bearing bushes lined with non-metallic synthetic bearing materials. They shall be oil-lubricated with a forced circulating system and fitted with leak detection and drain tank for the inboard and outboard ends.

Stern tube seals shall be of a radial type with either an air seal or an additional gravity head tank. The tank shall cover normal operational draught ranges, which allows an optional low head to be set to prevent external contamination when operating in ports and coastal waters.

A fabricated steel rope guard shall be provided between the after end of stern boss and propeller hub, and a net protector and rope cutter shall be provided.

The seal casing and the aft seal shall be designed to allow the replacement of sealing rings without

removing shafting and propellers. A spacer shall be provided. Stern tube bearing monitoring system shall be duplicated and fully redundant.

5.3.3 Propeller

Propeller(s) shall be of a solid, wet-fit keyless and nickel aluminum bronze type with hydraulic nuts. The propeller is to be designed in conjunction with analysis of propulsion efficiency, cavitations and vibration to the hull's structure and machinery.

Propeller(s) shall conform to ISO/484/1 (1981) Class I with regard to static balancing and Class S with regard to manufacturing and surface finish.

Propeller(s) withdrawal shall be possible without removal of rudder(s) and tail shaft(s).

5.4 Electric Generating Plant

The electric generating plant is to consist of three (3) or four (4) diesel generators in engine room and one (1) emergency diesel generator in emergency generator room.

Each diesel generators of equal capacity shall be provided. Each diesel generator shall have a sufficient capacity for supplying the electric power required at normal operating condition.

One (1) emergency generator shall be provided and located outside of the engine room.

5.4.1 Diesel Generator Engine

The dual fuel diesel generator engine shall be a 4-stroke cycle turbocharged engine, single acting, solid injection, trunk piston, forced lubricated, fresh water cooled, compressed air start, direct coupled to its generator. The engine shall have a self contained jacket cooling system and lubricating oil system served from engine room by fresh water cooling system. The dual fuel diesel generator engines shall be fully compliant with MARPOL Annex VI Regulation 13 and the NOx Technical Code. The dual fuel diesel generator engines shall be capable of automatically starting from cold, run-up and load share with other generators.

5.4.2 Generator

Generators shall be of a brush-less, synchronous type and shall be run at constant speed.

5.4.3 Emergency Generator

An emergency generator shall be rated for continuous operation and be capable of performing the following duties:

- To start one diesel generator engine

- To supply electric power to the equipment requested by SOLAS amendments and one (1) motor driving L.O pump and one (1) cargo pump

The emergency generator engine is to be stopped automatically after five (5) minutes of normal source recovery. The cooling and lubricating system are to be completely self-contained. The generator is to be fitted space heater.

Two (2) starting devices are to be provided. Starting and running are to be totally independent of any electric supply.

A diesel oil storage tank for the emergency generator engine shall have a sufficient capacity to run it at the full load for 24 hours.

5.5 Lubrication System

5.5.1 Machinery Lubricating Oil System

The main engine(s) and dual fuel diesel generator engine(s) shall be provided with an independent self-contained lubricating oil system with a circulating sump tank arranged. Lubricating oil circulation system shall be arranged according to maker's standard. One complete spare pump per ship shall be supplied and carried onboard.

The main lubricating oil system for main engine(s) shall be provided with two (2) duty electrically driven pumps of 100% capacity each, one running and one standby.

Lubricating oil storage tanks having sufficient capacity shall be provided for main engine(s) and dual fuel diesel generator engines and for main shaft bearings, thrust bearings.

All electric driven pumps shall have mechanical seals and be arranged for the automatic start of a standby pump in case of the failure of a running pump or low lub. oil pressure.

Fresh water-cooled lubricating oil cooler(s) for main engine(s) shall be provided. The capacity of the cooler is to be sufficient for the MCR loads at a sea temperature of 33ºC plus a 20% fouling margin.

Automatic back flushing filter(s) for main engine(s) shall be to be provided according to manufacturer's standard.

Lubrication system for main engine(s) shall be fitted with replaceable duplex filters. Automatic back flushing filters shall be fitted with differential pressure gauges and with alarms to indicate high differential pressure.

Each dual fuel diesel generator engine shall have its own lub. oil system consisting of engine

driven lub. oil pump, lub. oil cooler and electric driven priming pump according to engine manufacturer's standards.

5.5.2 Purification

Piping and storage tanks shall be arranged in accordance with the engine maker's recommendations about lubricating oil quality suitable for all conditions of main engine(s) and dual fuel diesel generator engines.

One (1) lubricating oil purifier (100% capacity) per dual fuel generator diesel engines shall be provided for continuous operation. Each purifier shall be sized to treat seven(7) times the sump lubricating oil quantity per day.

Purifiers shall be of an automatic self-cleaning type and shall be equipped with steam heated lubricating oil heaters.

Lubricating oil purifiers shall be inter-connected. Purifiers shall be installed in the purifier room(s).

5.6 Fuel System

5.6.1 Fuel Oil Tank

The following fuel oil tanks shall be provided. H.F.O service tanks shall be connected by crossovers. Each service tank (H.F.O, Low sulfur M.G.O, M.D.O & M.G.O) shall be able to supply to main engine(s) and dual fuel diesel generator engines.

Tanks shall be fitted with level and temperature monitoring devices and incorporated into the IAS with digitalized indication on the CCR.

5.6.1.1 H.F.O Tank

Two (2) settling tanks having at least a capacity corresponding to two (2) days consumption at NCR without using BOG shall be provided.

Two (2) service tanks having at least a capacity corresponding to two (2) days consumption at NCR without using BOG shall be provided.

One (1) service and one (1) settling tank shall be installed on each side (Port & Stbd) of the engine room.

5.6.1.2 Low Sulfur M.G.O Tank

Two (2) settling tanks and two (2) service tanks having sufficient capacity for operation in areas with low sulfur exhaust gas limits shall be provided.

One (1) service and one (1) settling tank shall be installed on each side (Port & Stbd) of the engine room.

5.6.1.3 M.G.O Tank

One(1) storage tank and two(2) service tanks having sufficient capacity for main engine(s), dual fuel diesel generator engines, IGG, GCU, etc. shall be provided.

5.6.1.4 M.D.O Tank

One(1) storage tank and one(1) service tank having at least a capacity corresponding to two(2) days consumption at NCR without using BOG shall be provided.

5.6.1.5 Oil Transfer System

Two(2) sets of H.F.O transfer pumps also operable for low sulfur H.F.O, one(1) pump for L.S.M.G.O, one(1) pump for M.G.O and one(1) pump for M.D.O shall be installed. The transfer pumps for L.S.M.G.O, M.G.O and M.D.O are to be interchangeable.

Transfer pumps shall be connected so as to transfer fuel oil between tanks to and from any of the tanks to the ship's manifold amidships.

A simplex strainer shall be fitted to the suction of pumps. Suitable means of preventing overflow shall be provided to each storage, settling and service tank.

Fuel oil for an emergency generator engine shall be supplied from a fuel tank in the engine room to a fuel tank of the emergency generator engine via transfer pump(s).

The means of gas oil transfer to an inert gas generator fuel tank and a gas combustion unit, if fitted, shall be provided.

5.6.2 Fuel Oil Supply and Treatment System

5.6.2.1 H.F.O System

Fuel oil heaters, pumps and purifiers shall be provided for handling H.F.O and installed in the purifier room.

Two(2) sets of fuel oil purifiers, each having 100 % capacity, shall be provided.

Purifiers shall be of an automatic self-cleaning type and shall be equipped with steam heated fuel oil heaters.

Fuel oil heaters shall be designed including 20% fouling margin.

All flanged joints in fuel oil piping shall be shielded. Piping arrangement in addition to standard

practices shall facilitate one fuel oil purifier to re-circulate the service tank while the other fuel oil purifier transfers heavy fuel oil from the settling tank to the service tank. Purifiers shall be also able to be operated in parallel at reduced capacity.

Two (2) sets of fuel oil supply units including heaters (100% capacity) to each main engine(s), dual fuel diesel generator engines and auxiliary boilers shall be provided. In addition, electric panels to control them shall be provided near the modules.

5.6.2.2 Low Sulfur M.G.O System

Two(2) sets of L.S.M.G.O/M.G.O purifiers, each having 100 % capacity, shall be provided and shall be of an automatic self-cleaning type.

All flanged joints in L.S.M.G.O/M.G.O piping shall be shielded. Piping arrangement in addition to standard practices shall facilitate one L.S.M.G.O/M.G.O purifier to re-circulate the service tank while the other purifier transfers L.S.M.G.O/M.G.O from the settling tank to the service tank. Purifiers shall be also able to be operated in parallel at reduced capacity.

Two (2) sets of low sulfur M.G.O supply units including coolers or chillers (100% capacity) to each main engine(s), dual fuel diesel generator engines and auxiliary boilers shall be provided in case required by the manufacturers' recommendations. In addition, electric panels to control them shall be provided near the modules.

5.6.2.3 M.D.O System

Marine diesel oil storage and purification system may be able to supply M.D.O to main engine(s), dual fuel diesel generator engines and auxiliary boilers with fuel complying with the engine manufacturer's recommendations.

Marine diesel oil storage tanks may be equipped at the aft bottom part with a well collecting the settled water, a drain cock for water extraction and with engine suction sufficiently above purifiers' suctions.

One(1) marine diesel oil purifier may be provided for continuous operation.

5.6.2.4 Purifier Room

Purifier room(s) shall be provided with independent fire alarms and the remote shut-down system. The arrangement of the room(s) shall be readily accessible for maintenance and the reduction of fire risk.

Purifier room(s) shall be fitted with a steel work bench with stainless steel wash basin, tool crack, vice and over head I-beam trolley, etc. for cleaning and repairing of purifiers.

All purifiers shall be in the purifier room.

5.6.3 Emission Control System

Emission control system for complying with MARPOL Annex VI Reg. 13, Reg. 14 and the NOx Technical Code shall be provided, if required. Such system shall be controlled and monitored from the IAS system with appropriate safety devices.

5.6.4 Fuel Gas Supply System

The capability of fuel gas supply system (FGSS) shall be sufficient to handle the maximum anticipated fuel gas required to run all available main engine(s) and dual fuel diesel generator engines.

5.6.5 Fuel System Monitoring and Control

Permanently installed flow meters shall display the quantity of fuel oil and fuel gas consumed for each main engine(s) and dual fuel diesel generator engines independently with both local indication and remote display on the IAS.

Gas flow measurement shall be in mass (kg) units with automatic compensation for variations in temperature, pressure and calorific value.

Positive displacement meters, both local indication and remote display on the IAS, shall be provided for recording fuel oil and fuel gas flow with compensation to make up for re-circulation flows.

Pulse outputs from the flow meters shall be provided for the accurate remote readings of fuel oil and fuel gas flows with input into the IAS and the ship performance monitor.

5.7 Air System

5.7.1 Starting Air System

Two (2) electric driven, air cooled starting air compressors of 100% capacity and two (2) of main receivers shall be provided in the engine room.

The electric power for one (1) main compressor will be supplied through the emergency switchboard. Furthermore, one (1) small manually started diesel engine driven emergency starting air compressor and one (1) starting air receiver for the emergency diesel generator shall be provided.

5.7.2 Control Air System

Two(2) control air compressors shall be installed and shall discharge air to the control air receiver.

One(1) control air dryer for machinery space and two(2) control air dryers for cargo area shall be

provided. The air quality shall comply with ISO Standard 8573-1 Class 2.

5.7.3 Service Air System

Two(2) service air compressors shall be installed. The compressors shall discharge 0.8 MPa pressure of air to the service air receiver.

For dry-dock, the control air system shall have an emergency supply from the starting air system through a pressure reducer.

A cross-over with a valve shall be fitted between the control and service air receivers' inlets and outlets.

5.8 Cooling Water System

5.8.1 Sea Water Cooling System

The sea water system shall consist of sea chests and a crossover provided with filters and stainless steel strainers.

Three(3) sea chests with crossover piping shall be provided. Two(2) low sea chests are installed at st'bd and port side. One(1) high sea chest, which is approximately 2m below harbor loading /unloading draught, is preferably installed at st'bd side.

All main valves shall be of butterfly type, remotely actuated and manually operated. Each sea water filter shall have an inlet valve and an outlet valve.

All sea chests shall have hinged protecting grids with fastening system which allow underwater cleaning and inspection by divers.

A MGPS(Marine growth prevention system) shall be provided for all sea chests and connected pipe system except for the evaporator seawater system and its sea suctions.

Three (3) main cooling water pumps of 50% capacity each shall serve the main seawater cooling system. This system shall supply cooling seawater to the two (2) main freshwater coolers of the centralized cooling water system. The capacity of each freshwater cooler shall have 100% capacity including 20% fouling margin. On sea water side, the two (2) main coolers shall be equipped with additional connections for cooling during dry-docks.

Heat Exchangers:

The fouling margin shall be as follows ;

- Tubular type : 20 %
- Plate type : 20%

The design temperature shall be as follows ;

- Sea water : 33℃
- Fresh water : 38℃

5.8.2 Fresh Water Cooling System

All cooling system shall be fresh water cooled except as otherwise specified.

A centralized freshwater cooling system with high and low temperature circuits shall be provided. Each circuit shall include two(2) cooling water pumps, one for normal operation and one for the back-up.

The pre-heating heaters of main engine(s) and dual fuel diesel generator engines shall be of steam heating type.

5.8.3 Dry Dock Water Cooling

In dry dock, the following equipment shall be operational.

- One(1) dual fuel diesel generator engine
- Refrigerating plant for cold room
- One(1) service air compressor
- One N_2 generator compressor
- Air conditioning plant for
  - Engine control room
  - Main switchboard room
  - IAS main cabinet rooms and their UPS
  - Technical room containing the transitional source UPS;
  - Etc.

For this purpose a specific water cooling shall be arranged. It shall be either based on a fresh water circulation between fresh water piping and a fresh water tank (Aft peak, etc) or by a suitable sized sea water supply connected to the cooling sea water piping.

5.8.4 Distilled and Domestic Water System

The distillation plant shall consist of two(2) vacuum type fresh water generators of equal capacity, each of a minimum of 20 tonnes per day. Under these conditions, the salinity at rated output shall not exceed 4 ppm and a probe type salinity detector shall provided.

The main heating medium shall be cooling fresh water of main engine(s) and dual fuel diesel generator engines' cooling. Chemical dosage equipment shall be fitted to both units.

Piping from each distillation plant shall be separately arranged to domestic fresh water tanks so as to fill tanks independently. A U.V sterilizer shall be provided in the line to the domestic water tanks also a mineral injection system shall be provided.

A combined sanitary and fresh water supply system shall be provided. Water services shall be divided into the necessary sections to suit the accommodation arrangement. All domestic piping materials shall be copper or PVC.

The hot water system, which will be a circulation loop, shall have two sets of electric heating elements. Two hot water circulating pumps, each 100% of the required capacity, shall be fitted in the return line of the loop.

5.9 Aux. Steam Boilers and Auxiliary Heating Requirements

The steam generating plant shall be complete with fuel oil supply pumps, feed water pumps, supply and circulating pumps, steam traps, condensate drain coolers, condensate collecting/observation tank, oil content monitoring, boiler water treatment and all further necessary equipment.

They shall be sized to provide sufficient heating for each condition of the cargo & machinery system operation as follows:

- Low and high duty gas heater
- Forcing vaporizer
- LNG vaporizer
- Glycol heater
- Dual fuel diesel generator engines pre-heating
- Fuel & lubricating oil system tanks heating and treatment
- H.F.O storage tanks and lines (steam tracing)
- Engine room bilge & sludge tank heating and treatment
- Accommodation heating, etc.

The exhaust gas recovery boilers shall be protected against explosion in exhaust gas pipes.

5.10 Machinery Space Ventilation

Mechanical supply ventilation system for the engine room shall be provided and designed in accordance with ISO Standard ‘ISO 8861 Shipbuilding – Engine room ventilation in diesel engine ships – Design requirement and basis of calculation (1998(E))’.

Fans will be vertical axial type directly electrically driven by totally enclosed motors, two(2) speeds, installed on hinged maintenance doors. Exhaust fans, if combined with gas piping system, will be explosion proof type.

At least four (4) supply fans and two (2) exhaust fans shall be supplied for the engine room. Even if one (1) of any engine room fans is out of order, the operation of main engine(s) and dual fuel diesel generator engines will be possible at MCR.

A steering gear room, purifier room, bow thruster room, inert gas generator room(if fitted), GVU room and paint store shall have independent ventilation.

All ducts and inlets shall be fitted with remote and local control fire dampers.

5.11 Incinerator

An incinerator of the continuous feed type shall be provided which shall be capable of incinerating within 4 hours all domestic and engine room solid waste (including plastics) produced over 3 days by 40 persons. One (1) incinerator with a burner shall be provided and installed and the sludge burning process shall be fully automatic.

The incinerator shall be located in a dedicated enclosed compartment with fire detection and a fixed fire fighting installation.

5.12 Engine Room Bilge System

5.12.1 Bilge Water Treatment

One (1) bilge water transfer pump shall be provided with alarm for long running to transfer bilge content to bilge holding tank.

One (1) bilge water transfer pump shall be provided to transfer between:

- Clean bilge water tank to bilge holding tank
- Bilge holding tank to clean bilge water tank
- Bilge holding tank and clean bilge water tanks to bilge water shore connection, etc.

One (1) bilge holding tank with heating coils shall be provided. The capacity of bilge holding tank shall be about 100 m^3.

One (1) oily water separator including an oily separator pump shall be provided to manage bilge water before overboard discharge. The overboard discharge shall be monitored by an oil content sensor complying with IMO Resolution MEPC.107(49).

An emergency bilge suction shall be fitted to the largest capacity sea water pump in the engine room.

5.12.2 Sludge Treatment

Sludge tank(s) shall be provided with a heating coil. Sludge tank(s) collect the sludge from lubricating oil and fuel oil purifiers, from main engine(s) and dual fuel diesel generator engines and from various drip trays, etc.

A sludge pump having sufficient capacity shall be provided. The sludge pump shall be able to transfer sludge between:

- Sludge tank to sludge shore connection
- Sludge tank to waste oil settling tank
- Oily bilge tank to sludge shore connection, etc.

5.13 Gray Water System

A gray water tank having a sufficient capacity to store gray water in accordance with the latest regulation of US Environmental Protection Agency Vessel General Permit(US EPA VGP) shall be provided.

5.14 Sewage Unit

A fully automatic biological type of sewage treatment plant for black water from the water closet and urinal shall be provided for all persons onboard. The sewage treatment plant is to be fitted with two (2) discharge pumps and two (2) blowers according to the maker's standard.

The vacuum toilet system shall be provided. The sewage collection tank shall be provided with sufficient storage capacity(at least 10 days capacity).

5.15 Workshop & Stores

The following workshop and stores shall be provided:

Main Engineering Workshop.

The workshop shall be air conditioned and sound-proofed. It is to be provided with the following equipment:

- Benches with three 150 mm and two 100 mm vices, racking system for tools, and cupboards and drawers for ready use materials
- High quality engineer's tools and measuring / calibration equipment
- Joint punching machine / table
- Consumable stores for a six month period
- One lathe, length between centre 2000 mm and height of centre 300 mm
- Combination multi-purpose boring milling machine with all necessary accessories and cutting tools
- Shaping machine with 600 mm ram stroke
- Pedestal drilling machine with the necessary chucks and drills up to 50 mm
- 16 mm bench drilling machine with the necessary chucks and drills up to the maximum size
- Twenty tone hydraulic press
- Pipe bending machine up to ND 100mm capacity. Pipe threading machine with all accessories

- Sawing machine with 150 mm stroke capable of cutting 200 mm round bar and 200 x 200 mm square bar. Spare blades shall be supplied
- Pedestal grinder to take 300 mm diameter wheels with a spare set of grinding wheels
- Induction type bearing heater, etc.

All machines must be fitted with adjustable guards of substantial construction (and the required safety interlocks) to protect cutting tools and rotating parts. An emergency stop shall be fitted to each machine and a general trip system for all machines shall be installed with push buttons at four strategic locations in the workshop including at each entrance doorway.

Lifting equipment storage area

The Engineer's workshop shall incorporate a dedicated area for the storage of lifting equipment.

Hot Work area

The main engineering workshop shall incorporate a shielded welding bay provided with the following equipment:

- Oxy-acetylene (bottles outside the engine room) welding equipment with all accessories, cabinet of welding tools and spare gas bottles
- Two welding machines
- Plasma cutting torch and gas supply, etc.

The welding bay shall be protected by a fire detector that can be isolated by a bulkhead mounted timer switch. High capacity exhaust fans shall be fitted for the welding bay.

Diesel Engine Machinery workshop.

This workshop shall be soundproofed and air conditioned. It shall be conveniently located for the main diesel machinery rooms and contain the following equipment:

- Benches with three 150 mm and two 100 mm vices, racking system for tools, and cupboards and drawers for ready use materials
- High quality engineer's tools and measuring / calibration equipment
- Joint punching machine / table
- 16 mm bench drilling machine with the necessary chucks and drills up to the maximum size
- Pedestal grinder to take 300 mm diameter wheels with a spare set of grinding wheels
- Diesel fuel valve test injection equipment
- Diesel exhaust valve grinding equipment

- Lifting points and crane(s) required to facilitate the overhaul of engine components
- All main engine tools and lifting equipment
- All main engine machinery stands – as applicable, etc.

The workshop shall be sufficiently spacious to facilitate the overhaul of one complete engine.

Fuel Oil, Lub Oil and water test laboratory

The water test laboratory shall be integral with the engine control room.
Laboratory for diesel engine fuel, lubricating oil and cooling water analysis shall be fully equipped with all equipment and consumables needed for six months operation.

Electrical and Instrumentation Workshop.

A separate workshop shall be provided for electrical work and shall incorporate an area for instrumentation and electronic maintenance and testing, fully equipped with all the necessary equipment. Pneumatic test and calibration equipment shall be provided.
The workshop shall be air conditioned and sound-proofed.

Maintenance Access

Main and auxiliary machinery, including pumps and steering machinery shall be served by a lifting rail system which will allow the items of machinery to be removed from the machinery spaces to be transported to the engineer's workshop. The system will also allow for the lifting of spare parts and equipment from respective stores spaces.

Where it is necessary to transfer an item of machinery from one rail system to another the adjacent walkway shall be designed to withstand the weight of the relevant item of machinery.

Suitably rated and certified lifting eyes shall be fitted (welded) above all major machinery, including heat exchangers, to allow overhaul and lifting. All lifting points shall be load tested and provided with certification.

Stores

General store rooms shall be provided for paint, chemicals, lubricating oils and greases as outlined in chapter 3.

Spare gear stores shall be provided as follows:

Machinery Spare Gear – this store shall be within the main machinery space and enclosed by solid bulkheads. It is to be well lit and ventilated.

Cargo system spare gear - this store shall be within the main machinery space and enclosed by solid bulkheads. It is to be well lit and ventilated.

Electrical Spare Gear – this store shall be within the main machinery space and enclosed by solid bulkheads. It is to be well lit and ventilated.

Electronic Spare Gear – this store shall be enclosed by solid bulkheads and air conditioned. It may be located within the accommodation.

Where practicable, spare electrical motors are to be stored in the Electrical Spare gear store. A permanently installed low voltage motor heating system shall be provided and each spare motor connected to it.

A materials stock storage area shall be provided in a location considerate to the engineer's workshop. The storage area shall be constructed to provide safe storage for pipes, bars, angle iron and flat plates. Safe means of securing and lifting shall be provided.

All storage rooms shall be provided with locks to prevent unauthorised access.

6 Instrumentation and Control

6.1 General

This specification of instrument and control equipment shall be equally applied to machinery and cargo system. All materials and equipment shall be of the highest quality and shall have been suitably proven for marine application on board LNG vessels for unrestricted service.

Particular care shall be taken with instrumentation, control equipment and associated equipment to ensure that they will be resistant to corrosion, independent of protective coatings. This shall include casings, supports and fixing arrangement.

All instrumentation and control system shall be of design on a fully modular concept incorporating the minimum number of different types of standard modules approved by Classification Society. This standardization shall be for both cargo and machinery system.

There shall be one focal point of responsibility for design, installation and commissioning of instrumentation and control equipment for both cargo and machinery system. The supplier should be the responsible focal point.

Shutdown system shall be independent of control and alarm system. Each component of a shutdown system shall be designed that any fault will make the fail-safe condition for the system and the vessel wholly.

The design of control system shall allow automatic operation of the plant across the full operating ranges with their variable set values. All control loops shall be capable of being manually operated from manual/automatic stations.

The test and maintenance on instruments and system with isolation, venting and function test equipment shall be capable of being carried out by vessel’s crews.

Electronic analogue measurement and control system shall have a signal operating range of 4 to 20 mA or DC 1-5 V in general.

Where running and stand-by electric pumps are fitted, both pumps shall be available for either duty.

The design of control system shall allow the unattended operation of the vessel at sea, in manoeuvring and in port. Remote control from the IAS shall be also capable of local manual control in general. The monitoring system shall enable one(1) man to monitor the all operation.

The system integrator shall provide training for operators and maintainers prior to the ship’s delivery. A Failure Mode and Effects Analysis (FMEA) shall be performed by the system’s expert on the IAS and the results shall be presented to the owner for approval.

All equipment on board shall be correctly name-tagged.

6.2 Instruments

The accuracy of all instruments shall be in accordance with the ISO standards or equivalent and shall fulfil the following:

- Pressure ± 0.75% of spot reading
- Temperature ± 0.75% for thermocouples
  ± 3% for resistance temperature detectors
- Level ± 25 mm unless otherwise specified
- Flow ± 1.5% unless otherwise specified
- Controllers/Receivers ± 2% of set point(steady state) or better within the following environmental conditions:
  - Operating temperature 20-55 ℃ Controlled environment
    10-55 ℃ Machinery space
    -25 ℃ to 70 ℃ Open deck
  - Humidity 95%
  - Vibration to comply with IEC60092-504 requirements
  - Vessel motion ± 22.5°, 10 sec. rolling period
  - Electric power supply :
    Voltage ± 10 % nominal
    Frequency ± 5 % nominal
    Air or oil supply ± 15 % nominal

The test cock or 3-way valves shall be fitted for pressure/differential pressure transmitters and pressure switches for test and maintenance.

The test and calibration equipment shall be provided for the vessel.

Complete thermometers with thermometer pockets, pressure gauges, flow indicators, isolating valves, vents and test cocks, etc. shall be provided to check all instruments and alarm sensors.

Transmitters and local controllers shall be mounted near the measuring point.

6.3 Cargo Control Room(CCR), Engine Control Room(ECR) and Wheel House(W/H)

Three(3) main control centres shall be provided; Cargo Control Room(CCR), Engine Control Room(ECR) and Wheelhouse(W/H). These centres shall be provided with air conditioning system and insulation against noise.

All control, operation, monitoring and alarm functions of the IAS shall be arranged in the cargo control room(CCR), the engine control room(ECR) and the wheelhouse(W/H).

6.4 Integrated Automation System (IAS)

The IAS system shall be of the latest microprocessor based on utilising VDU's and distributed field processors. The communication shall be based on dual redundant network and shall be provided with automatic changeover in the event of failure. The distributed field processors shall be segregated into sub-systems (i.e. cargo, ballast, auxiliary machinery etc.). Interface to sub-systems shall as far as possible not be mixed within one distributed field processor.

The emergency shutdown system shall be independent by dedicated local control station. Full monitoring and maintenance shall be done from IAS by utilizing same basic hardware and software as IAS. The system shall not be dependent on IAS workstations for normal operation, but data logging, maintenance and monitoring shall be done from IAS. The system shall discriminate different causes of shutdown and shall indicate the cause of shutdown until manually reset. Presentation of the emergency shutdown system shall be based on online Cause & Effect. These online Causes & Effects charts shall be dynamic:
From this online C&E, it shall be possible to force inputs and outputs, provided that operator has the proper login level.
This C&E shall indicate in different colors signals that are activated, inhibited, in normal state, etc.

The data logging facilities shall be provided to continuously monitor all data necessary for safe and efficient operation of the cargo and machinery system. A print facility including the event recording shall be provided.

Machinery alarms shall initiate audible/visual alarm in the machinery spaces.

Alarm boxes shall be provided in prominent places in the machinery spaces to clearly indicate the followings:

- General alarm
- Fire alarm
- CO2
- Machinery alarm
- Telephone
- Telegraph

6.4.1 Basic Configuration

The IAS workstation shall utilize graphical displays as much as possible. Mimic diagrams shall be included for the presentation of machinery and cargo monitoring and control functions and shall

permit an overview of the status at all times. Mimic diagrams shall make consistent use of symbols, colors and graphics, which are visually representative of the equipment under control. All graphics shall be subject to the owner approval.

The status of control sequences and interlocks, the individual causes of control sequence interruptions and all trip conditions shall be indicated by the IAS and shall be available until manually acknowledged or manually reset.

Flat screen display units shall be used and shall be an integral part of the consoles (fitted on vertical sections and suitable for viewing from a standing position). The minimum viewable image size shall be 20".

The use of external discrete hardwired electromechanical relays and similar control components for interlock, sequence or signal shall be minimized.

The IAS shall provide at least the following modes of operation and an appropriate security key (password and/or key-switch) shall be included to restrict access where applicable:

- An 'operator' mode for normal operating procedures including start and stop of equipment, monitoring correct operation of sequence controls, viewing process variables, adjusting set points and alarm management.
- An 'engineer' mode to allow tuning of controllers and other plant configuration changes. Workstation duty shall be changeable in this mode, e.g., the W/H IAS workstation can be used for cargo control in an emergency.
- A 'system administrator' mode for access to critical system configuration and application data, including the ability to execute software download from system drives.

6.4.2 IAS Performance

The control system arrangement shall be that single fault or failure of the power supply will not affect the plant control. Redundancy shall be built into workstations, field processors, serial links and serial link processors. This shall be by means of hot-standby synchronized equipment including dual disk drives and processors. Standby equipment shall be monitored to ensure its availability on demand.

The control level networks shall be independently operated with workstation data communication networks.

The control system shall provide the facilities for historical data trends over selectable time scales. A screen print facility using a color printer shall be provided for each control room.

The data logging facilities shall be provided to monitor, on a continuous basis, all data necessary for safe and efficient operation of the cargo and machinery system.
A log print facility shall be included, with a facility for operator configurable logs.

6.4.3 Application Software

These requirements shall be applied to all programmable parts of the IAS including the CTS(Custody Transfer System).

In addition to statutory requirements and Classification Society requirements, the system software shall be developed in accordance with an agreed software quality plan conforming to recognized industry practices.

The software developer shall have a qualification to deal with project management system in place, addressing all activities affecting the integrity of the software from conceptual design to in-service operational support. The software quality plan shall indicate how the management system guarantees the integrity of the application software and this aspect shall be addressed in the basic design documentation provided for the owner approval.

The software quality plan shall confirm that suitable procedures are in place and shall identify those who are responsible for their application. The plan shall confirm that proposed changes are subject to appropriate risk assessment and authorization, and then completed changes are subject to verification and validation.

Application software shall undergo formal factory acceptance test according to recognized standards, in the presence of the owner, to ensure correct operation and safety. Factory acceptance test shall be carried out on a representative platform, i.e. using the same operating system and hardware type(s) which will be installed in the vessel.

Appropriate use shall be made of simulation tools to represent the behavior of the equipment being controlled during factory acceptance test in order to ensure that control algorithms are suitable for the application before any ‘live’ onboard test.

Combustion control for main engine, dual fuel diesel generator engine and burner management for auxiliary boilers shall be tested in conjunction with a verified main engine, dual fuel diesel engines and boiler simulation model provided by each manufacturer.

Functional test of software shall be additionally carried out after commissioning to confirm that interfaces (field inputs and outputs, serial communication links, etc.) are correctly configured.

The test procedure shall be prepared by the system integrator and shall be submitted to the owner for approval.

6.4.4 Extension Alarm System for Machinery System

The extension alarm system required for UMS(Unmanned management system) operation shall be integrated into the IAS and shall include group alarm information such as 'Machinery Fire', 'Machinery Critical', etc.

Extension alarm system panels shall be provided in all officer cabins and public rooms including the general office. In the case of senior officers who have more than one room, the panel shall be located adjacent to the bed with an extension buzzer in adjacent rooms.

In the event of system failure, all users shall be alerted. The extension alarm system may be started and stopped from the IAS workstation or from dedicated panels on the control room consoles.

The extension alarm system shall incorporate an intrinsically safe radio pager system for the use of the duty engineer so that an audible alarm is repeated to the pager. The working range shall include the whole of the accommodation, the main and auxiliary machinery spaces and the open deck.

6.4.5 Cargo Alarm System

The audible alarm for the cargo and ballast system shall be different in tone from that used for the machinery system.

Cargo alarms are to be provided and repeated in the W/H and public rooms including the general office during periods at sea when the CCR are unattended.

Facilities shall be provided to allow cargo alarms to be repeated in the cargo engineer's cabin. An extension buzzer for cargo alarms shall be fitted in the general office.

The cargo alarm system shall incorporate an intrinsically safe radio pager system for the use of the cargo engineer.

6.4.6 Bridge Alarms

The integrated bridge system (IBS) shall include the centralized alarm management for W/H equipment, and the bridge operations shall be used in conjunction with the IAS workstation. The IBS shall be interfaced with the IAS and arranged to support this operational concept. The system integrator shall contact with the bridge integrator to ensure that the following features are included:

- The IBS shall be the primary means of alarm handling on the W/H.
- The IAS workstation in the W/H shall be configured to eliminate unnecessary duplication of work in response to alarms.
- The IAS alarms shall be audibly signalled unless they can be acknowledged from the IBS.
- IAS alarms at the Bridge workstation shall be acknowledged and accepted from the IBS.

The cargo and machinery alarms shall be transferred to the IBS during periods when the control rooms are unattended. Critical alarms shall be individually displayed, but non-critical alarms may be allocated to the appropriate group alarms.
Extension alarm panels shall be provided in the W/H – these functions shall be integrated in the IBS.
An agreed set of bridge alarms shall be transferred from the IBS to the IAS for management at the cargo workstation when the bridge is unattended in port.

The VDU of the IAS workstation on the bridge shall be identical to those used by the IBS and shall, as far as practicable, be arranged to present the same operating interface so that all bridge operator procedures are consistent.

6.4.7 Personnel ("Patrolman") Alarm

A personnel alarm shall be provided in accordance with the requirements of Section 7 of the IMO Code on Alarms and Indicators. This alarm shall be a function of the IAS.

6.4.8 Engineers' Alarm

In addition to statutory and classification requirements, the engineers' alarm shall be actuated from pushbuttons located in the machinery space and from pushbuttons located in the ECR.
The power supply to the engineers' alarm shall be provided from an un-interruptible source.

6.4.9 General Emergency Alarm System

The 'strategic points' referred to in Reg.6.4 of SOLAS Chapter III Part C shall include the machinery control console in the ECR, the cargo control console in the CCR and the fire control station.

General alarm buzzers shall be fitted in all cabins. The power supply to the General Alarm shall be provided from an un-interruptible source.

6.5 Propulsion Control System

In addition to the Classification Society's requirements, the following shall apply:
Final approval of the propulsion control system shall be subject to a hazard and operability study (HAZOP) involving the designer, the purchaser and other relevant parties involved in its development and use. This exercise is intended to highlight operational risks inherent with the detailed design so that these can be safely and effectively managed by the relevant party.

The propulsion control system shall be single-fault tolerant with no adverse loss of functionality and no hidden failures; a preliminary FMEA shall be carried out to confirm this prior to a purchase order being placed.

The manufacturer shall provide a functional specification to assist with the above work, and this The status of control sequences and interlocks, the individual causes of control sequence shall be updated as the design progress.

The following modes of control shall be provided:

- Automatic control (by telegraph) from the Bridge and Bridge wings
- Automatic control (by telegraph) from the ECR
- Remote manual control from the ECR
- Local manual control.

The control responsibility shall be delegated from ECR to bridge and bridge wings; audible warnings shall be provided until control is accepted at the new position. The ECR shall be able to take immediate control at any time from the bridge and bridge wings, with audible warnings in those positions.

Telegraph movements shall be recorded on a dedicated bridge maneuvering printer. Each movement shall be time stamped.

Individual propulsion control system alarms shall be indicated on the IAS workstations. Group alarms are not permitted.

6.6 Fuel System Control System

Permanently installed meters shall measure fuel oil and fuel gas flow to each consumer, taking account of spill-back arrangements. The IAS shall record individual consumption levels. The specified accuracy shall be achieved across the entire measurement range.

Gas flow measurement shall be carried out by the vortex shedding method and indicated in mass units (kg) with an accuracy agreed with the purchaser.
The measurement shall be done with automatic compensation for variations in temperature and pressure including the changes of calorific value. (set at the IAS workstations).

Fuel oil flow measurement shall be the flow meter with an accuracy of ±1%.

Positive displacement meters shall be fitted.

Fuel flow meters shall be provided with both local indication and remote readout. Fuel flow shall be recorded in the IAS. Compensation shall be made for re-circulated liquid fuel flows.

Fuel oil heaters, where provided, shall be regulated by a temperature controller. The set point shall be determined by a viscosity control system using an electronic viscometer.

Fuel oil and gas flow and/ or pressure at the consumers shall be regulated to ensure that sufficient fuel is available to prevent spurious trips.

Fuel oil filters (hot and cold) shall be provided with local differential pressure gauges. Differential pressure switches shall initiate alarms in the IAS.

The IAS shall maintain fuel gas supply pressure at the distribution manifold to match fuel gas supply demand by main engine and dual fuel generator engines(s)

Operators will control the thermal oxidizer manually from the IAS in response to high cargo tank pressure.

6.7 Lubricating Oil

The IAS shall control lubricating oil temperature within ±2% of the set value.

Lubricating oil filters shall be provided with local differential pressure gauges. Differential pressure switches shall initiate alarms in the IAS.

6.8 Cooling Water

The IAS shall control temperature (and pressure where required) for all cooling water system.

6.9 LNG Vapor System

The vapor control system shall be provided and integrated into the IAS(integrated automation system).

All controller loops integrated in the IAS shall have facilities to select manual / auto control mode, set operating limit and display input / output values.

The vapor header pressure shall be automatically controlled by the following controller loops in the IAS, each of which can be independently set at desired pressure between 950 and 1,258 mbar(abs).

- Pressure control of vapor to shore (1pc)
- Pressure control of vapor to forward mast (1pc)
- Pressure control of vapor to main engine & dual fuel generator engines (2pc)
- Feed control of LNG to vaporizers (2pc)
- Press & Feed control to GCU(1pc)
- Re-liquefaction system (if necessary)

Temperature controller loops for vaporizer outlets shall be also integrated in the IAS and controlled automatically/manually with the facilities to set limit value, select auto/manual and display parameters.

The emergency shutdown system(ESD) shall be applied.

6.10 Shaft PRM Indicating System

The RPM pick-up shall be carried out on the shaft and the RPM indicator shall be provided in the following places.

- ECR
- Bridge console
- Wheel house front wall
- Each bridge wing
- Display on IAS monitors
- Captain & Chief engineer's day room
- Local EM'CY control station

6.11 Ship Performance Monitoring

Ship performance monitoring function shall be provided for the analysis of available various data in the IAS.

Ship performance monitoring function shall display present vessel's conditions and give the information to the operator to maintain optimum vessel condition.
The ship performance monitoring system shall be interfaced with the SMS(ship management system). Trend curves, bar graphs, numeric values and some instructions shall be displayed for performance monitoring. The following available data in the IAS shall be used for the performance monitoring.

<u>Ship performance</u>

- Latitude / longitude position
- Total speed log distance
- Rudder angle
- Depth of water
- Heading
- Atmosphere temperature
- Atmosphere pressure
- Relative wind speed
- Relative wind direction
- Ship speed
- Ship trim / list / draft
- Vapour vent to FWD mast
- Vapour header pressure
- Vapour temperature
- N_2 vent inlet header pressure
- N_2 vent relief header pressure

- Gas flow to main engine & dual fuel generator engines
- Gas flow to GCU, etc.

Engine performance

- Shaft power / torque
- Ship speed
- Shaft RPM
- F.O flow
- Gas flow
- F.O temp.etc.

6.12 Auxiliary Machinery Control

The essential auxiliary machinery including E/R air supply/exhaust fans for main engine(s) and duel fuel diesel generator engines shall be remotely started and stopped in the IAS.

6.13 Motor Vibration Monitoring

Fixed vibration monitoring system(s) shall be provided for the following rotating machines:

- Gas compressors
- Generator sets, etc.

The system shall:

- Continuously monitor overall vibration levels for indication, alarm and tripping, if required.
- Allow periodic plug-in measurement and recording of vibration frequencies and amplitudes for fault indication, diagnosis and survey requirements

An intrinsically safe portable data collector shall be provided for measurement of vibration data with 'Windows based data storage and analysis software' which is suitable for installation on the ship's computer network. Software shall include a facility to enable data to be transferred to the computer-based planned maintenance system. The system supplier shall be responsible for a first survey and analysis during commissioning and sea trials.

6.14 Control, Alarm and Monitoring

Control, alarm and monitoring system shall be 20" colour VDU base. The system shall be duplicated. Data high way shall be provided and duplicated.

Analogue type gauges shall be provided, if necessary.

The major equipment are as followings:

- ECR : 20” colour VDU x four(4) sets with two(2) keyboard
  14” colour VDU x two(2) sets (portable type)
  Two(2) plug and six(6) plug in E/R
- W/H and cabins (extension): 20” colour VDU x ten(10) sets
- One(1) data logger (ECR)
- One(1) alarm printer (ECR)

6.15 Shaft and Bearing Monitoring

Propeller shaft power shall be measured by a power meter with the accuracy of +/- 0.5%. The terminals, which shall be located in the ECR and on the bridge, shall display power, thrust, torque and revolutions.

The shaft power meter shall be automatically reset at zero when the shaft is stopped.

Stern tube bearing temperature sensors shall be duplicated and shall provide both analogue indication and high temperature alarm in the machinery control room.

6.16 IAS Supervisory Control

The IAS shall provide for effective supervisory control and monitoring of the electrical power generation and distribution plant without compromising PMS operation or local control/protection arrangements.

Control and monitoring shall be carried out primarily using mimic diagrams displaying the principle power schematic(s) and status of main consumers and their associated switchgear. Mimic diagrams shall be visually representative and shall include the following information:

- Running status of generators and main consumers
- Duty/standby status of auxiliary services
- Opened/closed status of circuit and bus-tie breakers
- Consumed and available power for each generator
- Total consumed and available power
- Power factor
- Supply and load currents
- Voltages at generators, switchboards and distribution boards
- Motor and transformer winding temperatures
- Running hours

Alarms shall be provided by the IAS in the event of the following electrical faults:

- High/low frequency
- High/low voltage

- Asymmetrical load sharing
- Circuit breaker trip
- Earth fault (low insulation levels)

The IAS workstations shall be used to start and stop individual consumers and open and close distribution circuit breakers provided they are not inhibited or interlocked by the PMS. The IAS shall also allow for the selection and de-selection of generators and main consumers (except propulsion motors which shall be under the control of the propulsion control system) including designation of generator running order and duty/standby status of auxiliaries as applicable.
Where a particular mode of operation requires a sequence of separate control actions, the IAS shall be used to initiate and monitor the sequence.

6.17 Shipboard Management System

A ship management system shall be provided for communications and processing of spare parts inventories, planned maintenance records, accounts and documents. This shall include a network fileserver computer, network server multiple-CD storage device, eight(8) personal computer workstations each with local printers, a network colour printer for up to A3 size documents and plans printing, data network and network gateway devices.
Gateway devices (routers) shall be provided as follows;

- For the MPDS connection to the FBB500 equipment.
- For connection to the PABX.
- For connection to the stability computer (data import only).
- For connection to the IAS (data import only).

Network cabling shall be of the structured type terminating in a rack mounted patch panel. Cable shall be ethernet twin twisted pair designed, installed and tested to CAT5E standard. Network outlets shall be provided in each cabin at each office desk, recreation rooms and at each desk in controls rooms and equipment rooms. The complete system, including hardware and Windows-based operating software, shall utilize the latest proven technology available at a date six months prior to delivery of the vessel.

The Builder shall be responsible for supply, installation and commissioning of the system including application software for systems specified elsewhere, e.g., vibration data storage and analysis, loading and stability computer etc. The Builder shall provide a spare parts inventory in a form suitable for direct electronic merging to the ship operator’s database.

The SMS shall be capable of the following :

- Spare parts inventory system linked with a maintenance management system and incorporating :
  - Equipment description and spare parts master files
  - Equipment description report
  - Spare parts status reports
  - Spare parts requisition
  - Delivery receipts
  - Spare part identification (bar code input system or equivalent)
- Maintenance management system linked to the spare parts inventory system and incorporation
  - Calendar based maintenance routines
  - Condition monitoring techniques using portable and fixed data collection equipments
  - Equipment maintenance history
  - Work order assignment
- Word processing and data filling system
- Compilation of dry-dock repair specification

The entry information shall be carried out by the builder.

The Owner shall be responsible for supply, installation, and commissioning of office type application software.

7 Electric and Navigation

7.1 General

All materials and equipment shall be of good quality and shall have been proven suitable for marine application on board vessels for unrestricted service wherever possible and shall be type approved by the Classification Society.

A single electrical philosophy and single set of standards shall be adopted throughout the installation to ensure that repair and maintenance procedures can be consistently and safely applied. Equipment design shall also be consistent, with the minimum of suppliers involved, to achieve maximum inter-changeability of components.

The electrical equipment shall be designed, constructed and installed in accordance with the IEC(International Electro-technical Commission) standards.

The type and construction of electric equipment incorporated or packed with the appliances, shall be in accordance with the manufacturer's standards.

Electrical equipment shall be located in such as way that access is ensured for maintenance and component replacement.

Electrical equipment shall be so located that they are not exposed to a risk of mechanical injury or damage from water, oil or excessive heat as far as practicable.

Electrical equipment located on the open deck outside of the hazardous areas shall, wherever possible, be of a type certified for use in Zone 2 locations as defined by IEC publication 60092-502. All control and monitoring circuits in these areas and in hazardous areas shall be of the certified intrinsically safe type. Where Zone 2 certified equipment is not available for particular applications the equipment may be of the explosion proof type subject to the approval of the Purchaser and a manufacturer’s certificate of conformity to a relevant recognized standard.

Sensitive equipment and luminaires in locations susceptible to heavy vibration and mechanical shock, including the steering gear compartment and all locations in the forward areas, shall be installed using vibration and shock absorbing mountings.

A Failure Mode and Effects Analysis (FMEA) shall be performed on the electrical power supply and distribution system, its utility system and its control system and the results shall be submitted to the Purchaser for approval. The FMEA shall be carried out to a recognized standard agreed by the Purchaser, preferably by persons not directly responsible for its design. Where a manufacturer contributes to the FMEA, a single focal point shall be responsible for ensuring that the analysis is complete and accurate.

The FMEA shall demonstrate that:

- Any single fault, when operating with more than one generator connected, and with the plant set up for normal operating conditions, shall not result in complete loss of electrical power or communications, loss of propulsion or steering, or loss of navigating capability, or cargo discharge capability, or result in other unsafe conditions.

- Any single fault, after the failure of a single connected generator and with the plant set up for normal operating conditions, shall not interrupt the recovery within 30 minutes of electrical power, communications, propulsion, steering, navigating capability, and cargo discharge capability.

- Control circuit faults, including failures of components such as relays, timers and electronic control units, shall not result in an un-safe condition or cause damage to equipment.

The FMEA report shall include worksheets and a summary of the results.
The results of the FMEA shall be verified by testing.

Proven power system analysis software packages shall be used for the determination of load flow, short circuit current, stability, protection co-ordination and harmonic analysis.

The Total Harmonic Distortion (THD) shall be satisfied with the requirement of the Classification Society. Fault current calculations for the electrical system, which shall be approved by the Classification Society, shall generally be in accordance with the recommendations of IEC 61363 or IEC 60909. The resistance of cables and transformer windings shall be included in the calculations. Balanced and unbalanced fault conditions shall be considered.

A meeting shall be arranged between the Builder, Electrical Contractor and Purchaser prior to the beginning of design work. The objective of this meeting shall confirm the scope of supply, the functional arrangements, the performance requirements, and the extent of integration with the IAS and other system. It shall also clarify the extent of testing required at makers' factories, at the shipyard and at sea trials.

The Electrical Contractor shall include in his scope of work:

- The electrical system FMEA.
- Harmonic study and filter design study.
- Neutral earthing study.
- A motor starting study.
- Fault current analysis.
- Protection and coordination study.

Total harmonic distortion shall not exceed 8% and single harmonic distortion shall not exceed 3%.

Except where otherwise approved by the Purchaser, the supplies to all equipment and control circuits shall be switched and protected in each pole.

All circuit breakers and switches on proprietary equipment, for example socket outlets, light switches and protective devices intended for disconnection of electrical supplies, shall be designed to interrupt all poles.

All circuits and equipment shall be provided with isolating facilities and locking devices to prevent inadvertent re-connection.

Documentation

Documentation prepared by the Builder for Purchasers approval, and prepared in a format agreed with the Purchaser shall include:

- A single line diagram of the electrical system.
- An electrical load analysis covering all operating conditions to confirm equipment ratings and capacities.
- A specification for the design and construction of cables (ratings <1000V).
- A specification describing the design, installation, termination and testing of cryogenic duty cables and cables for high voltage duty.
- A hazardous area plan, certificates for safe type equipment and a schedule of such equipment.
- An EMC management plan.
- A fault current level calculation and a protection device coordination study.

Electromagnetic Compatibility (EMC)

EMC shall be ensured in accordance with IMO Resolution A.813 and the requirements of IEC 60533. In addition, equipment that may be susceptible to interference shall meet the required performance criteria in Table 4 of IEC 60533 when subject to the actual electromagnetic phenomenon at its location on the vessel.

The EMC management plan shall cover the design, testing and installation of all control, navigation and communications equipment, and control and ship management network system and signal transmission system. In particular, manufacturers of such equipment shall provide relevant documentation, including EMC plans, standards of compliance, design criteria, and test reports.

The EMC management plan shall include details of the equipment covered by IEC 60533 and the measures to attenuate the effects of this equipment on the electrical distribution system.

The EMC management plan shall describe the extent of compatibility test to be carried out on the completed installation.

Equipment Design

Equipment shall be provided with an enclosure suitable for the area in which it is located and which is designed and tested in accordance with recognized codes or standards. The following table indicates the minimum level of protection to be provided for equipment by location (ratings are in accordance with IEC 60529 – the IP code).

Consideration of equipment service requirements may lead to a higher level of protection being applied as follows:

- Fixed equipment on consoles and desks shall be designed or located to avoid damage by spilled liquids. The minimum level of protection by design shall be IP44. (This does not apply to plug-in telephones, PCs and other portable type equipment, but shall apply to PA/GA access stations, telecommunications and similar equipment where there is a risk and where the equipment cannot be promptly replaced).
- In general, instrumentation field equipment (e.g., sensors in the machinery spaces and on the weather decks) shall be provided with IP66 enclosures.
- For spaces protected by water mist fire extinguishing system the minimum level of protection for all equipment shall be IP55.

Where the required level of enclosure protection can only be achieved by the additional use of greases, tapes or similar arrangements this shall be subject to approval by the Purchaser.

For assemblies that contain withdrawable or plug-in type components the degree of protection from live parts afforded when the component is not in the service condition shall be at least IP20. This requirement shall also apply to live parts other wise accessible after opening panel or starter doors, or removing normal access covers.

	Minumum Proection		
Location	Switchboard, distribution board, MCC, starter, transformer, UPS.	Rotating Electrical Equipment	Luminaries, receptacles, junction box, other equipment
Air conditioned living and working spaces (cabins, offices, public rooms, equipment rooms, Bridge, control rooms)	IP21	IP44 with IP55 terminal boxes unless otherwise agreed	IP20
Galley, laundry. Refrigerated storerooms. Lavatory spaces.	IP56	IP56	IP56

	Minumum Proection		
Location	Switchboard, distribution board, MCC, starter, transformer, UPS.	Rotating Electrical Equipment	Luminaries, receptacles, junction box, other equipment
Light mechanical spaces – inert gas rooms, incinerator room, and workshops. Forward spaces.	IP44	IP44 with IP55 terminal boxes	IP44
Generator rooms, transformer spaces.	IP55	IP44 with IP55 terminal boxes	IP44
Heavy mechanical spaces – main machinery space, hydraulics rooms, pump spaces, compressor rooms, motor rooms, bow thruster rooms.	IP55	IP55	IP55
Air-conditioned switchboard rooms, UPS rooms and electrical rooms.	IP22	IP22	IP22
External areas open to weather (outside deluge area).	Not to be used	IP56	IP56
External areas open to weather (inside deluge area or open to seawater spray).	Not to be used	IP66	IP66

7.2 Power Supplies and Distribution

The main electric power generation and distribution system shall have sufficient capacity to meet the vessels' requirements in any operating mode with one electrical generator set or unit of distribution equipment (e.g., transformer, switchboard etc.) out of service, and with each generator set operating with at least a 15% margin on capacity, and each transformer operating with at least a 10% margin on capacity.
Global power factor(cosø) shall not be less than 0.90.

The electrical system shall be of the insulated a three phase three wire type or a single phase two

wire type as appropriate.

Electrical generator sets and, in general, motors rated 250kW and above shall operate at 6.6kV 60Hz. All other electrical equipment shall operate from supplies at 440V or 220V 60Hz, or 24V DC.

All equipment designed for operation from the normal 440V 60Hz supply shall be capable of operating from a shore supply of 380V 50 Hz, without damage and the discharge of storage batteries.

The electrical supply and distribution system shall incorporate the following features:

- Electrical generator sets in individual compartments in the main machinery space, each arranged with independent auxiliaries and control system.
- Switchboards provided with fully rated alternative supplies and means of isolating damaged sections of bus bar (e.g., by providing bus section circuit breakers).
- Switchboard sections housed in separate compartments such that duplicated services are not both affected by smoke or fire in one compartment, or the de-energisation of the switchboard section in that compartment.
- 6.6kV equipment located in dedicated rooms with restricted access.
- An emergency generator operating at 440V 60Hz, located outside the confines of the main machinery space, complying in all respects with the requirements of SOLAS and in accordance with 5.4, and connected to an emergency switchboard in an adjacent compartment.
- An emergency switchboard normally supplied by the main switchboard, and with the facility to supply electrical power to the main switchboard from the emergency generator.

7.3 Ambient Design Condition

Transformers shall be of a dry type. Liquid-filled transformers are possibly accepted with the agreement of the Purchaser.

7.4 Transformers

The distribution transformers shall be drip-proof (IP23), dry type or cast resin type (high voltage only), natural air cooled and insulation class “F”, delta/delta connection, and located in dry, clean and well ventilated spaces free from dripping water and moisture.

6.6 kV/440V transformers shall be provided for supply of the two 440V busbar sections of the low voltage switchboards with full load redundancy.

A step-up transformer(440V/6.6 kV) capable of operating a cargo pump shall be provided.

Each 440V/230V transformer supplied by low voltage switchboards shall have 100% capacity.(One by Stbd and the other by portside bus bars)

440V/230V transformer supplied by the emergency switchboard shall be provided for emergency lighting.

One(1) temperature sensor in each phase shall be provided for high voltage transformers and connected to the IAS.

6.6kV transformers shall be of the epoxy resin insulated type and shall be fitted with two sets of three PT-100 resistance sensors for winding temperature protection and monitoring.
Local indicators shall be provided.

Duplicated transformers supplying switchboards shall be capable of operating in parallel.
Transformer impedance shall be selected to avoid excessive voltage variation when operating between no-load and full load. The use of non-standard features, particularly those designed to change the electrical characteristics of the transformers and which affect performance and interchangeability, shall be agreed with the Purchaser.

Interlocks shall be provided to trip the primary circuit breaker when the secondary circuit breaker is tripped.

Zero sequence impedance measurements shall be included in makers' tests of transformers rated 1kV and above to provide data for use in the short circuit calculations.

Separate cable termination boxes shall be provided for 6.6kV, for 400V and for other voltage circuits.
Galley and Laundry equipment shall be supplied via isolating transformers.

7.5 UPS and Battery Supplies

A battery system consisting of independent two(2) sets of 24V DC batteries(100% capacity each) with battery charger shall be supplied for the 24V DC distribution system and capable of continuous supply to the emergency lighting system, etc. The capacity of batteries shall be complied with the requirements of Classification Society.

Separate, single-fault tolerant UPS power units shall be provided for the following main equipment groups:

- IAS (including workstations).
- IBS.
- General field equipment and system controlled by the IAS (including level gauging, valve control, inert gas controls, electrical generator set controls).
- Emergency shutdown system.
- PMS (including 6.6kV switchboard protection, tripping and closing supplies).
- PA system and general emergency alarm, Engineers alarm.
- Engine control console

Single-fault tolerant UPS units shall comprise dual redundant converters, automatic synchronised by-pass for rectifiers / converters, two sets of batteries, and mains by-pass switches (incorporating isolation transformers) for maintenance. Batteries shall be removable with the UPS on line.
The autonomy time for the UPSs for IBS and IAS shall be at least 60 minutes.

Additional small UPS and battery equipment shall be provided local to equipment as required, and shall include a UPS for the server computer for the on-board management system.

All UPS equipment, including batteries, shall be obtained from a single supplier as far as practicable.
UPS equipment shall be installed in air-conditioned spaces.
UPS rated 5kVA and above shall utilize 3 phase input power circuits.

Batteries shall be of the sealed nickel cadmium valve regulated recombination type with a design life of at least 10 years except for diesel engine starting batteries that shall be lead acid.

7.6 Power generation

Three(3) or four(4) sets of synchronous AC alternators shall be installed for the primary electric power generation of the vessels driven by dual fuel diesel generator engines. All generators shall be capable of running continuously in parallel; this will require similar voltage and speed control characteristics.

A power management system(PMS) shall be provided which controls coupling, synchronization, load sharing and non-essential consumers' automatic trip. Manual coupling facilities shall be also provided.

The emergency generator shall be provided with manually controlled kW load sharing function and automatic voltage regulator.

A space heater of suitable capacity shall be provided in each generator frame according to the manufacturer's standards to prevent the condensation of moisture when the generator is not running.

Space heaters shall be automatically disconnected from the circuit whenever the applicable generator circuit breaker is closed and shall be interlocked with the air circuit breaker.

Automatic and manual synchronizing equipment shall be provided for the dedicated use of each generator. The use of common synchronizing circuits with selection switches or relay selection system is not acceptable.

Electric circuit breaker control function shall be provided at the respective switchboard panels for

the generator sets. Local control, monitoring and synchronizing operations for the generators, and control of main distribution circuit breakers shall be provided at a supervisory console or forming part of the main switchboards. These facilities shall be independent of the IAS.

AC generator winding insulation shall be Class F with Class B temperature rise.
Each generator shall be of brushless type and shall have over-current, reverse current, differential protection, under-excitation protection, de-excitation and running hour's meter.

Separate terminal boxes shall be fitted for the auxiliary devices including heaters.
AC generator bearings shall be of the pedestal type.

Reverse power protection relays and automatic synchronizers shall be of the manual reset type, with indication and reset facilities in the IAS and on the supervisory console. Differential protection shall be provided for generators rated 750kVA and above and shall initiate de-excitation of the AC generator and generator set shut down. Protection against under and over excitation faults shall be provided.

The emergency generator diesel engine shall be provided with high jacket water temperature and low oil pressure protection enabled by a switch at the switchboard when the generator set is run for test purposes. High jacket water temperature, low oil pressure, differential and excitation protection shall be disabled in the emergency generator mode of operation.

The emergency generator shall have a sufficient capacity to supply the necessary electric power for emergency service according to the requirements of SOLAS.

The emergency generator shall be automatically started by battery starting device and one other additional starting device in the event of failure of main power and fed to emergency switchboard, and shall be stopped by manual.

The generators shall be closed air circuit, water-cooled. Each generator shall be capable of providing at least 80% of its rated capacity when operating open ventilated in the event of cooler failure with temperature rise in accordance with Table A1 Appendix A of IEC 60092-301.

The emergency generator shall be closed air circuit, air-cooled.

Stator windings of AC generators shall have two embedded Pt100 temperature sensors in each phase for alarm and trip functions.
AC generators shall be fitted with an automatic voltage regulator (AVR) located inside the switchboard. Manual voltage regulator shall be provided as a back-up to the AVR with step-less changeover.

Interconnection of AVR circuits for kVA sharing purposes is not acceptable.

AC generators shall be designed not to be affected by the injurious effects on a short circuit at the outgoing terminals, while operating at full load and at the voltage and frequency limits specified. Under short circuit conditions the excitation system shall maintain a short circuit current of at least 300% of the nominal current for 3s. Factory routine tests shall include, for all AC generators, a sustained three-phase short circuit test, a sudden three-phase short-circuit test, and a voltage recovery test in accordance with lEC 60034-4.

7.7 Switchboards

The design and manufacturing of the switchboards shall meet the requirements of the Classification Society.

All switchboards shall be installed in air-conditioned rooms. Steam, water or oil lines shall not be passed through any switchboard.

The switchboards and internal components shall be capable of withstanding shipboard vibration without damage or faulty operation.

The emergency switchboard air-conditioning is not expected to operate when the emergency generator is operating in emergency mode.

Switchboards shall be self-supporting, deck mounted type with front and rear access as far as practicable. They shall be of a proven marine design and complying with the IEC standards.

Switchgear and control gear assemblies, and busbar system shall be designed to minimize the risk of short circuits and arcing faults and to ensure safety in all operating conditions, inspections and maintenance.

Protection devices shall be of the multi-element electronic type.
Switchboards shall be designed to permit the use of safe and non-intrusive thermo-graphic monitoring techniques.

Multi-cubicle type, form 4b (type 5, 6 or 7) construction shall be used for switchboards operating at less than 1kV.

6.6kV switchboards shall be of metal-clad construction; the degree of protection provided by internal partitions shall be agreed with the Purchaser.

Outfitting and commissioning of spare panels as well as connecting main, control and auxiliary cabling shall be possible whilst the switchboards are energized and in operation.

Switchgear and control gear assemblies, and bus bar system shall be certified by a recognized testing authority for the applicable short circuit current. The use of fault-free zones in meeting this

requirement shall be subject to approval by the Purchaser. Assemblies shall comply with a recognized standard with regard to internal arc testing.

The applicable short circuit current shall be determined with all generators connected, and with the maximum connected motor load for any ship operating condition; no reduction shall be allowed for momentary parallel connections. The use of fault current limiting reactors or active limiting devices is not acceptable.

Equipment operating at 1kV and above shall be provided with integral earthing facilities for current carrying parts. This shall be operated with cubicle doors closed. The earthing arrangements shall be effectively even with a ruptured fuse.
Circuit breakers and contactors operating at 1kV and above shall be withdrawable with cubicle doors closed.

Circuit breakers operating below 1kV fitted in switchboards, and those supplying section and distribution boards shall be withdrawable or of the plug-in type.

Each breaker shall be of identical type and interchangeable. All breakers and contactors shall be withdrawable.

The switchboard shall be properly illuminated and some part of these lightings shall be fed from the emergency supply system. Handrails and insulated mats approved for electrical use shall be provided at front and rear of each switchboard. All doors shall be provided with earth bonding connections.

Space shall be provided in all switchboard rooms for handling and maintenance of switchgear. Lifting devices, handling trolleys and mobile access platforms shall be provided as required.
Clear working space shall be arranged at the front and rear of switchboards sufficient to provide passage, and safe working and handling with panel doors open and equipment in the withdrawn position.

Checking devices, arranged with indicating key switch overrides, shall protect each manual synchronizing facility, including those associated with local control desks if fitted. The checking device shall not execute closure of a circuit breaker.

In addition to normal interlocks, two bus bar voltage relays to monitor all three phases and each having a 'drop out' voltage set at approximately 15% of the nominal system voltage shall be provided for each section of switchboard to which a generator is connected. This shall enable its circuit breaker to be connected to de-energized bus bars.

Closing, tripping and protection circuits for generator and main distribution circuit breakers shall be supplied from UPS units. AC closing supplies are also acceptable, and shall be employed for the

emergency generator circuit breaker. Each section of a switchboard shall be provided with a dedicated UPS unit.

An emergency switchboard shall be located into the emergency generator room. The emergency switchboard shall provide feedback for the main switchboard(s). Facilities shall be provided at the emergency switchboard to synchronize between main and emergency supplies for changeover without disruption to services.
Earth fault monitoring, with adjustable alarms, shall be provided for main and emergency switchboards.

7.8 Starters

Starters shall be conformed as the same constructional and design requirements of switchboards. Starters shall be grouped in motor control centres (MCCs) installed in air-conditioned rooms, and may be separate to, or integrated into switchboards. Exceptions shall be subject to approval by the Purchaser. Separate MCCs containing services for propulsion, cargo and ballast operations shall be provided with alternative sources of supply.

Starters shall be of the withdrawable type; components within the starter assembly may be of the fixed type. Starters rated 1kV and above shall be withdrawable with the cubicle door closed.
Starters shall be provided with a facility for testing the operation of the control gear with the starter tray in a semi-withdrawn position, and with remote control circuits still connected.

The starters of high voltage motors located in dangerous areas shall be equipped with earth fault detection in stop condition with insulation meter, alarm and starting interlock.

Starter doors shall be fitted with a safety interlock that ensures that the main supply is isolated from the starter circuit.

Where reduced voltage starting is required, the autotransformer method shall be applied. Autotransformers shall not restrict the design starting capability of the motor (repeated starting). Autotransformers shall be provided with high temperature protection.

With the exception of essential interlocking connections, each starter control circuit shall be completely independent. Control circuits external to a starter shall be energized via a safety-isolating transformer fitted within the starter. In general, control circuits shall be insulated from earth. Control circuit voltages shall not exceed 220V and shall be standardized as far as practicable.

Vacuum or SF6 type contactors or air break circuit breakers shall be used for circuits operating at voltages above 440V.

Motors operating at voltages above 440V shall be provided with multi-element electronic protection relays. Submerged motors shall be provided with low current and high current protection.

Motors operating at voltages of 440V and below shall be provided with ambient temperature compensated 3-element overload protection; incorporating single-phase protection, with external reset facility (for each winding in the case of two speed motors).

Each starter shall have a switch for selecting the control position, which can be selected to:

- Machinery side
- Local starter
- Remote or Auto

Local control shall be disconnected from all remote control functions, except those associated with remote emergency stopping devices located outside the machinery spaces (e.g. fire shutdowns). The "Off" switch position shall be lockable.

Ammeters, marked with the motor rated current, and running hours recording shall be provided for all motors of 5 kW and above. Where these motors are controlled or monitored by the IAS running hours recording shall be provided by the IAS.

In general, the starters shall be of magnetic contactor type except for non-essential small motors below 0.4 kW.

Steering gear, emergency fire pump and other safety starter shall be independent and locally installed.

Winding temperature trip relays (PT-100 resistance sensor type) and remote winding temperature indication shall be provided for motors rated 160kW and above. Starters for motors of this size shall also be fitted with permanent insulation resistance monitoring devices in operation at all times when the motor is stopped.

All automatic starting, duty / standby functionality, and interlocking shall be provided by the IAS.

7.8.1 Electric Motors

General

AC 6.6 kV motors shall generally be supplied in accordance with the manufacturer's standard and IEC, and special precautions (clear warning plate) shall be made to identify these motors as AC 6.6 kV on the machines themselves.

Motors shall be of squirrel cage induction type of International Electro-technical Commission (IEC) standard frame designed for AC 440 V, 3Ph, 60 Hz, except for the small motors (0.5kW or less) may be AC 220 V single phase or three phase type.

Special motors shall be of the manufacturer's standard.

Motors installed within dangerous area shall be of certified type in accordance with the requirements of the Classification Society.

Enclosure

In general, enclosure of motors shall be in accordance with the following criteria, unless otherwise specified in the Specifications.

- Water-proof type (IP56) : Motors exposed to weather
- Totally enclosed type (IP44) : Motors in engine room, BWTS room
- Drip proof type (IP23) : Motors, unless specially noted.
- Explosion proof type : Motors installed in the hazardous area

Insulation

Generally, motor windings shall be designed and constructed as class B or F insulation according to the manufacturer's standard unless otherwise specified in the other section.
HV motor windings shall be of class F insulation with B temperature rise, with winding temperature detector.

High Voltage Motors

For big consumers high voltage motors shall be provided and shall be supplied from high voltage switchboards.

Other motors

Above 100 kW rating, motors shall be fitted with windings temperature sensors.

7.9 Shore Power Connection

A shore power connection, suitable for 440V/60 Hz and 380V/50 Hz shall be provided at a convenient location at upper deck or poop deck level. The arrangements shall ensure that shore supply is always available to the required services with any switchboard de-energized for maintenance.

Shore supply capacity shall be sufficient to allow the following services to be maintained:

- Lighting
- Heating, ventilation and air conditioning
- Domestic fresh water and sanitary services
- Food storage, preparation and cooking facilities

- Communications and entertainment system
- Alarm and monitoring system
- Battery chargers and UPS system
- Fire detection and fire-fighting services

The following devices shall be provided:

- A kW meter
- A kWh meter for recording total power consumption
- An incoming supply voltmeter
- A phase rotation check device
- An isolation circuit breaker

7.10 Distribution Boards

Distribution board shall be of drip-proof, wall mounting or recessed steel plate type depending upon its location.

No board shall be fitted in a position liable to be damaged from spray and leakage from steam or water pipes.

Distribution boards shall be provided at suitable positions to supply power to the various consumers of power, heating, lighting, communication and navigation equipment throughout the vessel.

Galley and laundry equipment shall be supplied through residual current circuit breakers (RCCBs).

7.11 Electric Cable and Installation

7.11.1 General

In general, electric cables provided throughout the Vessel except for special services and manufacturer's standard shall be approved by the Classification Society and complied with the relevant IEC standards.

The voltage drop on the power and lighting circuits at final point shall be in accordance with requirement of the Classification Society.

Cables exposed to high temperatures shall be specified for the relevant temperatures.

Cable application and installation shall be in accordance with Class requirement and the Builder's practice.

All contact connector equipment shall have type approval certificates.
Instrument cables shall be in accordance with IAS maker's recommendation.

Cabling for emergency stop circuits shall be of a type that remains functional at fire
Mineral insulated cables shall not be used for this application.

Routing and cabling and installing equipment under deck passageways, trunk-ways, forecastle space and etc shall be carried out as far as practicable to minimise exposure to the elements.

7.11.2 Cable Application

In general, the cables shall be EP (ethylene propylene) rubber insulated and PVC (polyvinyl chloride) sheathed and steel wire braided under mentioned exception.

Cables installed where exposed to weather shall be covered with PVC.
Cables used for motors in the cargo tanks and cables used for sensors and etc in the insulation space shall be of suitable type for cargo cryogenic service.

The prospective shore circuit current at any point shall be considered when determining ratings.

7.11.3 Cable Installation

Electric cables shall be laid with a view to avoiding places of high temperature and high humidity and protected against any mechanical damage as far as practicable.

Cable in E/R liable to be exposed to mechanical damage shall be protected by galvanized steel plate, galvanized steel pipe, flexible tube or other suitable means. And cable on exposed deck liable to exposed mechanical damage shall be protected by stainless steel pipe, flexible tube or other suitable means.

Cabling shall be continuous and carefully routed to minimize deterioration from ambient conditions and mechanical damage. The installation shall be designed so that in the event of a fire the cabling remains substantially in its installed location. The use of stainless steel cable clips shall be considered.

Where cables pass through water tight, gas-tight bulkheads or to exposed weather deck, the type approved cable penetration or compound to be used.

Cable penetration between hazardous and safe areas shall be via proprietary fireproof compounds according to Class requirement.
Measures shall be taken to ensure that cables used for instrumentation, communication and navigation purposes are suitable and installed properly to avoid any form of interference.

Cable shall be secured by means of PVC covered stainless steel clips for outside deck and wet space. The use of steel hoops and steel buckles or nylon clip in accommodation is accepted.
Consideration shall be given where practical, to installing cables in the under deck passageways. Essential duplicated service cables shall not run in the same passageway.

Where cables are run in exposed areas, e.g. main deck, they shall be installed in corrosion resistant pipes / cableway supports.

Cables for intrinsically safe circuits shall be separated from Non-I.S. cables by a minimum of 50 mm, as far as applicable.

7.12 Earthing

All metallic non-current carrying equipment must be locally earthed to the ships hull.
A colour coded cable shall be used for the earth conductor.

This colour (green with yellow) shall be dedicated to earthing conductors stripes is preferred, to prevent confusion with current carrying conductors.
Cables for intrinsically safe circuits shall have their screens connected to earth at one(1) point only.

7.13 Lighting

7.13.1 General

The Vessel shall be adequately lighted with fixtures suitable for marine use.

The vessel shall be illuminated by LED or fluorescent discharge lamps for internal areas, tungsten lamp for supplementary internal lighting and external access lighting, and high pressure sodium lamp for flood-lighting. Lamps and tubes shall be those readily available in the intended operating areas for the vessel. Lighting fittings shall be sited for ease of maintenance.

Machinery space light shall be so arranged/supplied that the failure of any one branch circuit may not cause any space to be entirely dark.

In general, fixtures and fittings shall be of the appropriate type for their location in which they are installed.

The emergency lighting shall be fitted at stairs, exits, passageways, boat stations, wheelhouse, chart space and machinery spaces normally fed from 220 volt section of emergency switchboard on failure of main supply.

Emergency lighting shall be provided in all normal areas of access.

A battery powered escape lighting system shall be fitted to serve the CCR, ECR, emergency generator and switchboard room and in escape trunks and passageways, stairways, lift and lift shaft, galleys, radio room, Captain and C/E day room, generator engine side and the main switchboard side.

Lighting equipment on deck and open areas are to be of strong material and of high resistance to sea water, ambient atmosphere and of preferably stainless steel(304) or copper alloys but not aluminium alloy.

In addition to the requirements of 7.1, all external lighting (hazardous area) equipment shall be of a "safe type".

In general, fluorescent lamps or LED lamps shall be used in preference to incandescent type.
Where more than one lighting is provided in a space they shall be supplied from two(2) circuits one of which may be emergency lighting circuit.

Lighting shall be arranged so as to obtain the average illumination level for accommodation and machinery space.

The illumination levels shall be provided as follows :

Area		Lux
Offices	General	200
	Desk	350
Cabins	General / Bed	150
	Desk	200
CCR		400
ECR/Switchboard room		350
Engine room		200
Bridge general		200
Chart table (with dimmer controlled)		750
Galley/Pantry		200
Work shop		350
Mess room		200
Cargo Machinery room		200
Deck	General	30
	Working	100
Gangway, manifold & Mooring area		100
Pipe duct area		50
Accommodation	Inner passage	200
	Outer passage around	75

The illumination level of other areas shall be decided mutual agreement between the owner and builder.

The signal light and navigation light shall be fitted in accordance with the Regulations concerned.

Search light(s) shall be provided in each bridge wing.

7.13.2 Deck/Flood Lighting

Floodlights should be of a mercury vapour or quick start high pressure sodium type.
All deck lights shall be switched from the wheelhouse.

All lighting equipment exposed to the weather shall be manufactured from materials which are resistance to corrosion in a salt laden.

Searchlights with the night vision cameras are to be fitted on the top bridge and bridge wings to provide sufficient lighting ahead of the vessel at night.

7.13.3 Emergency/Escape

Approximately one third of the vessel lighting should be distributed from the A.C. emergency circuits.

This shall provide sufficient lighting at locations including but not limited to the following:

- All berth lights also be fed from these circuits
- Boat stations, on deck and oversides, in alleyways, exits, public rooms, hospital
- Communications position, wheel house, accommodation, machinery spaces and all essential machinery operating positions

Emergency escape battery lighting shall be provided for all principal escape routes, including life boat and life raft embarkation areas together with routes from Navigation Officer's accommodation to the wheelhouse, and Engineer Officer's accommodation to ECR and emergency generator room.

7.13.4 Navigation Lanterns

Single duplicated navigation lanterns shall be used and separately wired from the control panel.
A control panel with mimic identification shall be provided on the wheelhouse and supplied with two(2) switchable supplies.

One(1) supply shall be from the emergency AC source.
Navigation lights to be fitted with heated-traced glass if necessary.

7.13.5 Portable Lamps

Twenty(20) sets of AC 220V, 60W and five(5) sets of DC 24V, 20W incandescent portable lamps of waterproof type shall be provided.

Twenty-five(25) sets of explosion proof portable hand lamp(6 dry cells) shall be provided.

7.14 Miscellaneous Circuits

7.14.1 Shaft and Rudder Earthing

Main shaft and rudderstock earthing shall be provided and monitored.

7.14.2 Welding System

Electric power for welding system distributed throughout the machinery spaces shall be provided.

7.15 Low Voltage Equipment

7.15.1 General

The 24V DC supplies shall be non-interruptible.
The battery chargers shall be capable of supplying the total connected load as well as fully charging the batteries from a discharged state.

Provisions shall be made to allow removal of the batteries without causing a loss of supply to the consumers.

The batteries shall be of maintenance free and capable of supplying the requirements of the consumers continuously for a period of at least 18 hours.

7.15.2 Instrument 24V DC Supply

This supply shall be dedicated to instrumentation.

7.15.3 General Service 24V DC Supply

The services shall be supplied emergency AC/DC power as per the requirement of the rules.

- International Communications
- Fire detection
- Gas detection
- NUC lights
- Emergency escape lighting
- Fire & general alarms
- Radio equipment
- Shipboard Management System, etc

7.16 Fire Detection

Comprehensive early warning fire detection system shall be fitted. The system shall be self-monitoring, fail-safe and provide comprehensive fault alarms covering all abnormal conditions.

The fire detection system shall cover all machinery spaces, switchboards, control rooms, service areas and the entire accommodation block including individual cabins.
Intrinsically safe fire detection equipment shall be fitted to cover hazardous areas.
The system shall differentiate between detectors and manual call points.

An intelligent addressable type system such that the location of fire outbreak is readily identified at the control point shall be fitted.
The main control station shall be in the wheelhouse with repeater panels situated in CCR, ECR and fire control station.

Fire doors shall be arranged for automatic magnetic release.
Test kits for each type of fire detectors (3 sets) shall be provided.

7.17 Navigation and Communication Equipment

7.17.1 General

Navigation and communication equipment shall be selected on basis of reliability, flexibility, efficiency and ease of maintenance. Where appropriate, duplication shall be considered.

Internal communication system shall be provided to allow normal operational and emergency communications throughout the vessel.

External communication system shall comply with requirements of GMDSS (Global Maritime Distress and Safety System) as per SOLAS 1974 amendments (1998) and shall meet the Owner's commercial communications requirements.

The navigational equipment shall comply with or exceed the requirements of SOLAS 1974 with IMO Performance Standards for Navigation Equipment.

7.17.2 Internal Communications

The following system shall be provided as minimum. However, other equipment not mention below may be provided based on the agreement of owner and builder.
System shall provide point to point and/or multi point communications as necessary. All external loudspeaker (hazard zone) shall be a safe type.
The system provided shall include but not be limited to :

<u>Public Address and Alarm System</u>
A public address, fire and general alarm broadcast throughout accommodation, machinery spaces, and all deck areas shall be provided.

- Main unit : Radio room
- Control panel : Wheelhouse, CCR

<u>Talk back system</u>
Talk back system between Wheelhouse and ECR, CCR, steering gear room, forward and aft mooring decks shall be provided.

<u>Automatic telephone</u>
An electronically automatic telephone exchange with minimum capacity of 80 extensions /6

circuits shall be provided. Interface with satellite and public address system shall be provided.

Intercom system

Common battery telephone shall be provided for following areas :
Wheelhouse, CCR, ECR, generator space, emergency generator room, cargo office, bow thrusters room, ship's office, CO_2 room, MSBD room, steering gear room, cargo compressor room and Bosun store.

UHF transceiver system

UHF communications throughout the vessel by means of master transceivers, portable transceivers (25 sets) and antenna network(s) shall be provided.
The unit intrinsically safe fully duplex UHF communication system with mobile handsets and fixed charging facilities shall be fitted. Batteries and spare batteries shall be included.
Operating frequencies and the location of the aerials shall be selected in mutual agreement between owner and builder.

Intrinsically safe telephone

Internal communications between cargo part including CCR, cargo machinery room, both cargo manifold, cargo switchboard room, ECR and conference room shall be provided.
Equipment shall interface with standard connection(s) provided at loading and discharge terminals and be compatible with the system in operation at these terminals.

Communal aerial system

Amplified AM / FM / TV reception facilities shall be distributed throughout the vessel.
A system of power amplified and / or sound powered telephones shall be fitted as a secondary linkage all necessary positions including wheel house, CCR, ECR, emergency generator room, steering gear room, fire control station, bow thrusters room, Bosun store, E/R floor and DFD emergency manoeuvring station.

Call bell system

- Cold provision store alarm
- Elevator alarm
- Hospital call
- E/R calling system
- Engineer call system

Electric clock system

An electric clock system shall be fitted comprising a master clock in the chart room with minimum 70 slave clocks fitted in each cabin, public rooms, control rooms, cargo switchboard room, galley, pantries, wheel house control room and radio space clock to be fitted with second sweep hand.
Hospital clock to be fitted with silent movement.

7.17.3 External Communications

An external communications system shall be fitted incorporating all equipment necessary to meet the current and known future requirements at the time of contract for operation on the Global Maritime Distress and Safety System (GMDSS) in areas A1, A2 and A3, with shore based maintenance.

The primary communications control position shall, subject to Governmental Administrations agreement, be located in the wheelhouse. Secondary control for commercial operations shall be remotely available at ships office, CCR and Captain's room.
Security and confidentially of communications shall be assured.

The equipment to be provided shall include but not limited to:

Inmarsat satellite communications – 2 channels standard Vsat(Ku-band which is compatible to Ka-band) and FBB500 terminal with facilities including telex, voice, facsimile and data. Additionally, a standard C terminal shall be provided as back up.
Inmarsat receiving stations are to be fitted for the reception of meteorological graphic information.

MF/HF radio installation – with full telephone and DSC facilities and NBDP with printer.

Satellite EPIRB – 406 MHz float free type.

VHF radio telephone – two(2) system with telephone, DSC and remote control facilities with DSC printer.

Search and rescue locating devices (quantity 2), two(2) watt VHF radio telephone (quantity 3), navtex receiver, fixed VHF radio (in each lifeboat).

The telephone shore connection box to be arranged on the safe area connected to telephone at one(1) number shore telephone to be incorporated with auto telephone exchanger so as to communicate four(4) places in ship.

7.17.3.1 Ship/Shore Communications for Cargo Terminals

Communication between alongside vessel's CCR and shore terminal control room shall be carried out via special connecting sockets able to transmit operational, safety and emergency communications through hot line, terminal internal telephone network, shore public telephone network, mooring line tension information system from terminal when equipped.

The following facilities shall be provided for use when the vessel is alongside LNG terminals:

- A 'Hotline' call telephone installed on the CCR cargo control console, providing voice communications with shore control room via the optical fibre link system.

- A pushbutton telephone installed via sockets in the CCR, providing communications to the terminal' s internal telephone network via the optical fibre and electric link system.
- A pushbutton telephone installed via sockets in an acoustic booth located in the CCR, providing communications to the shore public telephone network via the optical fibre and electric link system.
- A telephone socket for fax communications installed in the CCR and connected to shore via the Pyle-National electric link system.

Communication links shall be carried out via optical fiber, pyle-national electric link system, etc.
Electrical earthing line system shall be installed.

7.17.4 Navigation Equipment

Navigation equipments shall be provided to meet the requirements for safe, efficient and economical navigation with reduced manpower levels and high reliability (one(1) man bridge watch keeping system).

The following equipment/system shall be provided as minimum. However, other equipment/system not mention below may be provided based on the agreement of owner and builder.Integrated bridge navigation system – integrating the information / system as listed below.

- Three(3) radar system with ARPA, two(2) 3 cm (X-band) with true motion respectively and one(1) 10 cm (S-band) with true motion. One(1) warning alarm of ARPA shall be provided at the bed room of captain.
  One(1) 3 cm(X-band) scanner to be sited forward.
- Two(2) master gyro compasses (inter-switching) and repeater system to include bearing repeaters on each bridge wing, on the navigating bridge and in the steering gear room.
- One(1) magnetic compass with TMC.
- One(1) Dual Adaptive autopilot.
- Rudder angle indicator system.
- Doppler log system for normal ship's speed measurement and for docking.
- Echo sounder with transducer fitted forward and aft.
- Satellite navigator receiver(s) - Two(2) DGPS
- Two(2) weather facsimiles, wind speed and direction indicators.
- Rate of turn indicator.
- Independent off course alarm.
- Satcom system (standard-C) telex facility as main and Vsat(Ku-band which is compatible to Ka-band) and FBB500 with voice / facsimile / telex facilities with telephone handsets.
- Total navigation system with multi function two(2) ECDIS.
- One(1) anemometer with display at wheel house and CCR.
- Propeller shaft speed indication system with repeaters on each bridge wing also rudder angle indicators on each bridge wing.
- Bridge engine control system with facilities for relaying, indicating and recording

comments and engine movements.
- Window wipers, washers and heaters and engine movements.
- Clear view screens for bridge forward facing window, Port and Starboard.
- Ship's bell & watch bell.
- Bridge watch alarm system with alarm channels with watch timer unit with public space/accommodation buzzers.
- Whistle.
- Miscellaneous navigation equipment. (Sextants, barometers, binoculars, thermometers, clinometers, megaphones, chronometers, etc.)
- Sufficient flags and books.
- External bridge wing console repeater.
- Sufficient distress signals.
- VDR.
- AIS, etc.

* These systems shall include repeaters on each bridge wing with illumination and dimming facilities.

Bridge wings shall be sheltered.

7.17.5 Entertainment System

A radio and television communal serial system incorporating an amplified signal distribution system shall be installed. Dual (radio and television) outlets shall be installed at the all relevant area.

The entertainment equipments shall include, but not be limited to the followings (Adapt the latest model) :

- 50'' LED video/audio system (2 sets)

And the vessel shall be provided aerial system to be capable of receiving the satellite broadcasting signal (Worldwide type, vessel's sailing zone).

7.17.6 Closed Circuit Television System (CCTV)

Explosion proof, all weather colour CCTV system shall be provided.
System shall incorporate cameras with remote control of focus, zoom, pan and tilt and four(4) colour monitors.
Supervision from wheelhouse, CCR(2), ECR with 20 inch colour monitor / controller.

The system shall be provided for monitoring of engine room, cargo manifold areas (P/S), and fore & aft winch stations as follows :

Camera :	Manifold area (P/S)	4 sets
	Mooring winch (F/A)	2 sets

Bridge wing with searchlight	2 sets
Engine room	4 sets.
Cargo comp. room	2 sets.

Additional cameras shall be installed for security purposes covering the main and poop decks. Passive night vision system will be fitted. Accommodation and control space security to be considered and to be in compliance with IMO. Guardhouse overlooking the shore gangway will be fitted with heating and ventilation system.

Attachment # 1 : Spare Gears

1. Basic Provision

Spare parts and tools shall be provided for each ship according to the following list.
Spare parts for other machinery and equipment not mentioned in this list shall be supplied in accordance with Makers or the Builder's standard.
Note: Spare parts, tools and test equipment specified here-in shall be subject to change if models, type etc. change with design development.

2. Hull Spares

2.1 Windlass(for 2 sets)

2 Set bearing metal for each size
1 Hydraulic pump or electric motor per each type
1 Hydraulic pump per each type
1 Shaft seal assembly

2.2 Mooring Winch

1 Hydraulic motor or electric motor per each type
1 Set bearing metal of each size
1 Hydraulic pump per each type
25% working 0-ring seals for each type

2.3 Life Boat Davit and Winches

1 Set bearing for winch for each type
1 Set bearing for air motor for each type
1 Set fall wire

2.4 Mooring Ropes

1 Complete mooring rope (abt. 275m length) with nylon braid tails

2.5 Anchor cable

1 Anchor
2 Kenter shackles
1 taper pin for anchor shackle
3 Taper pin for kenter shackles
1 Anchor shackle
4 Chain hook
1 Shackle punch

1 Pin punch
2 Anchor hammer
1 Disengage tool for kenter joining shackle
1 Swivel piece with joining shackle
1 fore runner, complete

2.6 Manifold/Provisions/Engine parts Cranes

1 Bearing per each size and type
1 Spare hoist wire
1 Spare luffing wire
1 Shaft seal

2.7 Ballast System Valves

1 Seat ring per each size
3 Branch line valves
3 Hydraulic actuators

2.8 A/C and Auxiliary A/C System

1 Motor for main fan unit
1 Motor for auxiliary fan unit

2.9 Others

Spare parts of for the following machinery and equipment shall be supplied as per the Maker's or the Builder's standard.

Steering gear
Life boat engine
Refrigerating plant for ref. provision store
Refrigerating plant for air conditioning system
Hydraulic oil pump unit for forward F.O. pump
Accommodation ladder winch
Sewage treatment unit
Ventilation fan
Lift
Hydraulic oil pump unit for deck machinery

3. Cargo Spares

3.1 Cargo pumps

· 1 Set impeller and inducer

- 4 Sets bearings

3.2 Spray pumps

- 1 Set impeller and inducer
- 2 Sets bearings

3.3 Fuel gas pumps

- 1 Complete pump with electric motor
- 2 Sets bearings

3.4 High Duty Compressor

- 1 set bearing and shaft seal assemblies, gas bulkhead seals, etc.,
- * <impeller and shaft>

3.5 Low Duty Compressor

- 1 set bearing and shaft seal assemblies, gas bulkhead seals, etc.,
- * <impeller and shaft>

3.6 Safety Valves

- 1 Spare of each size
- 1 Overhauling kit

3.7 Expansion Bellows

- 1 Complete for each size of liquid line(Moss), vapore line(Membrane)

3.8 Cargo System

Butterfly Valves

- 1 Complete valve for each size of flanged type
- 3 Seals for each size of valve
- 1 Hydraulic actuator for each size

Other System Valves

1 Complete of each valve type and size
1 Actuator for each valve type and size
1 Pressure relief valve of each size

Remote Control System for Cargo Handling Valve

1 Set of solenoid coil for each kind

1 Set of position transmitter for each kind & size

Nitrogen Generator

2 Sets of line filters

Inert Gas generator

1 Complete set of fuel oil supply pump
1 Complete set of controller for I.G. pressure control

Vacuum Pumps(Membrane)

1 Set of bearings, shaft seals, gaskets, shaft, mouth ring, impeller & key Gauge of Pressure, Level and Temperature of cargo tank outside
1 set of each kind

Transmitter for pressure

1 Set of `each kind

4. Machinery spares

4.1 Auxiliary Equipment
1 set of each kind and size strainer filter for L.O. system

4.2 Shafting and Propeller
1 set of O-rings and packing for the stern tube sealing
1 complete tail shaft
1 complete propeller
1 complete of bonnet for propeller nut

4.3 Main Engine
Items and the number of each spare for main engine are to be decided in accordance with the recommendations of the manufacturer based on the agreement between the owner and the builder.

4.4 Emergency Diesel Generator Engine
1 complete set of O-ring seals
1 piston(connecting) rod bearing
1 thrust race
1 oil pan gasket
1 main bearing
1 set of piston rings for one engine
1 sleeve bearing bush

1/2 set of fuel injectors for one engine
1 set of fuel pumps for one cylinder
1 set of main bearing shells for each kind
1 starter motor (fitted) rotating elements of all attached pumps
1 cylinder heads complete
1 set of fuel injectors
1 set of fuel pumps for the engine
1 piston
1 cylinder liners
1 governor complete

4.5 Auxiliary Machinery and Equipment

1 Complete spare unit including motor for each type of pump of 1.5 kW & below.
Control, Ship Service and Starting Air Compressors and dryers

For each type of compressor:

1 crank shaft bearing
1 set of crank pin bearing metal for one cylinder
1 set of piston pin bearing metal for one bearing
1 set of piston rings for one cylinder
1 set of bolts and nuts for one cylinder cover
1 set of suction valves and discharge valves assembly for each compressor, all cylinders
1 spring of each size (including safety valves)
1 packings of each size and type
1 glass of each size and type
1 V belt for starting air compressor
1 set of spares for each type of air dryer as recommended by the manufacturers

Emergency Air Compressor

Compressor

1 crank shaft bearing
1 set of bearing shells
1 set of piston rings
1 set of bolts and nuts for cylinder cover
1 set of suction valves and discharge valves assembly
1 spring of safety valve
1 packing of each size and type
1 V belt

Engine

1 bearing shell
1 set of piston rings

1 set of inlet valve and exhaust valve assembly
1 spring of each size and type
1 packing of each size and type
1 set of fuel injector, injection nozzle and high pressure pipe

4.6 Rotating Pumps (2.2 kW & over)

Centrifugal pumps;
For each type of pump;

1 impeller shaft complete with impeller but excluding coupling and bearing
1 set of bearings for one pump
1 set of casing ring for one pump
1 set of coupling bolts, nuts and rings for one pump
1 set of shaft seal for one pump
1 rotor shaft complete with rotor but excluding driving face for vacuum pump, if fitted
1 liner for vacuum pump, if fitted
1 hot water circulating pump complete with motor
1 set of each kind of spring (if fitted)

Screw pumps:
For each type of pump;

1 set of rotors for one pump
1 set of bearings for one pump
1 spring for relief valve
1 set of shaft seals for one pump
1 set of coupling bolts, nuts and rings for one pump

Gear pumps:
For each type of pump;

1 set of shafts & gears for one pump
1 set of bearings for one pump
1 spring for relief valve
1 set of shaft seals for one pump
1 set of coupling bolts, nuts and rings for one pump

Snake pumps:
For each type pump;

1 stator
1 set of bearings for one pump
1 set of shaft seals for one pump
1 set of V belts for one pump
1 spring for relief valve

Rotary vane pumps:

For each type pumps;

1 set of manufacturers' recommended spares

Reciprocating Pump

Bilge pump:

1 set of bucket ring for one pump
1 set of suction and discharge valve for one pump
1 relief valve spring for one pump
1 set of crank pin shells and bolts for one pump
1 set of bearing for one pump
1 set of gland packings for one pump
1 set of liners if applicable

4.7 Oil Purifiers

For each type of purifier;

Bowl:
1 main seal ring
1 disc
1 set of O-rings for each type
Frame:
1 brake lining
1 set of set screw
Cover:
1 set of O-rings for each type
Shaft:
1 set of ball bearings for each type
1 set of friction block

4.8 Others:

As recommended by the manufacturer

Fans

Forced draft fans:

1 complete set of grid-members for fork coupling
1 set of packings for bearing housing

Engine room ventilating and exhaust fans:

1 set of bearings for each size of motor

Fuel gas piping duct exhaust fans:

1 grid-member for fork coupling
2 ball bearings
1 set of packings for stuffing box
1 set of bearings for each size of motor

Heat Exchangers

Shell and tube type heat exchangers:

For each heat exchanger

2% of total number of cooling or heating tubes
1 set of water chamber packings for feed heater
1 set of gasket and packing
1 spring of relief valve for each type
1 set of water level gauge glass

Platetype heat exchangers:

4 spare plates of each size and material type, with gasket

Oil heaters:

1 set of gasket
1 spring for relief valve

Distilling plants:

For each plant

2% of total number of cooling and heating tubes
1 set of level gauge glasses complete with packings for one plant

Reducing and control valves

1 set of diaphragms and bellows for each size and type
1 set of springs and piston rings for each size and type
1 set of special packings and gaskets for each size and type

Relief valves

1 set of springs for each size and type

Filters and strainers

1 set of elements for each size and type
1 set of cover gaskets for each size and type

Others

1 set of principal springs for each size of part, not mentioned above

1 packing for each 10 packings

5. Electrical Part Spares

Generator

The following list shall be based on the total equipments of each type and size supplied by each Maker for 1-vessel.

1- Bearing lining for each 4 or less
1- Bearing lubricant seals for each 4 or less
1- Space heater element for each 10 or less
1- Rotating rectifier generator complete for each set type
1- Resister for exciter for each 4 or less
1-Automatic voltage regulator for each size of generator installed

Switchboard and distribution board

1- Main contact and arcing for each size installed
Contact - corresponding to 10 sets of each type breaker or contactor
1- Auxiliary contact set for 10 sets or less
1- Attachment of auxiliary set for 10 sets or less contact
Fuse element (non-renewable) - Same as use (1 for 1)
1- Moulded case circuit for each 10 or less (max. 5) breaker
1- Operating and shunt coil for each 6 or less
1- Resister element for each 10 or less (max. 4)
Bulb for indicating lamp - Same as use (1 for 1)
1- Globe for indicating lamp for each 10 or less
5- Fuse remover
1- Auxiliary relay for each 10 or less
1- Operating switch for each 10 or less
1- Timer relay for each 10 or less, up to a max. of 4
1- Transformer for control for each type circuits
1- Protection relay for each 10 or less
Electronic module/PCB for each type (2 for more than 5 of same type)

Electric Motor

Bearing sets - 1 for each 4 of same size or less

Group & Individual Starter

1- Main contactor set for each 6 contactor or less
1- Auxiliary Contactor for each 6 contactor or less
1- (Aux. relay) 10 contactor or less
1- MCCB for each 10 or less
1- Coil for MCCB (shunt trip for each 10 or less or under voltage)
Fuse element (non-renewable) - Same as use (1 for 1)

Bulb for indicating lamp - Same as use (1 for 1)0
1- Globe for indicating lamp for each 10 or less
1- Thermal type over load for each type relay
1- Timer relay for each 6
1- PCB/electronic module for each 10 or less
1- Control Transformer for motor for each type/size control circuit
1- Current limiting fuse circuit unit for each 3 circuit units or less
1- Resister element for each 10 or less (max. 4)
Spring for each 4 or less

Lighting fixture
1- Fluorescent tube for each 10 or less
1- LED lamp for each 10 or less
1- Glow lamp (Starter) for each 10 or less
1- Incandescent lamp bulb for each 10 or less
1- Floodlight lamp bulb for each 10 or less
1- Plastic globe for each 20 or less (max. 10)
1- Glass globe for each 10 or less (max. 10)
1- Socket for fluorescent for each 20 or less (max. 10) and incandescent lamp
1- Switch (non water-proof type) for each 20 or less (max. 5) type
1- Switch (water-proof type) for each 20 or less (max. 5)
1- Receptacle (non water-proof type) for each 20 or less (max. 5)
1- Receptacle (water-proof type) for each 20 or less (max. 5)
1- Plug (non water-proof type) for each 2
1- Plug (water-proof type) for each 5 or less (max. 5)
1- Ballast for fluorescent for each 20 or less
1- Lamp bulb for navigation lamp - Twice for use (2 for 1)
1- Socket for navigation lamp for each type

Bulb for indicating lamp - Twice for use (2 for 1)
1- Globe for indicating lamp for each 10 or less
1- Socket for indicating lamp for each 20 or less
1- Relay for each 10 or less
1- Switch for navigation for each type lamp circuit
Fuse element (non-renewable) - Same as use (1 for 1)
Bulb for day signal lamp - Twice for use (2 for 1)
1- Globe of vessel signal lamp for each type and colour

Internal communications
1- Spare circuit board fitted for each type
to automatic telephone exchange
1- Spare circuit board fitted for each type

to the intrinsically safe Telephone

1- Spare circuit board fitted for each type

2- to the ship/shore communication system

Standard Spares of Maker's for each item of equipment

External communications

1- Spare circuit board fitted for each type to the MF/HF radio installation

1- Spares of maker's standard for each equipment

Navigation equipment

1- Spare circuit board fitted for each type to the radar installation

1- Spare TFT screen for each type fitted to the radar installation

1- Spare TX/RX unit for the for each radar

1- Spare magnetron for each type fitted

1- Spare circuit board fitted for each type to the Doppler log

1- Spare circuit card fitted for each type to the echo sounder

1- Spares of Maker's standard set for each equipment

Storage battery

1- Connection bar for each 10 or less

1- Fixture of connection bar for each 10 or less

IAS

2 years operational spares as recommended by the maker but shall include the following

1- Power supply unit for each size fitted

2- Analogue input card (current)

2- Analogue input card (temperature)

2- Analogue output card (current)

2- Digital I/O card for each type fitted

1- Operator station keyboard

1- Operator station display

1- Multi-port fibre optic converter

1- Single point fibre optic converter

1- Watch cabin unit

2- Serial isolated adapters

1- Relay (ordinary type) for each 10 or less (max. 20)

1- Relay (non contact type) for each 10 or less (max. 5)

1- Socket for relay for each 20 or less (max. 5)

1- Switch for each 10 or less

1- Push button switch for each 10 or less

2- Bulb for indicating lamp (max. 100)

2- Globe for indicating lamp for each 10 or less (max. 10)

2- Socket for indicating lamp for each 10 or less (max. 10)
Fuse element - Same as use (non-renewable)

6. Controls and Instrumentation Equipment

Instrumentation
1- Instrument equipment for each 10 or less outside cargo tank (temperature, level, pressure, and etc.)
1- Electronic box for radar set type level gauge

Electronic System
1- Spare circuit board for each type (2 for more than 5 of same type)

HV Switchboard
1 - Circuit Breaker of each size fitted
1 - CT transducer of each size fitted
3 – Fuses of each size fitted
4 - Auxiliary contactors
4 - Auxiliary relays
4 - Auxiliary Timer relays
1 - MCCB complete for each type fitted
3 – Spring Charge Motor
12 – Signal lamp for each type fitted
Control Valves (including cargo, ballast and bunkering valves)
Plug, seats, gasket, spindle - 1 for each size
gland packing, diaphragm, nuts, bolts and actuator components

Flow Meters
Flow meter - 1 for each type/size

7. Machinery Part Special Tools

Main engines
Full set of Maker's recommended spares as listed in Maker's maintenance manual.
In addition:
1 - polishing tool for intake and exhaust valves
1 - nozzle cleaning tool
1 - nozzle test pump
1 - deflection gauge
1 - thickness gauge
1 - cylinder bore gauge (inside micrometer)

1 - cylinder liner position gauge
1 - micro meter for crank shaft
1 - maximum pressure indicator
1 - set of special tools for turbocharger
1 - set of cleaning tool for blower of turbocharger
1 - set of blanking pipes for turbocharger
2 - sets of hydraulic oil pumps (two sizes)
1 - set of high pressure hoses
1 - set of oil pressure ram assembly
1 - set of hydraulic oil jack cylinders
1 - nozzle cleaning tool
1 - nozzle test pump
1 - deflection gauge
1 - thickness gauge
1 - cylinder bore gauge (inside micrometer)
1 - cylinder liner position gauge
1 - bridge gauge for crank shaft
1 - maximum pressure indicator
1 - set of special tools for turbocharger
1 - set of cleaning tool for blower of turbocharger
1 - set of blanking pipes for turbocharger

Dual fuel diesel generator engines

Description	Quantity
Side Screw	4
Nut	8
Main Bearing Shell (upper)	4
Main Bearing Shell (Lower)	4
Cylinder Liner	4
Anti polishing ring	4
O-ring	8
Thrust bearing half	8
Bearing Shell	4
Bearing Bush	4
Stud	8
Gasket set	4
Connecting Rod Lower Part	3
Nut	4
Screw	4
Nut	4
Bearing Shell (upper part)	8

Bearing Shell (lower)	8
Shim	2
Connecting Rod Upper Part	3
Securing Ring	4
Piston Ring Set	12
Gudgeon Pin	4
Piston complete	6
Sealing set for cylinder head	6
Repair kit for cylinder head overhaul	6
Cylinder head	6
Set of exhaust valves	6
Set of inlet valves	4
Starting valve complete	4
Sealing set for starting valve	24
Push rod	8
Sealing ring	8
Bearing bush	8
Tappet roller	8
Roller pin	8
Valve tappet complete	8
Stud	60
Nut	60
Turbocharger rotating element	1
Turbocharger set of bearings	2
Turbocharger set of seals/gaskets	2
Camshaft piece	4
Camshaft piece	4
Gasket set complete	4
Pump element	24
Sealing set for pump overhaul	6
Injection pump complete	6
Injection valve complete	24
Sealing set	24
Connection piece	4
O-ring	1
O-ring	1
Main injection pipe complete	6
Service kit	2
Sealing set for thermostatic valve	2
Bellows	4+ 4
Sealing Ring	4
Solenoid valves	2

Limit switches	2
Relay card	2
NDE card	4
Voltage card	2
TC-card	2
Support ring	8
Guide ring	8
O-ring	16+8
Liquid level switch	2
Charge air cooler	2+2+2
Limit switch, engine overload	2
Limit switch	2
Speed pick-up	2
Pressure Transmitter	2
Knock Sensor	2
Starting Air Pressure Sensor	2
Engine Speed Pick-up	2
Temperature sensor, HT Water Engine Outlet	2
Temperature Sensor, Exhaust gas turbo outlet	2
Control Unit CCM-10	4
Control unit MCM-700	2
Pressure transmitter	2
Temperature Sensor	2 x 2
Quick Coupling	2
Sealing Set	2 x 5
Level Switch	2 x 2
Pressure Transmitter	2 x 9
Sealing Ring	48 + 96 + 96
O-ring	48 + 48 +(96 x 9)
Core Plug	96
Sealing set for pump overhaul	48
Plug	96
Nozzle	96
Gasket	12
Guide ring	48
Support Ring	96
Fresh air filter	24
Filter cartridge	208
Gas filter cartridge	12
Butterfly valve positioner	4
Gas admission valve complete	2

Guideline Specifications for 174,000cbm KOGAS LNG Project (2 Stroke Low Speed Diesel Engine)

Based on 4*V12, amounts shall need to be adjusted for final engine configuration

Shafting and Propeller

1 - set of spanner for propeller nut
1 - set spanner for coupling nut of each kind
1 - set of Maker's standard special tools for the stern tube sealing

Auxiliary Boiler (for one vessel)

1 - set of spanners each for glass water gauge, manhole, handhole and safety valve
1 - set of tube plugs, repair and renewal tools with hammer
24 - for each kind of tube plugs
100% of safety valve gags per boiler
1 set of lapping tools for valves
1 set of tools for cleaning of tube external and drum internal surface
1 electric portable ignitor
1 set of tools for burners (cleaning base, vice and burner wrench)
1 set for of removal tools for economizer welding part.
1 set of tools for soot blowers
1 standard pressure gauge
1 set of repairing tools for refractory

Emergency Diesel Generator Engine

1 - polishing tool for intake and exhaust valves

Auxiliary Machinery and Equipment

Control, ship service and starting air compressors for each type:

1 - piston set nut removing tool for control air compressor
1 - piston rod cap for control air compressor
1 - piston removing tool for control air compressor

Purifier

1 - dismantling stand
1 - bowl nut spanner
1 - disc nut spanner
1 - cap nut spanner
1 - lifting tool for vertical shaft
1 - lifting tool for bowl body
1 - set of other overhauling tools including jacks, push bolts, etc.

Heat Exchanger

Shell and tube type cooler, heater and distilling plant:

1 - set of tube expander for each tube size

1 - set of cleaning tool for each tube size

1 - set of overhauling tool for each tube size

Calibration testing tools for sensors(pressure, temperature, level) shall be supplied.

The testing tools for each kind of fire detectors (3 Sets) shall be supplied.

Other Auxiliary Machine and Equipment According to Maker's standard.