Table of Contents

1.0 Background

2.0 General description

The Basis of Design is premised on a shipyard designed and constructed vessel using internationally accepted industry practices and standards for an LNG Carrier. All materials and workmanship used in the construction of the vessel is to be of International shipbuilding and marine quality and to conform to the requirements of the Classification Society, the applicable Regulatory Authorities and Cargo containment system designers.

Shipyard to use recognized industry codes and standards for the work, where Government legislation, Flag State requirements, Classification Society Rules, this BOD, and the Shipyard's codes and working standards do not explicitly prescribe codes and standards.

The hull form, together with propulsion and power generation systems, shall be designed for maximum efficiency and fuel economy. Within the Ship Builders technical documentation, along with the usual Vessel plans, a detailed fuel consumption calculation, using both Fuel Gas (BOG) and Liquid Fuels, shall be submitted considering both laden and ballast voyages. The fuel consumption calculations shall include details of the savings in consumption for the use of any type of re-liquefaction system intended to be installed on the ship.

2.1 Abbreviations and Definitions

ABS	American Bureau of Shipping	BOD	Basis of Design
BOG	Boil off Gas	BOGR	Boil Off Gas Rate
BSRA	British Ship Research Association	CCTV	Closed Circuit Television
CTS	Custody Transfer System for measurement of LNG cargo	CCR	Cargo Control Room
dB(A)	'A' weighted decibel	DFDE	Dual Fuel Diesel Electric
DFT	Dry Film Thickness	DNVGL	Det Norske Veritas Germanischer Lloyd
ECR	Engine Control Room	ECDIS	Electronic Chart Display Information System
EPA	Environmental Protection Agency	EPIRB	Emergency Position Indicating Radio Beacon
ESD	Emergency Shut Down system	FFA	Fire Fighting Appliances
FMEA	Failure Mode and Effects Analysis	FEA	Finite Element Analysis

FW	Fresh Water	GCU	Gas Combustion Unit
GRP	Glass Reinforced Plastic	GTT	Gas Transport & Technigaz
GVU	Gas Valve Unit	IEC	International Electro technical Commission
IGC	International Gas Carrier	ISPS	International Code for Security of Ships and Port Facilities
ILLC	International Convention of Load Lines	ILO	International Labor Organization
IMO	International Maritime Organization	IGG	Inert Gas Generator
ISO	International Organization for Standardization	ITTC	International Tank Towing Conference
JT	Joule Thomson	kPaG	Kilo Pascal Gauge
LNG	Liquefied Natural Gas	LNGC	LNG Carrier
LRS	Lloyds Register of Shipping	LSA	Life Saving Appliances
ME-GI	Main Engine Gas Injection	MDO	Marine Diesel Oil
ME	Main Engine	Mlc	Meter Liquid Column
NCR	Normal Continuous Rating	OCIMF	Oil Companies International Marine Forum
PWM	Pulse Width Modulated		
SIGTTO	Society of International Gas Tanker and Terminal Operators	SMCR	Specified Maximum Continuous Rating
SOPEP	Shipboard Oil Pollution Emergency Plan	SUS	Stainless Steel per Japanese Industrial Standards
TMCP	Thermo-Mechanical Controlled Process	USCG	United States Coast Guard
VGP	Vessel General Permit	WHR	Waste Heat Recovery

2.2 Registry

The vessel to be registered with one of the major flags (Bahamas, Hellenic, Liberia, Marshall Islands, Panama, Qatar etc.) and is to satisfy applicable maritime rules and regulations for international trade and for entry into the ports specified by Owner (See Appendix A at the back).

Shipyard shall additionally provide list of other Loading and Discharge ports from Witherby's LNG Port Database where compatibility of the proposed vessel is acceptable with

- No restrictions.
- With gangway restrictions.

2.3 Classification and Regulations

The Vessel is to be built and classed in full compliance of either American Bureau of Shipping (ABS), Bureau Veritas (BV), Det Norske Veritas (DNV GL) or Lloyds Register of Shipping (LRS).

Selection of another Classification Society to consider its' LNG experience, knowledge of the Flag State requirements and sufficient presence of surveyors in the trading area and to be approved by Owner. The Class notation will depend on tank type but to be at least equivalent to the following:

- **American Bureau of Shipping (ABS) notation**: ✠ A1 , Liquefied natural gas carrier, Ship type 2G (Maximum pressure 35 kPaG and Minimum Temperature -163^{o}C), SH, SH-DLA, SHCM, AMS, ACCU, SFA(40), NBLES, ENVIRO, RRDA, CRC(SC), DFD, UWILD, BWT, RW, IHM, ESA, CPS, R2, F-AMC (without certification).

- **Bureau Veritas** I +HULL +MACH Liquefied gas carrier / Ship type 2G (Max. vapour pressure 0.35 bar, Min. temperature -163), -dualfuel, ESA, Unrestricted Navigation, +AUT-UMS, BWT, CLEANSHIP, CPS(WBT), GREENPASSPORT EU, INWATERSURVEY, LI-HG-S3, MON-SHAFT, +SYS-NEQ-1, +VeriSTAR-Hull CM FAT 40 years. . In addition, F-AMC (without certification).

- **Det Norske Veritas Germanischer Lloyd (DNV GL notation):** +1A1 Tanker for Liquefied Gas, NAUTICUS (newbuilding), PLUS-2, COAT-PSPC, CSA-2, HMON-1, OPP-F, FLS1, RSD, CMON, EO, NAUT-OC, UWILD, TMON, BWM T, LCS, Cyber security. In addition, F-AMC (without certification).

- **Lloyd's Register (LRS) notation**: ✠100A1 Liquefied Gas Tanker, Ship type 2G, Methane(LNG) in Membrane or Moss tanks, Maximum vapour pressure 35 kPaG, Minimum cargo temperature minus 163°C, ShipRight (ACS(B), SDA, FDA plus (40, WW), CM), ECO(BWT), CAC2**,** *IWS, LI, ✠ LMC, UMS, NAV1-IBS, BWTS, LFPF(GC, NG), PSMR, ShipRight (BWMP(S, T), IHM, SERS, SCM), ShaftRight[N], F-AMC (without certification).

The vessel should 'at least' comply with the following rules, regulations and requirements of the Authorities (with reference to Lloyds Register "Future IMO Legislation" latest edition) in force, and pending to be enforced in the next 8 years as on the date of the contract signing, or 5 years from Delivery, whichever comes later.

1. Maritime laws, Rules and Regulations of the Country or Registry government.
2. IMO: International Convention for the Safety of Life at Sea (SOLAS) Consolidated 1997, 2000 and subsequent amendments.
3. IMO: International Code for the Construction and Equipment of Ships Carrying Liquefied Gasses in Bulk (IGC Code), as revised by Resolution MSC 370(93) and amendments.
4. IMO: International Life-saving Appliances Code (LSA Code) 1997, adopted by Resolution MSC. 48(66) and amendments.
5. IMO: International Code for Fire Safety Systems (FSS Code), adopted by Resolution MSC. 98(73) and amendments.
6. IMO: International Convention on Load Lines 1966, with protocol of 1988 and its amendments.
7. IMO: International Convention on Tonnage Measurement of Ships, 1969 as amended by IMO Resolution A.1084 (28).
8. IMO: International Convention for prevention of Collisions at Sea, 1972 including all subsequent amendments.
9. IMO: International Convention for prevention of Pollution from Ships, 1973 (Annex 1, IV, V & VI), as modified by the Protocol of 1978 relating thereto and by the Protocol of 1997 and its amendments (herein called "MARPOL 73/78").

10. IMO: International Ship & Port Facility Security Code (ISPS Code), 2003; application to be limited to Ship Security Alert System and IMO number" under SOLAS section.
11. ILO Maritime Labour Convention (MLC), 2006 – Title 3 Regulation 3.1 & Standard A3.1- Accommodation and Recreational Facilities (including separate sanitary for male and female).
12. ILO Convention for all lifting appliances including engine lorry crane and lift - C152 - Occupational Safety and Health (Dock Work) Convention, 1979 (No. 152).
13. Rules of Navigation of Suez Canal Authority and tonnage regulations.
14. Rules of Navigation of the Panama Canal Authority including Regulations for the Measurement of Tonnage.
15. IMO: International Convention for the Control and Management of Ships' Ballast Water and Sediments (2004).
16. International Telecommunication Union (ITU) Radio Regulations, 2016.
17. Hong-Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009 and Inventory of Hazardous Materials in accordance with IMO Res. MEPC 269(68), "2015 Guidelines for the Development of the Inventory of Hazardous Materials")
18. EU: Regulation No 1257/2013 of the European Parliament and of the Council of 20 November 2013 'on ship recycling and amending Regulation (EC) 1013/2006 and Directive 2009/16/EC.
19. IMO: Res.MSC.215(82) "Performance Standard for Protective Coatings for dedicated seawater ballast tanks in all types of Ships and double-side spaces of Bulk Carriers" (PSPC) amended by MSC.1/Circ.1381 and Res.MSC.341(91).

The vessel to be built in compliance with the following Guidelines and Recommendations:

1. All applicable OCIMF recommendations, guidelines and standards.
    a. OCIMF Mooring Equipment guidelines, 4th Edition (2018).
    b. SIGTTO / OCIMF Manifold Recommendations for Liquefied Gas Carriers, 2018
    c. ICS / OCIMF / SIGTTO / CDI Ship-to-Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases 2013
    d. OCIMF Recommendations on Equipment for the Towing of Disabled Tankers, 1981 (incorporated in MEG3)
    e. OCIMF Effective mooring 2010
    f. OCIMF Guidelines and Recommendations for the Safe Mooring of Large Ships at Piers and Sea Islands, 1994 (including special conditions of the intended terminal).(Incorporated in MEG3)
    g. OCIMF, Recommendation for ships fittings for use with tugs, first edition 2002
    h. OCIMF: Guidance for hazard identification for use of and switching to low sulphur marine gas oil in auxiliary boilers and associated equipment on board tankers to meet requirements of the EU sulphur directive 2005/33/ec.
2. All applicable SIGTTO recommendations, guidelines and standards.

a. SIGTTO “ESD Arrangements and Linked Ship/Shore Systems for Liquefied Gas Carriers” 2009 and Addendum 2017.

b. SIGTTO Guidelines for the Alleviation of Excessive Surge Pressures on ESD FOR Liquefied Gas Transfer Systems 2018.

c. SIGTTO Guide for Purchasing High Modulus Synthetic Fibre Mooring Lines 2014.

d. SIGTTO LNG Marine Loading Arms and Manifold Draining, Purging and Disconnection Procedures. 2017.

e. SIGTTO Thermowells in LNG Carrier Liquid Lines 2011.

f. SIGTTO Guide for Planning Gas trials for LNG Vessels 2008.

g. SIGTTO The selection and Testing of Valves for LNG applications 2008.

h. SIGTTO Recommendations for the installation of Cargo Strainers on LNG Carriers

i. SIGTTO Port Information for LNG Export and Import Terminals.

j. SIGTTO recommendation on LNG Cargo Valves.

3. ICS Guide to Helicopter/Ship Operations, 4th edition, 2008 (Helicopter winching mark for Day Operation only – Motion monitoring and motion sensing system not to be applied).
4. IMPA: International Maritime Pilot’s Association Guidance for Naval Architects and Shipyards on the Provision of Pilot Boarding Arrangements 2012.& IMO Res. A.1045(27) as amended (Pilot Transfer Arrangements) & European Pilots Association Recommendations.
5. IMO: MSC.1/Circ.1387 “Revised Guidelines for the approval of fixed water-based local application fire-fighting systems for use in category A machinery spaces”.
6. IMO: Code on Alerts and Indicators, 2009 (IMO Resolution A. 1021(26)).
7. IMO: Code on Noise Levels on board Ships (Res.MSC.337 (91))
8. IMO: Resolution A343 (IX), “Recommendations on the method of measuring noise levels at listening posts”.
9. IMO: Resolution A601 (XV) “Provision and Display of Maneuvering Information Onboard Ships”.
10. IMO: Resolution A708 (XVII) “Navigation Bridge Visibility and Functions”.
11. IMO MSC Circular 982 “Guidelines on Ergonomic Criteria for Bridge Equipment and Layout”
12. IMO: Resolution MSC 137(76) “Standards for ship maneuverability”.
13. IMO: MSC Circular 1053, “Explanatory notes to the Standard for Ship Maneuverability”. (Latest edition).
14. IMO: Publication 978, “Performance Standards for Shipborne Radio communications and Navigational Equipment” (2016).
15. IMO Res.MSC.148(77) as amended by Res.MSC.430(98) "Revised performance standards for narrow-band direct-printing telegraph equipment for the reception of navigational and meteorological warnings and urgent information to ships (NAVTEX), as amended"

16. IMO Res.MSC.306(87) as amended by Res.MSC.431(98) "Revised performance standards for enhanced group call (EGC) equipment, as amended"
17. IMO: MEPC. 177(58) Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines (NOx Technical Code) and Amendments.
18. IMO: AFS Convention - The International Convention on the Control of Harmful Anti-Fouling Systems on Ships, 2001.
19. IMO: Res.MEPC.127(53), amended by Res.MEPC.306(73), Guidelines for ballast water management and development of ballast water management plans
20. BWM.2/Circ.62 (Guidance on contingency measures under the BWM Convention)
21. European Union Council directive 2005/33/EC amending 1999/32/EC of 26 April 1999 in relating to introduce 0.1% sulfur limit for marine fuel.
22. SOx emissions requirement of Californian Air Resource Board (CARB) - Code of California Regulations Title 13 - 13 CCR §2299.2 "Fuel Sulfur and Other Operational Requirements for Ocean-going Vessels within California Waters and 24 Nautical Miles of the California Baseline"
23. IMO Resolution MEPC.308(73) - 2018 Guidelines on the method of calculation of the attained EEDI for new ships.
24. IMO Resolution MEPC. 254(67) amended by Res.MEPC.261(68) and Res.MEPC.309(73) “2014 Guidelines on Survey and Certification of the Energy Efficiency Design Index (EEDI), as amended”
25. International Electro-Technical Commission (IEC) Publication 60092 “Electrical Installations in Ships”.
26. IEC 61439-1:2011 - Low voltage switchgear and control gear assemblies.
27. IEC 60079-10-1:2015 - Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres.
28. IEC 60092-502:1999 - Electrical installations in ships - Part 502: Tankers - Special features.
29. IEC 60079:2018 Series Explosive atmospheres.
30. IEC TR 61641:2014 - Enclosed low-voltage switchgear and control gear assemblies - Guide for testing under conditions of arcing due to internal fault.
31. IEC 60332:2019 Series - Tests on Electrical and Optical Cables under Fire Conditions.
32. IEC 60331-1:2018 - Tests for electric cables under fire conditions - Circuit integrity - Part 1:
33. IEC Publications 60533, “Electrical and Electronic installation on Ships – Electromagnetic compatibility”.
34. IEC 61363-1:1998 - Electrical installations of ships and mobile and fixed offshore units - Part 1: Procedures for calculating short-circuit currents in three-phase a.c.
35. ISO/IEC/IEEE 15288:2015 Systems and software engineering -- System life cycle processes.
36. ISO 484-1:2015; “Shipbuilding – Ship screw Propellers- Manufacturing tolerances – Part 1; Propellers diameters greater than 2.5m”.
37. ISO 2923:1996 / inc. Corr 1:1997; Acoustics – “Measurement of noise onboard vessels”.

38. ISO 6954:2000; “Mechanical Vibration – Guidelines for the Measurement, Reporting and Evaluation of Vibration with Regard to Habitability on Passenger and Merchant Ships”.
39. ISO 20283-5: 2016 – “Mechanical vibration - Measurement of vibration on ships - Part 5: Guidelines for measurement, evaluation and reporting of vibration with regard to habitability on passenger and merchant ships”.
40. ISO 10816 Mechanical vibration -- Evaluation of machine vibration by measurements on non-rotating parts:
    a. ISO 10816-1:2016 Mechanical vibration -- Measurement and evaluation of machine vibration -- Part 1: General guidelines
    b. ISO 10816-3:2009/Amd 1: 2017 Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ.
    c. ISO 10816-5 (2000, Mechanical vibration -- Evaluation of machine vibration by measurements on non-rotating parts -- Part 5: Machine sets in hydraulic power generating and pumping plants).
    d. ISO 10816-6:1995 Amd 1: 2015 Part 6: Reciprocating machines with power ratings above 100 kW.
41. ISO 4867-1984(E) and 4868-1984(E); Code for the measurement and reporting of local and global vibration data of ship structures and equipment.
42. VDI 2056 Criteria for Assessment of Mechanical Vibrations in Machines.
43. VDI 3838 2004 Measurement and evaluation of mechanical vibration of reciprocating piston engines and piston compressors with power ratings above 100 kW - Addition to DIN ISO 10 816-6.
44. ISO4406:2017; “Hydraulic Fluid Power – Fluids – Method for Coding the Level of Contamination by Solid Particles”.
45. ISO - 15748-1: 2002, Ships and Marine Technology - Potable water supply on ships and Marine structures. Part 1: Planning and design.
46. ISO - 15748-2: 2002, Ships and Marine Technology - Potable water supply on ships and Marine structures. Part 1: Method of calculation.
47. ISO 14276-1; Ships and Marine Technology — Identification colours for the content of piping systems — Part 1: Main colours and media.
48. ISO 17894; 2005 Ships and Marine Technology - “Computer Applications – General principles for development and use of programmable electronic systems in marine applications”.
49. ISO 11604, Ergonomic design of control centers parts 1-7, where appropriate.
50. ISO-7457:2002 incl. C1:2008, Ships and Marine Technology - Air-conditioning and ventilation of accommodation spaces - Design conditions and basis of calculations.
51. ISO 8862:1987 Air-conditioning and ventilation of machinery control-rooms on board ships -- Design conditions and basis of calculations
52. ISO 8864:1987 Air-conditioning and ventilation of wheelhouse on board ships -- Design conditions

53. ISO 9099:1987 Air-conditioning and ventilation of dry provision rooms on board ships -- Design conditions and basis of calculations.
54. ISO 8861:1998; “Engine room ventilation in diesel engine ships – Design requirements and basis of calculation” and Swedish Standard SIS 78 07 26.
55. ISO 15016:2002(E); Standards Analysis for Sea trials is applied as builder’s standard.
56. ISO 8573-1:2010; Compressed Air for General Use - contaminant and quality classes.
57. ISO 8309-1991; Refrigerated light hydrocarbon fluid measurement of liquid levels in tanks containing liquefied gases
58. ISO 18132-1:2006 Refrigerated light hydrocarbon fluids – General requirements for automatic level gauges.
59. SNAME Technical & Research Bulletin 3-39 “Guide for Shop and Installation Tests”
60. SNAME bulletin 3-47 “Guide for Sea Trials” to be applied as far as practicable but IMO Res. MSC 137(76) to be applied for manoeuvring sea trial.
61. SNAME Technical Bulletin 5-2; “Gas trials guide for LNG vessels”.
62. Japanese Shipbuilding Research Association (SPSS-1975) “Standard for Preparation of Steel Surface Prior to Painting” and the Swedish Standard SIS 05.59.00.
63. Sacrificial anodes to US. Military spec 18001H.
64. Montreal Protocol on ozone depleting chemicals.
65. GIIGNL - LNG Custody Transfer Handbook 2017 5th Edition.
66. ExxonMobil MESQAC 2017 and subsequent variants (Must and Strongly Preferred items applicable to Gas carriers to be applied)

The Shipyard to provide a Letter of Compliance from the Classification Society for the following requirements and recommendations of the US Coast Guard (USCG):

1. USCG Regulations for foreign flag Vessels operating in the navigable water of the U.S.A.:
    a. CFR Title 33-part 164: Navigation Safety Regulation
    b. CFR Title 33-Part 104: Vessel security assessment.
    c. (Only AIS (Automatic Identification System, SSAS (Ship Security Alert System) and IMO Number (Ship‘s Identification Number) shall be provided by the Builder)..
2. USCG Rules regarding Oil Pollution, Sanitation and Navigation Safety including; Any US - EPA rules applicable to foreign flag vessel calling US ports.
    a. Ballast Water Management (CFR title 33 - Part 151 subparts C &D : Articles for Performance of BWMS
    b. Ballast Water Shipboard Testing (CFR Title 46 - Part 162) Protocol for the Verification of Ballast Water Technologies (EPA/600/R-10/146)
3. CFR Title 46-part 154, excluding Alaska.
4. CFR Title 33-part 155: Oil Pollution Prevention Regulations of Vessels.

5. CFR Title 33-part 156: Oil and Hazardous Material Transfer Operation.
6. CFR Title 33-part 159: Marine Sanitation Devices.

2.4 Reliability:

The machinery and equipment supplied on the vessel to be sourced from proven vendors in the marine industry. Equipment capacities, Materials, Spares and Quality to be selected based on life cycle costs (CAPEX + OPEX) rather than solely initial cost (CAPEX) and with worldwide coverage for spare parts and after sales services availability. The latest technology applicable to the machinery and equipment is to be supplied to the vessel. New equipment or designs to be introduced only with the agreement of the Purchaser following demonstration of appropriate due diligence being undertaken or technical qualification applied to a degree agreed with the Purchaser.

2.5 Material and workmanship:

The vessel is to be built in accordance with the latest shipbuilding practice and all workmanship to be accepted by the Classification Society and Purchaser.

- The vessel's Materials, Construction, and System installations to be tested, commissioned, and demonstrated to satisfy Classification Society and Flag State requirements. This is to include shop / factory, shipyard, dock, sea, and gas testing & trials;

- All materials used for construction of the vessel and its machinery, including forgings and castings, shall be of internationally accepted Shipbuilding and marine quality, and shall conform to the requirements of the Classification Society (Class), the applicable regulatory authorities and the cargo containment system designers, and to be physically and chemically in conformity with their requirements.

- All materials and equipment furnished by the Shipyard to be new and unused and designed to minimize degradation through corrosion and fatigue damage for a service life of 40 years. The shipyard to preserve and maintain all materials and equipment per the supplier's recommendations until the vessel delivery to the purchaser.

2.6 Dry Docking

- The Vessel shall be dry-docked within the 3 weeks before the commencement of sea trials for hull preparation and final anti fouling coating completed as well as propeller cleaned.

2.7 Measurement units:

- Metric (SI) System to be adopted for the design and construction of hull, machinery and equipment unless otherwise specified in the Specifications.

2.8 Identification of equipment:

- All units of equipment installed in the Vessel to be identified by name and, in case of multiple units, by name and numeral.

2.9 Spare Parts, Tools and Accessories:

- Spare parts, tools and accessories for the machinery and equipment to be supplied in accordance with the manufacturer's standards covering the recommendation of Classification Society and regulatory bodies

2.10 Vessel Model:

- One vessel model (scale 1:200) per each vessel to be delivered onboard upon delivery of the vessel.

3.0 General description/requirements:

- The vessel to be a Panama and Suez canal compliant ocean going LNGC for world-wide trading, with a containment system designed for a gross capacity of approx. 174,000 m^3 LNG (500 kg/m^3), when calculated at 100% volume, excluding liquid and gas domes, if any, and LNG temperature of -163^oC.

Principal Dimensions (approximate for guidance only):

Length overall	< 300.00 m
Breadth, molded	To be advised by Shipyard
Depth, molded	To be advised by Shipyard
Draught at summer freeboard (Extreme)	12.00 m
Designed draught, mld.	11.5 m
Scantling draught, mld	12.5 m
Deadweight	To be advised by Shipyard
Displacement	To be advised by Shipyard
Brake Horse Power (KW) @ MCR	To be advised by Shipyard
Brake Horse Power (KW) @ NCR	To be advised by Shipyard
Daily Gas and Fuel Consumption	To be advised by Shipyard

- The vessel to have a raked stem with optimized bulbous bow, a transom stern and a continuous upper deck; sunken aft deck is accepted.

- Vessel to have Fore peak void space and Aft peak ballast tank, Cargo tanks, Segregated ballast tanks, Fuel tanks, Cofferdams and Engine room. Underdeck trunk deck passageways to be provided port and starboard side for access over the cargo tank length.

- Scantlings of the structural members to comply with Class requirements based upon the 40 year world-wide fatigue specified, and scantlings not specified in the rules to be in accordance with the Shipyard's practice and approved by the purchaser.

- Coating Technical File (CTF) shall be approved by the Classification Society and the Purchasers before steel cutting.

- The Ballast system to be designed to allow concurrent de-ballasting during cargo loading or ballasting during discharge without at any time exceeding the max and min draught limits.

- In the base case, Vessel propulsion to be twin screw powered with dual fuel engines. Cargo BOG to be the primary fuel, and compliant fuel oil (fully compliant with 0.5% Global Maximum Sulphur and other restricted local regulations when entering at those applicable terminals) for pilot fuel or other operation, when LNG is not available. The minimum operational limits of the engines for gas consumption shall be provided.

- Two sets of full spade rudder or high lift section with a bulb to be provided.

- Alternatively, if a single skeg design is offered by the Shipyard, it will be considered.

3.1: Speed & Range:

- The maximum service speed of the vessel to be not less than 19.5 knots at the even keel laden draught and seawater temperature of 34^{o}C.

- Above speed guaranteed at Normal Continuous Rating (NCR) with clean bottom in calm water in deep sea conditions and a sea margin of 21% (unused).

- The cruising range to be 10,000 nautical miles plus five days margin in Tier II fuel mode.

3.2: Fatigue Life:

- Vessel to be designed for 40-year world-wide fatigue life (50% in Laden, 50% in ballast), for international trade.

- Fatigue Life criteria of the Pump Tower as required by IGC Code.

3.3: Vibration analysis:

- Vibration levels in the accommodation and working spaces during normal operating conditions to be within the range given by the lower limit in the ISO 20283-5:2016 and ISO 6954:2000 Guidelines. The vibration analysis should also comply with the vibration criteria of the Pump Tower specified by the Class.

- Design peak vibration velocities in living spaces to not exceed 1.5 mm/s over the frequency range 1-100 Hz.

- A vibration response analysis of the complete vessel by finite element analysis, independently assessed and analyzed by an experienced third party, to predict the vibration characteristics of the following main structural arrangements and interactions:

    - Hull
    - Deck house and Engine casing
    - Bridge wings
    - Radar masts
    - Pipe towers within cargo tanks
    - Cargo Compressor Room

- The analysis to include local areas and local equipment including Superstructures, local panels, Radar mast, Funnel, Steering gear space, Tanks in aft body and Main hull.

- Particular attention and assessment shall be undertaken by the shipyard to reduce vibrations caused by the propeller and/or machinery.

- Fixed vibration monitoring system to be provided for High Duty Compressors, Fuel Gas Compressors, Gas Combustion Unit (GCU) fans, Reliquefaction system Compander (where fitted). Portable vibration monitoring system to be provided for monitoring all motors and rotating equipment above 5 KW.

3.4: Noise levels:

- Noise levels under NCR conditions not to 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	55 dB(A)
Engine room excluding generator engine rooms	100 dB(A)
Generator rooms	110 dB(A)

- All other areas to comply with the IMO Code on Noise Levels on board ships (Res. MSC 337 (91))

- The noise attenuation rating of bulkheads to be at least 45 dB(A) between each cabin and between cabins and public spaces.

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

- In any case, reference also to be made to South Hook terminal noise restrictions for compliance.

3.5 Model testing:

- Model tests to be performed with the final hull form in design, scantling and ballast draught conditions and to determine data for the EEDI at an internationally recognized facility that employs ITTC recommended procedures for model testing & data processing, if the same has not been carried out previously for the design.

- Model tests should cover a range of speeds between slow speed and maximum ballast speed in increments of 1 knot in both the ballast and design draughts

- The tests to verify the design performance in the following areas:

    - Resistance in air and water (via towing tank resistance and wind tunnel tests)
    - Self-propulsion (in still water and in waves)
    - Flow-line
    - Cavitation
    - Wake
    - Sea keeping
    - Maneuvering (free sailing maneuvering tests)

3.6 Inspection, Tests and Trials

- All tests and trials to be carried out in accordance with the requirements of the Class and other regulatory bodies.

- An inclining experiment and a lightweight measurement to be carried out at the Builder's quay; the procedure and calculations to be approved by the Classification societies and the Purchaser.

- Shop trials except for those which are agreed between the Purchaser and Shipyard, to be carried out by the Maker on their responsibility without attendance of the Purchaser.

- Shop trials shall be carried out in accordance with the SNAME Technical Bulletin C-8 "Code on Installation and Shop Tests 3-39 Guide for Shop and Installation Tests". Specific Fuel Consumption shall be measured for each load test interval of 60 minutes using calibrated and certified equipment.

- Commissioning of all equipment, excluding cargo systems to be carried out to the Purchaser's satisfaction prior to sea trials. This is to include a dock trial with main propulsion plant developing at least 10% SMCR. As far as practicable, correct functioning of all equipment to be demonstrated in normal operating condition to Purchasers satisfaction.

- In ballast condition (identical to that of the model test), Sea trials to be conducted in Deep water with weather conditions not exceeding Beaufort **4** and tidal stream in tidal area not exceeding 0.5 m/sec. The progressive speed trial to consist of one double run (alternating in direction) at each main engine load of 30%, 50%, 70%, NCR and MCR with fuel oil consumption rate measured over a 2 hour run at each power level.

- Maneuvering trials to be conducted as IMO resolution MSC 137 (76) and MSC circular 1053, and to include Crash stop astern and ahead, Turning tests, Inertia tests, Zig-zag maneuvering test ($10^o/10^o$, $20^o/20^o$) and Minimum revolution tests.

- Endurance tests for 12 hours (8 hours at SMCR and 4 hours at NCR), during which fuel consumption data is to be collected and reported. In addition, a UMS test of 4 hours shall be required at some time during the Endurance test period. Fuel consumption tests for subsequent vessels will be conducted at 50% and 75% SMCR and Astern conditions. Post sea trials inspection of major propulsion and power equipment is to be conducted.

- Separate Endurance tests for 12 hours (8 hours at SMCR and 4 hours at NCR) on gas and trials to be conducted to confirm correct function and capacity of cargo handling equipment, propulsion and power equipment using LNG. In addition, a UMS test of 4 hours shall be required at some time during the Endurance test period. Suitable quantity of LNG to be loaded and paid for by the Shipyard. The Cargo tanks will be inerted, supplied by Vessel's Inert gas generator, and barrier spaces be filled with Nitrogen. Main engine fuel gas compressor tuning and progressive speed trial to confirm Main engine operation (50%, 75% SMCR and Astern) shall be replicated as before.

- During Gas Trials the commissioning of the GCU shall be carried out including normal and emergency (free flow) burning conditions.

- A Hammer Test on the Pump Tower and the Vibration measurement on the Pump Tower during the Sea Trials.

3.7 Accommodation:

- Accommodation will be built to CAC 2 of Lloyd's Register or similar requirements.

- Accommodation adequate for 34 persons, with necessary facilities for both male and female crew. In addition one cabin for six (6) Suez Canal Workers with three 2-tier beds and a shower/toilet to be provided. All spaces in accommodation to be provided with 2,200 mm free height. Safety equipment to be provided for the total persons including Suez Crew (40 persons).

- Administrative and Recreation facilities to commensurate for the total complement. These to include Officers and Crew mess rooms, Officers and Crew lounge, Gymnasium, Control rooms, cargo Office, Engine Office, Conference/Administration office, Wheelhouse / Chart room, Emergency Diesel generator room, Electrical equipment room, Fire Control room, Passage ways and Stairways, Public and Private toilet spaces, Hospital toilet, Laundry and Drying rooms, Galley and Pantry, Dry provisions stores, Refrigeration spaces, bonded stores, Changing rooms, Air Conditioning Handling Unit room, Miscellaneous stores and lockers.

- Machinery casing not to be integrated into accommodation deckhouse.

- Galley equipment, Pantry equipment, and Laundry equipment to all be heavy duty marine grade.

- One elevator for 8 people (600 kg) to be provided from Engine room bottom floor to the deck below Navigation bridge deck.

- A Citadel to be provided onboard within the steering gear room and to be discussed and finalized with the Purchasers

3.7.1 Air conditioning system

- 2 x 50% central Heat Ventilation and Air Conditioning (HVAC) system to be provided for all of accommodation block spaces, Electrical switchboard rooms, Engine control room, cargo control room, Engine room workshops and Equipment rooms. Refrigerant to be in compliance with Montreal protocol and approved by the Purchaser. Design conditions to consider summer 45^{o}C / 80% RH (outside) and 25^{o}C / 50% RH (inside), and winter -15^{o}C (outside) and 22^{o}C / 50% RH (inside) at fresh water cooling temperature of 36^{o}C. Air changes rate to be 6x/hr. for living spaces, 8x/hr. for public spaces and 15x/hr. for Bridge and Navigation equipment room.

- Two sets of Self-contained package unit air conditioning units, 100% capacity each to be supplied for
  - ECR (30,000 kcal/hr.),
  - Electrical switchboard rooms (45,000 kcal/hr.)

- One package unit to be provided for
  - Engineer's workshop (45,000 kCal/hr.),
  - Cargo Control Room (9000 kcal/hr.) as back up to Main AC system.
  - Galley (15,000 kcal/hr.) as back up to Main AC system.
  - Electric equipment room (10,000 kcal/hr.) as back up to Main AC system.
  - Cargo Switchboard rooms as back up to Main AC system.
  - Wheelhouse including Chart room, as back up to Main AC system.

- The capacities of the self-contained A/C units shall ensure the ambient conditions above can be met

- Mechanical ventilation to be provided for Mess rooms, Recreation rooms, Gymnasiums, Hospital, AHU room, Elevator machinery room, Galley, Emergency Generator room, High Expansion foam room, Laundry, Toilets, Lockers and Stores. Spaces which are neither air conditioned nor mechanically ventilated to be naturally ventilated.

3.7.2 Refrigerated Provision system

- Following chambers to be provided for freezing and refrigeration of provisions
  - Meat room -25^{o}C 30 m^{3}
  - Deep freeze room -25^{o}C 25 m^{3}
  - Vegetable room +2^{o}C 30 m^{3}
  - Dairy room +2^{o}C 20 m^{3}
  - Handling space +4^{o}C 15 m^{3}
  - Dry provisions +18^{o}C 120 m^{3}

- The cooling system to be an R-407F direct expansion with automatic control capability. Two sets of refrigeration units, 100% capacity each with one running for no longer than 16 hours a day at 36^{o}C Fresh water cooling temperature and outside temperature of 45^{o}C.

3.8 Radio and Navigation System:

- The Navigation & communication equipment to be provided in accordance with LRS NAV1-IBS notation.

- The extent and layout of navigation and communication equipment to be suitable for one-man bridge operations.

- The following equipment to be part of Navigation and Communication systems:

    - 1 x Hybrid type (supporting analog and IP telephone) automatic telephone system (at least 90 stations capacity)
    - 1 x Sound powered telephone system (at least 21 stations)
    - 1 x Public Address/general alarm & talkback system
    - 4 x Portable UHF transceiver (I.S. type)
    - 1 x Fleet Broadband 500 with facsimile
    - 2 x Gyro compass
    - 1 x Adaptive auto pilot with rate of turn indicator
    - 2 x Marine radar with ARPA (X-band, S-band); 3rd radar (X-band) on foremast in case of a MOSS type containment system vessel
    - 2 x ECDIS with route planning function
    - 1 x Conning display unit
    - 2 x DGPS navigator
    - 1 x Magnetic compass, transmitting type
    - 1 x Speed log system
    - 1 x Echo sounder with shallow depth alarm
    - 1 x Weather facsimile
    - 1 x Anemometer and anemoscope
    - 2 x Rudder angle indicator system
    - 1 x Automatic identification system
    - 1 x Long range identification and tracking system
    - 1 x Voyage data recorder with float-free type capsule
    - 1 x Independent type LRIT system in citadel
    - 1 x Iridium phone system in citadel
    - Radio equipment (GMDSS): A1, A2 and A3 area and shore based maintenance
    - 2 x Satellite communication equipment (standard-C); Ship security alert system to be incorporated in one (1) Inmarsat-C.
    - 1 x MF/HF radio
    - 3 x VHF radio telephone (2 x wheelhouse, 1 x Citadel, One remote controller in CCR)
    - 1 x Navtex
    - 1 x Satellite EPIRB
    - 2 x Search and rescue locating device
    - 3 x Portable VHF transceiver

4.0 Materials and Equipment:

- The Shipyard to provide a complete list of Equipment Make and Model that will be installed onboard, and to procure all materials and equipment from sources specified on the final mutually agreed “Makers List” which is to be an integral part of the Contract Specification. If the Shipyard subsequently wishes to add to the agreed list, the Purchaser’s written agreement to be obtained before going out for enquiries.

- Equipment and materials of construction to be chosen to provide a minimum 25-year service life (i.e. Suppliers and equipment to be confirmed as being fully supported for after sales service and spare parts for a period of at least 25 years), when a suitable marine based maintenance program is utilized.

- The Shipyard to propose only those vendors who are properly equipped to meet the requirements of the Project Specification with proven in service experience on LNGC vessels.

- Materials to be tested, inspected and certified by Classification Society and other regulatory bodies concerned.

- The use of materials compulsorily legislated by International Codes & Regulations such as asbestos, shall be strictly prohibited in the manufacture of any part of the Vessel including items and equipment brought in from subcontractors. MSC Res. A962 (23) Guidelines on Ship Recycling as amended by A.980 (24) and ShipRight (IHM) to be applied or ECO (IHM) Notation or equivalent should be considered.

- The term “asbestos free” means clearly a zero percent asbestos content in any part of the vessel, its components and equipment and parts. If asbestos is detected in any part, component or material supplied to the vessel it shall be replaced and its original supplier will be held responsible for its replacement and any incidental costs. Random sampling of materials and products may be undertaken.

- For reasons of standardization, the Shipyard to select sources for materials in such a manner that the variety of types is restricted as far as possible. The Shipyard to aim at selecting a single vendor for similar types of equipment, such as firefighting 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 to 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.

- Preliminary list of proven Suppliers for Design selection purposes is as follows:

Coatings	International Paints, Jotun paints
Cargo Compressors	Atlas Copco, Cryostar
Fuel gas Compressors	Atlas Copco, Burkhardt, Cryostar
Gas Combustion Unit	Hamworthy KSE, Saacke GmBH, Wartsila Moss
Custody Transfer System	Kongsberg, SAAB

Dual Fuel Engines	MAN B&W, WinGD X-DF, Wartsila
Integrated Automation Systems	Kongsberg AS, Honeywell
Cargo Pumps	Ebara, Shinko
Boilers	Saacke
Gas detection System	Consilium, Salwico
Nitrogen Generator	Air Products,
Reliquefaction Plant	Wartsila, Air Liquide, DSME(PRS/FRS)

4.1. Materials list:

- Materials for piping systems and equipment to be selected with a view to minimizing in-service maintenance.

- Unless stated otherwise in this specification, pipes and valves material selection to be in accordance with Table below or better. Equivalents may be proposed, but acceptance will be subject to purchaser's approval on a case-by-case basis.

SYSTEM	PIPELINE	VALVES
Water Ballast Lines	Glass Reinforced Plastic (GRP) external to engine room. Polyethylene lined steel inside engine room.	Rubber Lined cast steel with Ni-Al bronze disc
Cargo Lines in Tank	Stainless steel 304L or Al 5084 dependent on containment system design; Sch. 10S	Cast stainless steel CF3M or CF8M
Cargo Lines on Deck	Stainless steel 316L LR grade 904 or equivalent; Sch. 10S	Cast stainless steel CF3M or CF8M
Inert Gas Lines	Stainless Steel 316L on deck and Hot-dip galvanized mild steel under deck; Sch. 10S	Rubber Lined cast steel
Hydraulic Lines	90/10 Cu-Ni or TUNGUM or duplex stainless steel	Ni-Al bronze (or compatible grade of duplex SS option)
Nitrogen Lines – Insulation spaces and Deck	Stainless steel 316L LR grade 904 or equivalent	Cast stainless steel CF3M or CF8M
Control Lines	90/10 Cu-Ni with polyethylene external coating	Ni-Al bronze (or compatible grade of duplex SS option)
Fire main	Solid drawn 90/10 Cu-Ni or polyethylene lined steel	Gunmetal with Ni-Al bronze disc
Water Spray System	Solid drawn 90/10 Cu-Ni	Gunmetal with Ni-Al bronze disc
Glycol water heating	ERW STPG370; Sch.40, aluminised inside	
Sea Water Cooling System	GRP or polyethylene lined steel for 65ND and above 90/10 Cu-Ni for 50ND and below	Cast steel with rubber lining with Ni-Al bronze disc (bronze body <200 mm)
Fresh Water Cooling System	ERW STPG370; Sch.40, galvanised	Bronze with bronze disc.
Fuel and Gas oil	SMLS STPG370; Sch.40	Cast steel with stainless steel disc.
Fuel Gas Pipes and Double wall piping	In accordance with Engine Makers recommendations and Class Approval	

Steam, 7kg/m^2 and below	SMLS STPG370; Sch.40	Cast steel with stainless steel disc.
Compressed air	SMLS STPG; Sch.40 galvanised	Cast steel with stainless steel disc.
Bilge System	Schedule 80 hot-dip galvanized mild steel	Cast bronze with Ni-Al bronze disc & stainless steel spindle
Domestic water system	SMLS Copper or PVC	Bronze
Fresh Water Pipes < 25 mm diameter	SMLS Copper	Bronze
Compressed Gas Pipeline < 25mm	90/10 Cu-Ni or TUNGUM or duplex stainless steel	Ni-Al bronze (or compatible grade of duplex stainless steel)
Air Vents	ERW STPG370; Sch.40 galvanised	
Scupper Pipes	GRP or extra heavy gauge galvanized steel. Accommodation external scuppers, to be synthetic material construction. Only to be applied in areas not subject to sea loading.	Heavy gauge bronze
Hypochlorite Injection System	Braided nylon or vinyl ester resin GRP and titanium injection pipes.	Titanium or FEP coated ductile iron

- Instrumentation and electrical equipment on deck and in open areas, including ventilation equipment spaces with external openings, to be constructed of non-corroding materials, which may include stainless steel (316L) or copper alloys. Aluminum and Aluminum alloy not to be used.

- Cast Iron valves to be discouraged but may only be considered on a case by case basis.

5.0 Hull:

5.1. General

Vessel to have sufficient hull girder strength and ballast capacity aft to avoid sagging limits over the range of 0-100% bunkers.

- Vessel to have sufficient stability in all conditions, including the simultaneous handling of cargo and ballast and bunker operations during loading and unloading operations. Hull to be designed, where possible for no limitations in loading patterns. Where unavoidable, these to be clearly identified and approved by the Classification Society. Except for the possible limitations to prevent sloshing damages within the vessel's cargo containment system, the vessel shall be capable of departure from berth at any state of loading.

- IMO 2008 IS code - International Code on Intact Stability, 2008 (except Part A, Ch.1.2 Dynamic Stability Phenomena in Waves) to also be applied.

- The hull shape has to be optimized for economical gas consumption in the higher speed range i.e. 15 knots to 18 Knots laden & ballast.

5.2. Scantlings

- Scantling calculations (Main deck and Cargo tank area) to be submitted to Purchaser for reference, with both actual scantling and Class requirement. Damage strength to be investigated as per IMO required damaged condition.

- Ballast tank structural steel thickness to exceed 11 mm, and inner hull plating to exceed 13 mm thickness to prevent ballast tank paint damage from welding of stud bolts.

- Slamming pressures calculated from sea keeping tests to be used in determining the minimum scantlings for forward bottom and bow flare shell plating and associated structure, for meeting the severest requirements of the three Classification societies.

- Scantling calculations to be submitted to Buyers, approved by Class, to demonstrate that the maximum stress levels defined by Cargo Containment Designers for the inner hull are not exceeding at any loading conditions, including ballast and any alternate cargo tank loading conditions. Stress levels in the inner hull not to exceed 90% of the limits defined by the Cargo Containment Designers.

- For scantling of the tug push up areas refer to section 5.4

- The hull scantlings on the flat side to be adequate to accept a fender reaction load of not less than 20 tons/ m^2.

5.3. Structural Analysis

- Structural analysis calculations, using finite element analysis ('FEA') methods, to be carried out for the vessel's main hull structure, including the structural integration of the trunk deck. The Shipyard to include a list of the local areas that will be analyzed through FEA methods verifying that the long-term structural performance satisfies the service life requirement on the trading routes specified by the Classification Society default trading routes. FEA stress levels not to exceed 90% of yield or that percentage of yield proposed by the Classification Society, whichever is more onerous. No rounding of analysis to be allowed.

- The structural analysis is to be carried out for a life span of 25 years for fatigue and corrosion margins based on a world-wide trading pattern of the Classification Society. In addition to this, an additional trading route specified by the Purchaser will also be assessed on the same basis which will be defined in due course.

- The Structural Analysis of the hull shall include the excitations (including phase angles) at the top and bottom location of the pump tower in Cargo Tank No. 4, for the RPM range specified in the Pump Tower procedure.

- Resistance against collision in the cargo block to be investigated and energy absorption to be determined, and calculations to be submitted to the Purchasers.

- The outcome of the Structural analysis shall be discussed at a three party joint meeting between the Purchaser, the Shipyard and the Classification society.

- A detailed construction plan for those locations identified as Critical Joints to be prepared by the Builders and submitted for approval to Classification and Buyers. Construction records shall be maintained through the new building. The vessel is to be constructed in accordance with LR Class notation ShipRight (CM), or equivalent.

5.4. Construction

- Hull material to comply with requirements of the IGC code and Classification society rules. The main hull structure and tank cover plates to be of mild steel construction except that consideration may be given to use of higher tensile steel in limited locations at deck and bottom plating, and associated longitudinals. The need for High Tensile (HT) steel to be minimized, clearly identified and designed in accordance with specified fatigue life. If the design requires higher than 30% HT steel, Purchaser to be consulted. Thermo-Mechanical Controlled Process (TMCP) steel to be avoided if possible and only used if fully coated.

- Structural steel to be in strict accordance with Class requirements regarding under rolling tolerances i.e. Cargo tank boundary plates to be controlled so that average thickness of each steel plate is equal or greater than the nominal thickness.

- Ambient conditions applied for temperature distribution analysis to meet the Class requirements of -18^{o}C air temperature for internal structure, 5^{o}C air temperature for external hull structure at 5 knots wind speed and 0^{o}C sea water temperature.

- Structure contiguous to the cargo containment system is to be in accordance with USCG Requirements.

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

    - Side shell longitudinal connections to frames and bulkheads
    - Bulkhead connections to the inner bottom and Main deck.
    - Horizontal Stringer end connections.
    - Knuckle arrangements in hopper and chamfers.
    - Foundation decks.
    - Corners of domes, or any large openings on deck.
    - Trunk deck scarfing etc., including doors and windows in stress path
    - Intersection of ring girder under tank skirt with transverse frame, including support brackets for Moss designs.

- Continuity of primary longitudinal structure to be maintained as far forward and as far aft as practicable, into the machinery space and the superstructure. Longitudinals not to terminate at bulkheads. Plates to be tapered using Classification methods, to within +/-3 mm, but where found necessary, soft toe, soft heel or equal leg size brackets to be sued at the junction of longitudinal and transverse structures.

- The quality of materials used for flanged knuckles to be specially considered. Transverse watertight bulkheads dividing holds to be of the flat plate type with vertical stiffeners. Within the water ballast tanks, all edges shall be three pass ground to facilitate correct application of the protective coatings in accordance with PSPC requirements.

- For Membrane vessels, full penetration welds to be used for all the applicable connections of the inner hull structure supporting cargo containment system, the use of partial penetration welds to be eliminated whenever possible.

- Steel bulwarks, of about 1.1m height, to be fitted on forward mooring deck to protect machinery at the bow and around the bridge wings. Breakwaters to be fitted where necessary, for example, to protect lifesaving equipment located on open deck and afford protection to exposed companionway entrances.

- Suitable access for operational and maintenance purposes to be provided to all pipe and cable runs, to all valves and to bridge and accommodation windows. Exposed vertical ladders (only to be used where inclined ladders with handrails are impractical) to have safety hoops or, if over 3 meters high, protective cages. All openings in railings in way of vertical ladders to be provided with a hinged bar arrangement at the upper railing course and chain / snap-hook arrangements at the intermediate and lower courses (if fitted) to prevent personnel from falling through the opening.

- Five areas of shell plating on each side of the vessel shall be internally reinforced from below the normal ballast line to one (1) metre above the scantling draught and marked for tug pushing. Marking shall be arranged on side shell and main deck.

- The pushing force of each tug is expected to be one hundred (100) tons with a contact area about 3.0m x 0.7m. The mooring fenders shall be designed to keep the pressure against the vessel's hull below 30 tons/ m^2. Reinforcement calculations shall be done according to this value.

- For the safe handling and securing of tug lines at normal in-port condition and also abnormal disabled condition of the vessel, at least fourteen sunken bitts to be provided at suitable heights and positions on the side shell, arranged in pairs (3 along each side and 1 in the transom), capable of handling a 10 inch towing hawser and a snatch load of 150 tons. .

- All weld examinations to be made by radiography, ultrasound or other equivalent techniques in accordance with Classification Society requirements. Purchaser seeks additional 10% allowance on all such tests. Where defects are found, Purchaser may increase the scope of additional testing on Shipyard’s account. All manual and semi-automatic welds part of the boundaries between inner hull and adjacent spaces to be 100% NDE tested using volumetric technique where possible and Magnetic Particle Inspection (MPI) examination for those non full penetration welds.

5.5. Hull Protection

- Real time hull stress monitoring and warning system to be provided.

- Surface of the all structural steel plates and, sections to be blasted and coated with one (1) coat of approx. 15 microns inorganic zinc silicate type shop primer. Pipelines etc. to be prepared/ground, blasted and coated in according to Shipyard's practice and the Paint manufacturer specification, to meet the intended design life for the coatings and hull structure.

- Coating preparation for water ballast tanks to be carried out in compliance with IMO Resolution MSC 215 (82) on Protective coatings. A minimum of two full coats of light coloured aluminum (minimum 9% by weight) pigmented pure epoxy to a minimum DFT 350 µm and two stripe coats with a minimum design life of 10 years. Ballast tanks to be protected by Zinc anodes for a 10 year life at a mean current density of 5 mA/ m^2 at ballast residence time of 50%.

- External hull to be protected by a suitable thyristor controlled impressed current system (ICCP), one forward and one aft with mean current density of 40mA/ m^2. Zinc anodes with a mean current density of 5mA/ m^2.

- Hull external coating will follow a 5-year protection cycle using fluoropolymer paint scheme. Hull roughness of underwater areas not to exceed 125 microns by BSRA hull roughness analyser method. The coatings supplier and Shipyard to provide the necessary extended warranty of five (5) years for the anti-fouling.

- Exposed decks, fittings and machinery to be coated with a minimum of two coats of aluminum pigmented pure epoxy and two coats of pure epoxy finish to a total DFT of 350 µm.

- External structure to be coated with two coats of aluminum pigmented pure epoxy and two coats of polyurethane acrylic finish to a total of Exposed decks, fittings and machinery to be coated with a minimum of two coats of aluminum pigmented pure epoxy and two coats of pure epoxy finish to a total DFT of 300 µm.

6.0. Hull Outfitting & Deck Machinery

- In accordance with the rules, Two Electro-hydraulic driven 2 x ram, 4 x cylinder type Steering gear units with 100% redundancy to be provided. Each Steering gear to be provided with 2 x 100% redundancy power actuating hydraulic systems, and will be split between Main and Emergency switchboard. The travel of the Steering gear will be designed such that rudder can be put to hard port or starboard at
    - 35^o at SMCR power in laden condition.
    - 45^o at all reduced speeds below 12 knots.

- Deck machinery to be designed, approved and constructed to satisfy OCIMF's Mooring Equipment Guidelines – revision 4. Anchoring and Mooring machinery to be of Split drum type, Electro-hydraulic driven, low pressure, non-auto tension, suitable for 44 mm diameter HMPE

rope x 275 mtrs. long. All mooring winches to be fitted with a manual band brake whilst Hydraulic band brake to be provided on Cable lifters. The brake drum surface lining on all the machines will be of Stainless steel (SUS 304) construction. Suitable Brake testing kit is to be provided.

- Windlass — Two nos. 30 tons x 15m/min units; 1 x Cable lifter + 2 x Mooring drum + 1 x Warping head each
- Mooring winches — Six nos. 30 tons x 15m/min units; 2 x Mooring drums + 1 x Warping head each
  Two nos. 30 tons x 15m/min units; 2 x Mooring drums each
- Mooring ropes — Twenty x 44 diameter x 275 mtrs long HMPE ropes.

- Two High holding type, stockless Anchors manufactured from Cast steel to be installed. The diameter and length of anchor chain to be one grade higher than the requirements of the Classification society. Specified anchorage depth is 110 mtrs. One set of chain compressors to be arranged between the hawse pipe and the windlass.

- Deck Hydraulic unit to be of low pressure type, with two independent groups located in the forward and aft part. Each group to consist of 2 x 100% electrically driven power packs, cross connected. Fore power pack rated to allow at least heaving the anchor at 12 m/min with one power pack on, or two mooring winches at rated load.

- One set of closed chock and strong point, each having a minimum SWL of 200 tons, pick up gear towing pennant and stowage drum for stern to be provided. Two x 42 mm diameter x 100 mtrs. long steel wire (MBL approx. 125 MT) with pneumatic driven stowage reel to be provided.

- All mooring equipment and fittings **to** be designed, constructed and fitted in accordance with ISO standards and to the latest OCIMF recommendations for LNG carriers, allowing for wind speeds of up to 60 knots.

- One set of chain stopper (200 tons SWL) and chafe chain (76 mm diameter x 8 mtr. long, grade 3) for bow Emergency towing to be provided.

- Mooring arrangements, where practicable, to be optimized for Ship to Ship Transfer (STS) operations

- The following lifting gear equipment to be provided:

Manifold Crane	2 x Electrohydraulic, luffing single jib type, 10 tons SWL x 10 m/min, 3.0 mtr. outreach beyond max beam and over the full manifold length
Provision Crane	2 x Electrohydraulic, luffing single jib type, 8 tons SWL x 10 m/min, 4.0 mtr. outreach beyond max beam and accessible to the engine room hatch.
Compressor room Crane	1 x Electrohydraulic, luffing single jib type, 6 tons SWL x 10 m/min, 3.0 mtr. outreach.

Accommodation Ladder	2 x Aluminum alloy, vertical storage and pneumatically driven within the parallel mid-body, width 600 mm and maximum inclination of 55^{o}when lowered to 1 mtr above ballast water line.
Shore Gangway	1 x Aluminum alloy curved step type, 6 mtrs long x 600 mm wide.
Pilot boarding doors	2 x Pilot boarding doors to be installed at the side shell but not in the strengthened fender area. Pilot boarding area to be gas safe, watertight and installed with bilge alarms.
Pilot Ladders	2 x Pilot ladders with pneumatic riven stowage reel
Emergency cargo pump handling davits	1 x 3.0 ton SWL, pneumatic driven
Bosun's Store davit	1 x 1.5 ton SWL, pneumatic driven
Steering Gear room davit	1 x 1.0 ton SWL, pneumatic driven
Suez Canal searchlight davit	1 x 0.5 ton SWL, pneumatic driven
Other davits around the vessel	2 x 1.0 ton SWL, pneumatic driven 3 x 0.5 ton SWL, pneumatic driven

- At least one of the cranes is to be design and tested capable of inching control and be certified for lifting personnel in open water.

- The Steering Gear room to be the designated citadel with the following supplies and facilities:
  - Weathertight steel doors with anti-piracy locking devices.
  - 2 x reinforced A-0 class doors with anti-piracy locking device.
  - 2 x reinforced A-60 class doors with anti-piracy locking device
  - 1 x portable aluminum ladder (3.0 mtrs.)
  - 2 x Air Vent pipes
  - Closing devices for ventilators (internal side)
  - 1 x Long Range Identification and Tracking (LRIT) system
  - 1 x VHF radio telephone
  - 1 x Iridium system with independent UPS

7.0 Life Saving and Fire Fighting Equipment

7.1. Life Saving Equipment

Lifesaving equipment and gear to be provided and arranged for 40 persons in compliance with the rules and maritime regulations of the Vessel's registry.

- 2 x FRP enclosed Lifeboats, water cooled diesel engine driven, 40 person capacity, on-load release davit system, capable of not less than 6 knots in smooth water. One lifeboat to be the designated Rescue boat.

- 2 x Hinged gravity type davits, electric motor driven with manual lowering capacity. Falls to comprise of stainless steel wire rope, with bronze or synthetic bushes, and all pins and sheaves

for remote brake control to be of Stainless steel construction, whilst other sheaves to be made of cast steel.

- 4 x 20 person inflatable type liferafts with hydrostatic release device and 1 x 6 person liferaft with manual release device to be provided.

7.2. Fire Fighting Systems

The fire precaution, fire extinguishing and firefighting apparatus to be in compliance with SOLAS, and maritime regulations of the Vessel's registry. In addition, the applicable regulations to comply with DnV GL Rules F(AMC) is to be applied to the vessel.

- Fire Control station for fire detection, firefighting and gas detection system to be arranged in Accommodation. It is to have an open access directly to deck and to accommodation. The Fire Control station to be able to control Emergency stops for Engine room ventilation and Accommodation ventilation, Emergency stops for fuel oil pumps, purifiers and quick closing valves on engine room tank, Start/stop of bilge, fire pumps, emergency fire pumps and Water spray pumps, High expansion foam system, Dry powder release box, Fire alarm repeater, Clean agent system and Water based local fire extinguishing system.

- The Fire detectors to be provided in various areas of Accommodation, Machinery rooms, Motor rooms, cargo machinery room, hazardous areas, paint lockers and others.

The following vessel areas to be protected:

• Engine Room	High expansion foam system, Sea water hydrants from Fire main and Portable extinguishers.
• Cargo Deck area	Dry chemical powder system, Water spray system, Sea water hydrants from Fire main, Nitrogen smothering system.
• Cargo Compressor room	High expansion foam system, Water spray system (outside area), Sea water hydrants from Fire main and Portable extinguishers.
• Accommodation	Water spray system, Sea water hydrants from Fire main and Portable extinguishers. Internal FW Fire Extinguishing system
• Electrical areas (ECR, Electric Motor room Switchboard rooms, Emergency Gen room Galley exhaust uptake, Cargo Compressor	Clean agent (FM 200) system

Rooms, Oil / Grease store)

• Fire hazard areas (Purifiers, Boiler front (Incinerator, Generator & M/E top, IGG, GCU)	Local water based firefighting application
• Paint store, Elevator machinery room, Purifier room, Chemical stores, Steering Gear rooms	High expansion foam system
• Other areas required by rules	Water spray system

- 2 x Dry Powder systems to be installed on either side of the vessel, each station to have an independent Dry powder storage tank with N2 bottles and distribution manifolds. These may be interconnected subject to F(AMC) requirements. Several hand hose stations for cargo tank area and two monitors for each cargo manifold to be arranged in compliance with Class rules.

- A fixed total flooding high expansion foam system to be provided for Engine room spaces with selective actuation to Purifier room, Incinerator room, Steering gear room, Paint store, Chemical store, Elevator machinery room. Motive sea water to be supplied by 1 x 560 m³/hr. x 100mTH High expansion Foam System Sea water pump, electric driven centrifugal, vertical and self-priming, local with remote starting. The foam expansion ratio not to exceed 1000 times of the volume of the mixture when sprayed on each deck.

- 2 x Engine room fire pumps, electric driven centrifugal, vertical and self-priming, local with remote starting.

- Fire Main to be Ring Type. Isolating valves, Hydrants and Hoses shall be located in accordance with SOLAS and IGC.

- 1 x Emergency Fire Pump, electric driven centrifugal, vertical and self-priming, with local and remote starting to be located at the steering gear room, separated from the main fire pumps and capacity in accordance with SOLAS and IGC

- 1 x 900 m³/hr. at 100 mTH, Water Spray pump electric driven centrifugal, vertical and self-priming, serving Cargo tank area, Cargo manifold area, Cargo Compressor room, Electric motor room, Accommodation wall and Lifeboat areas. Remote starting from Fire control station, CCR and wheelhouse. The capacity of the Water Spray Pump to be in accordance with IGC and preferable location within the Steering Gear Room separated from the main fire pumps.

8.0 Propulsion plant and Auxiliaries:

Shipyard to propose the most fuel efficient and reliable system using dual fuel gas system.

- The base case is a twin-screw propulsion system designed with BOG as the primary fuel, and compliant fuel oil as pilot and/or secondary fuel. With the present improvements in technology, the preferred options are MAN ME-GI and WinGD X-DF main engines.

- Given evolving technology, a DC Switchboard with Smart hybrid power management system DFDE propulsion system can also be considered.

- Diesel engines to be fully compliant with MARPOL Annex VI Regulation 13 and the NOx Technical Code. A fixed NOx monitoring system, that will record exhaust gases from all engines, boilers and gas combustion units on the vessel to be installed. Additionally, Shipyard shall provide 'Methane slip' emissions data over the full power range when burning BOG.

- Emission data of all oil/LNG/BOG burning equipment over 150 KW power rating shall be submitted at the bid stage.

- The main machinery installation to be designed so that maximum fuel efficiency (Considering BOG as primary fuel) is obtained at 85% SMCR.

- Each engine shall be capable of running on either cargo BOG with pilot injection of compliant fuel oil over the full load range, or continuous operation below 15% of rated output on compliant fuel.

- Main Engines pilot injection fuel consumption shall be the minimum which is available within latest engine technology.

- Any limitation on 'Methane Number' shall be clearly defined.

- Each main engine to have its own dedicated independent control system; the main engines to be capable of independently controlled and operated from all control stations, except local engine side control.

- Main Engines to be able to operate in Gas mode with the facility to stop gas operation in one cylinder.

- ME horizontal and vertical compensators may be required in case the Pump Tower vibrations are exceeding permitted criteria.

- A failure mode effect analysis (FMEA) examining possible gas faults affecting the combustion process in the gas engine to be carried out.

- If the access to the Engine room is from another enclosed space in the vessel, the entrance to be arranged with self-closing door. An alarm to sound at a continually manned location if the door remains open continuously for more than one (1) minute.

- The gas pipe not to be located less than 800 mm from vessel side. All gas pipes in the machinery space to be double walled and painted with bright yellow color.

- All equipment/machinery fitted inside the gas engine compartment to be of explosion protected design. Each Gas engine on the vessel to have a separate gas supply line such that shutdown of gas supply due to leakages in gas supply line is limited to the affected engine only, and does not

affect gas supply to another engine. Gas detection system to automatically shutdown gas and fuel supply and disconnect non-explosion protected equipment in a particular engine room to be fitted. In case the Master gas fuel valve automatically shuts down, automatic ventilation of the pipe piece between the master gas valve and the double block and bleed valve to be carried out.

- A manually operated stop valve to be installed outside the Engine room in the Main gas supply pipe to each engine. Each Gas valve unit (GVU) to be provided with a set of 'double block and bleed' valves for safe automatic or normal shutdown. The two block valves to be of fail to close type, while the ventilation valve to be fail-to-open type. Gas piping shall be subjected to radiographic testing as per Class requirements. Purchaser seeks additional 10% allowance on all such tests.

- The GVUs to provide the following safety functions as a minimum, which are to be tested during shop tests at manufacturers test facility as well as in the shipyard during the commissioning phase;

    - Gas leakage test by engine control system before engine start.
    - Control of the pressure of gas fed into the DF engine.
    - Quick stop of the gas supply at the end of the DF operation mode.
    - Quick stop of the gas supply in case of an emergency stop.
    - Purging of the gas distribution system and the feed pipe with air after DF operation.
    - Purging with N2 for maintenance option.

- All necessary instruments such as pressure transmitters, pressure gauges and thermocouples to be fitted for local monitoring as well as automatic operation of gas valve unit. Required interface with gas alarm system to be incorporated in gas control system.

- Shipyard shall submit a detailed list of outfitting and surveillance tools including, but not limited to Online Engine Diagnostic Systems, Shaft power meters, Oil Mist Detectors, and MIP System.

8.1 Diesel Generator Engines:

- Four sets of AC Synchronous Generators powered by Tri Fuel engines able to satisfy global emissions standards.

- The Diesel Generators to be designed so that maximum fuel efficiency (using Gas as primary Fuel) is obtained at 85% SMCR.

- Sufficient redundancy to be provided to cover a failure of the largest single generating unit.

- One Emergency diesel generator to be installed suitably rated for first start capability and supply of emergency services as required by SOLAS and IGC.

- Port in-loaded and port out-loaded conditions, in addition to Reliquefaction plant (where applicable), the electric load to include as a minimum a) Main engine Aux blowers, b) GCU Combustion air fans, c) Two Steering gears in operation, d) Hydraulic pumps for Deck machinery.

- Finalisation of Generator power configurations will be decided upon finalization of cargo handling system, however the following service conditions are to be met:

    - NCR Ballast passage — 1 x Genset operational
    - NCR Laden passage — 1 x Genset operational
    - Port in/out — 1 x Genset operational
    - Discharging — 3 x Genset operational (max)
    - Loading — 2 x Genset operational (max)
    - Idle — 1 x Genset operational

- Electric Load Analysis to include conditions such as 1) Seagoing Laden, 2) Seagoing ballast, 3) Seagoing ballast with cool down, 4) Port in-loaded, 5) Port out-loaded, 6) Cargo loading, 7) Cargo discharge, 8) Port idle with Cargo and 9) Port idle without cargo

8.2 Waste heat recovery:

- Waste heat recovery system to be installed to maximize thermal efficiency of the plant, and to provide heating for Fresh water evaporators, LNG vaporizers and domestic purposes.

- Soot blowing and Water washing arrangements complete with soot collection tank and disposal to be provided.

- If enough steam is not being utilized, Shipyard may propose an alternative of Waste heat recovery economizer/boiler in combination with an auxiliary fired, packaged steam generator feeding into a Turbo alternator.

8.3: Engine gas fuel system

- The primary fuel for Propulsion & Power generating engines to be the BOG from the cargo tanks.

- All gas fuel pipes on the engine to be of double wall type with minimum flange connections, where outer gas pipe to be dimensioned for a design pressure not less than that of the gas pipe. Gas piping shall be subjected to radiographic testing as per Class requirements. Purchaser seeks additional 10% allowance on all such tests.

- Appropriate gas filter(s) to be fitted in gas supply line to GVU with a differential pressure gauge and a differential pressure transducer connected to machinery alarm and monitoring system. Gas operation shall be possible at all times including when any gas filter is out of operation i.e. double isolation and N2 purging when one of the filter unit in parallel is out of operation.

- Electrical equipment inside gas duct and piping are to be of intrinsically safe type.

- During any change over from gas to liquid fuel, suitable provisions to be made for gas supply interruption in a safe manner.

- Ventilation of the double wall arrangements to be fully compliance with IGC and Class requirements.

- The fuel gas piping system shall be arranged to minimize the inventory of gas which requires to be vented in the event of a change over from gas to liquid fuels. The design arrangements for venting shall be made safe in accordance with IGC and Class requirements and minimize the noise during venting operation using suitable silencers.

8.4: Engine fuel oil system:

- A pilot fuel oil system for each DF engine to be fitted with necessary storage, settling and supply system as per Engine manufacturer's recommendations.

- Arrangements to be provided for changing from Gas operation to Fuel oil without interrupting the operation of the engine.

- Each engine to have a Fuel oil metering system and a Gas metering system for flow monitoring and performance analysis. Fuel oil flow measurement to be by remote reading, totalising Coriolis flow meter. Positive displacement meters to not be fitted. Note that the gas flow metering will be required for fiscal measurement, so gas flow meters are required to be of same accuracy as the CTMS system and calibration certificates provided by an approved Sworn Measurer.

8.5: Excess boil-off gas disposal:

- The vessel arrangements including, cargo containment and fuel gas to be designed to minimize any excess of boil-off gas. However, means of disposing BOG to be provided, when generated BOG quantities exceed the Propulsion and Power Generation demand.

- Suitable capacity designed Reliquefaction Plan could be an option to deal with the BOG; this is listed as primary option at the end of the BOD.

- As an operational residual secondary back-up arrangement for Tank pressure control, a Gas Combustion Unit (GCU) to accommodate the boil-off gas to provide this capability. In accordance with applicable rules and regulations, the GCU to have the following

    - Capacity at least that of the expected maximum BOGR of cargo under all cargo conditions.

    - Equipped with a Gas oil pilot burner(s) and Gas burner(s), with a free flow gas supply facility from the cargo tanks and natural air draft with minimum use of refractory material. A gas flowmeter to be provided.

    - The unit to be provided with a high energy ignitor system, an air-cooled combustion chamber, a double walled air-cooled exhaust and combustion blowers. Redundancy in

Flame scanners, Temperature sensors, Pressure sensors etc. to a degree that no single failure to prevent normal system operation or compromise the system integrity.

- Noise to be reduced to an extent that it allows full load operations at the terminals.

- Alternative arrangements will be considered if proposed e.g. Hybrid IGG and GCU combination. Ceramic lined combustion chambers may be considered.

8.6: Other Machinery

- Salt water pumps in Engine room to be of cast bronze construction, sea water resistant stainless steel impellers, Shafts and Sleeves. All centrifugal pumps to be able to operate within a range of +/- 15% of design capacity without cavitation.

- All pumps not to exceed 1800 rpm if feasible, with exception of smaller pumps with discharge head of greater than 60 mlc. Essential pumps to be fitted with cartridge type mechanical seals.

Shafting & Propellers	Two x Fixed Pitch, Ni-Al Bronze, keyless propellers. Shafting system to contain a forged steel Propeller shaft and an Intermediate shaft, complete with Shaft bearing, Torsionmeter, Shaft locking device, Shaft Earthing device and Revolution counter. Shaft survey interval up to 15 years. Propeller withdrawal possible without Rudder or Shaft removals. Propeller Boss Cap Fins to be included as standard.
Stern Tube bush	Cast iron with white metal lining complete with Forward and Aft Lip seal arrangements. Stern tube to meet US VGP requirements.
Steam Generator	Two Boilers, low pressure, sufficient for heating purposes; capable of full load operation on HFO & MGO. At least one of the boiler to be able to use Gas Fuel.
Cooling Water System	Central Fresh water cooling system
Main cooling Sea water pumps.	Based on SW temperature of 34^{o}C for MCR and 35^{o}C for NCR; three equally sized 50% redundancy divided into two loops.
Central cooling Fresh water pump.	Two units of 100% redundancy units, for each of the two loops.
Central Fresh water cooler (Titanium plate).	Two units of 100% redundancy each, for each of the two loops. Fouling margin of 15% to be considered
Main Cargo cooling Sea water pumps.	Two units with 100% redundancy; for Reliquefaction system as per Primary option in section 14.0
Main Cargo cooling Fresh water cooler.	Two units with 100% redundancy; for Reliquefaction system as per Primary option in section 14.0

Main Cargo cooling Fresh water pumps.	Two units with 100% redundancy; for Reliquefaction system as per Primary option in section 14.0
Main engine Jacket Fresh water cooling pump.	Two equally sized 100% redundancy units for each of the two loops.
Main engine Jacket Fresh water cooler (Stainless steel plate).	Two units of 100% redundancy each, for each of the two loops.
Auxiliary Cooling Sea water pumps	Two units with 100% redundancy, equally sized for each of the two loops.
Auxiliary Cooling Fresh water Cooler (Titanium plate).	Two units of 100% redundancy each, for each of the two loops
Auxiliary Cooling Fresh water pumps	Two units of 100% redundancy each, for each of the two loops
Main Lube oil pumps	Two units of 100% redundancy each, for each of Port and Starboard engine
Main engine Crosshead Lube oil pump (if required)	Two units of 100% redundancy each, for each of Port and Starboard engine
Main Lube oil cooler (Stainless steel)	Two units of 100% redundancy each, for each of Port and Starboard engine
Main engine Lube oil filter	One unit each for Port and Starboard engine with auto backflush capabilities; nominal 30 mic.
Stern Tube Lube oil pump	Two units of 100% redundancy each, for each of Port and Starboard engine
Stern Tube Lube oil cooler	One unit each for Port and Starboard engine.
Automatic self-cleaning Main Lube oil Purifier, Supply pumps and Steam Heaters	Two units of 100% redundancy each, for each of the two loops
Automatic self-cleaning Generator Engine Lube oil Purifier, Supply pumps and Steam Heaters	Two units of 100% redundancy each, for each of the two loops
Lube oil Transfer pump	Two units of 100% redundancy each, for each of the two loops
Main engine Cylinder oil transfer pumps	Two units of 100% redundancy each, for each of Port and Starboard engine
Fuel transfer pump	Two units of 100% redundancy, each of 50 m^3/hr. at 0.5 MPa located forward, if Forward deep tanks are designated bunker tanks.
MGO transfer pump	Two unit; 50 m^3/hr. at 0.5 MPa.
Main engine Fuel Supply pump	Two units of 100% redundancy each, for each of Port and Starboard engine; each sized for one Main engine and two Diesel generators at their SMCR.
Main engine Fuel Circulating pump	Two units of 100% redundancy each, for each of Port and Starboard engine; each sized for one Main engine and two Diesel generators at their SMCR.
Main engine Fuel Heaters (steam)	Two units of 100% redundancy each, for each of Port and Starboard engine.
Main engine MGO Cooler	Two units of 100% redundancy each, for each of Port and Starboard engine.
Main engine Fuel filter	One unit each for Port and Starboard engine with auto backflush capabilities; nominal 10 mic.

Main engine Pilot oil feed pump	Two units of 100% redundancy each, for each of Port and Starboard engine
Main engine Pilot oil Cooler	Two units of 100% redundancy each, for each of Port and Starboard engine.
Main engine Fuel Flowmeter (Coriolis)	One unit each for Port and Starboard engine, remote reading and totalising
Main engine Gas Flowmeter	One unit each for Port and Starboard engine.
Generator engine Fuel supply pump	Two units of 100% redundancy each, for each of Port and Starboard side; each sized for two Diesel generators at their SMCR.
Generator engine Fuel Circulating pump	Two units of 100% redundancy each, for each of Port and Starboard side; each sized for two Diesel generators at their SMCR.
Generator engine Fuel Heaters (steam)	Two units of 100% redundancy each, for each of Port and Starboard side.
Generator engine MGO Cooler	Two units of 100% redundancy each, for each of Port and Starboard side.
Generator engine Fuel filter	One unit each for Port and Starboard side with auto backflush capabilities; nominal 10 mic.
Generator engine MGO flushing pump	Two units of 100% redundancy each, for each of Port and Starboard side; one electric driven and other pneumatic motor driven unit.
Generator engine Fuel Heaters (steam)	Two units of 100% redundancy each, for each of Port and Starboard side.
Fuel Oil Viscorators	One unit each for P&S Main engine. Two units for Generator engines.
Generator engine fuel Flowmeter (Coriolis)	Two units Coriolis type, remote reading and totalising.
Generator engine Gas Flowmeter (Coriolis)	Two units Coriolis type, remote reading and totalising.
Boiler Burn Pumps	Two units of 100% redundancy each.
Boiler MGO cooler	One unit F.W cooled.
Incinerator and associated pumps	One unit, 150 kg/hr. sludge burning including plastics housed in a separate room.
Fuel Oil Tanks	3 or 4 x Fuel Bunker tanks. 2 x Fuel Settling tanks, P&S. 2 x Fuel Service tanks, P&S. 2 x LSMGO Storage tank, P&S. 2 x LSMGO Service tanks, P&S. 1 x MDO Storage tank. 1 x MDO Service tank. 1 x IGG LSMGO Service tank. 1 x Emergency Generator gas oil tank. 1 x Overflow tank.
Main Air Compressors	Three units, FW cooled, reciprocating type, 270 m^3/hr. FAD x 30 bar each.
Topping Air Compressor	One unit, FW cooled, reciprocating type, 100 m^3/hr. FAD x 30 bar.

Service Air Compressor	Two units, FW cooled, screw type, 350 m³/hr. FAD x 8 bar each.
Air Compressor for Gas Fuel double wall ventilation (where required by Class)	Two units with Driers. Capacity to be in accordance with Engine Makers.
Control Air Compressor	Two units, FW cooled, screw type, 350 m³/hr. FAD x 8 bar each.
Emergency Air Compressor	One unit, air cooled, reciprocating type, 22 m³/hr. FAD x 30 bar.
Main Air Reservoir	Two units, 13.5 m³ x 30 bar each; to be capable of providing 12 consecutive starts of each engine without further replenishment.
Service Air Reservoir	One unit, 5.0 m³ x 8 bar.
Control Air Reservoir	One unit, 7.5 m³ x 8 bar.
Auxiliary Air Reservoir	One unit, 1.0 m³30 bar.
Control Air Driers	One unit, regenerative, 280 m³/hr. and -25°C dew point. One unit, refrigerated, 280 m³/hr. and -25°C dew point each.
Oily Bilge Separator	One unit, Marinfloc type with White box.
Bilge pumps	Two units, 10 m³/hr. x 4 bar.
Sludge pumps	Two units, 10 m³/hr. x 4 bar.
Waste Oil shifting pump	One unit,
Bilge & Sludge tanks	4 x Bilge wells P&S forward, and one each aft for twin skeg areas. 1 x Bilge Primary tank. 1 x Oily Bilge tank (35 m³). 1 x Bilge Holding tank capacity (50 m³). 1 x Clean Bilge Drain tank (40 m³). 2 x Fuel oil Drain tanks. 2 x Lube oil Drain tanks. 2 x Fuel oil Sludge tanks. 2 x Lube oil Sludge tanks. 2 x Stuffing Box Drain tanks. 1 x Waste oil Settling tanks. 1 x Waster oil Service tank 1 x EGE washing water drain tank capable of holding one full wash cycle.
Fresh water Generators	Two units, Single stage flash evaporation type, 40 m³/day each. Primary heating medium is Main engine Jacket water, and secondary medium being steam from Steam Generators.
Sea water system fouling	One unit, Chloropac
Ventilation fans	In line with ISO 8861 standard, or equivalent. Washable air suction filters to be provided for Engine room intake.

	4 x Engine room, two of which are reversible 2 x Purifier rooms on each side 4 x Generator exhaust fans 2 x Generator engine GVU room 1 x GCU GVU room
Workshop Machinery	1 x Lathe. 2 x drilling machine. 1 x Pedestal grinding machine. 1 x Gas welding set. 1 x Electric welding set. 1 x Mechanical hack saw. 1 x Fuel valve grinding benches, M/E & G/E each. 1 x Pipe threading machine with accessories. 1 x Pipe bending machine for pipes of 100NB or less. 3 or more x Workbenches with vices

8.7: Vessel Performance Management System

- For decision support on optimising thermodynamic and propulsive efficiency, and support the Ship Energy Efficiency Monitoring Plan (SEEMP), a suitable Vessel Performance Management system to be provided and fully integrated to the IAS and data communication system. The parameters to be agreed with the Purchaser and retain an accuracy of 1% scale and resolution within 0.1% of scale.

9.0 Cargo system:

- The Cargo containment and handling system to be designed to the following criteria:

Minimum design temperature:	–163°C
Maximum cargo density a) For Scantling and Containment system design: b) Density of Cargo LNG c) For Boil off calculations:	 500 kg/ m³ 460 kg/ m³ 425 kg/ m³ (Pure methane)
Normal operating pressure:	1030 ~ 1100 mbar absolute.
NBOG (passive)	< 0.11% of 98.5% cargo volume

- In accordance with Shipyard's experience and valid license agreements, preferred cargo containment system to be of an approved and tested design of either:
  - Membrane systems of Gaz Transport & Technigaz (GTT) design.
  - Independent type B, self-supporting spherical Moss design. Encapsulating of the Moss tanks with continuous steel cover to lower air resistance to be considered if proven beneficiary.
  - Other proven membrane containment designs to also be considered.

- Filling restrictions due to sloshing effects to be minimized. It should also be noted that no isolated vapour pockets are created within the cargo tank as per the IGC Code Ch 15, 15.4.

- Maximum pressure of gas in tanks will be at 25 kPa MARVS, whilst minimum permissible vacuum pressure not to be lower than 1 kPa below atmospheric pressure.

- In the event that the Shipyard proposed containment system is significantly different from the licensor's current design, test reports, calculations, conclusions and reports on experience to be submitted proving the ability of the respective system to the satisfaction of Purchaser. Proposed system has to be approved by Class.

- The rated BOGR of the proposed insulation system has to complement the Propulsion demand for optimal gas consumption in the higher speed range i.e. 15 knots to 18 Knots at 34°C sea temperature, 45°C air temperature and 5°C cofferdam temperature.

- Cargo manifold to be in compliance with Volume "Category B or C" of the latest edition of OCIMF "Recommendations for Manifolds for Refrigerated Liquefied Natural Gas Carriers". The connections on each side **to** be arranged L-L-V-L-L. The following manifold configuration to be applied on either vessel side:

    - Liquid 4 x 16", ANSI 150 NB
    - Vapour 1 x 16", ANSI 150 NB
    - Bunker 2 x 10", 2 x 8"

- The vessel is also to be provided with least 4 off cargo reducers 16" to 20"

- Manifold cool down valves, temperature and pressure gauges to be positioned such that they can be operated / read outside of the manifold area.

- Rigid self-extinguishing polyurethane foam suitable for temperatures up to +80^{o}C to be used for Cryogenic pipe insulation.

- The vessel to be able to discharge the bulk of the cargo at a rate of 14,000 m^{3}/hr. when using three liquid manifolds (with 20/60 mesh strainers installed) with a 400 kPaG shore manifold backpressure. Bulk discharge time to exclude the build-up period for starting pumps and slow down or stripping at the end of discharge.

- The vessel to be able to load the bulk of cargo at a rate of 14,000 m^{3}/hr. (excluding slow starting and topping off) with a back pressure not exceeding approx. 240 kPaG at the manifold, employing three (3) liquid manifolds and including use of 60 mesh strainers. For maiden voyage cargoes the vessel to be provided with ASTM 200 mesh strainers

- In order to allow "ship to ship" operations, the cargo piping design and arrangements to be arranged to allow any combination of 1, 2 or 3 cargo tanks to be empty, in the seagoing condition, with the remaining tank(s) full.

- In order to allow maintenance and cargo tank isolation, the cargo piping and arrangements to be arranged to allow the possibility to gas free any cargo tank for tank entry, in sea going condition, with the remaining tank(s) full.

- The cargo emergency shutdown (ESD) system, which is required by the IGC, to be provided with an independent programmable logic control. ESD system to be designed and arranged in accordance with latest SIGTTO ESD Guidelines Recommendations.

- The operations to bring the vessel into service from fully gas free to cooled down ready to load to be performed within periods not greater than:

OPERATION	HOURS
Drying	20 hours (-40^{o}C dew point)
Inerting	20 hours (2% O2 by vol. & -40^{o}C dew point)
Gassing Up	20 hours (1% CO2 by volume)
Cooling Down	15 hours (-130^{o}C to 30^{o}C, mean temp of cargo tanks)

- The operations to take the vessel out of service, from completion of discharge to fully gas free, to be performed within periods not greater than:

OPERATION	HOURS
Warming up	48h (+5^{o}C on secondary barrier)
Inerting	20h (2% hydrocarbon by volume)
Aerating	20h (20% O2 by volume)

- The cargo system to be designed such that inerting, gas freeing and purging procedures can be carried out with all gases displaced from the cargo system being passed through the vessel's thermal oxidizer BOG vent, but without increasing its capacity as defined in section 6.4.

- Any increase in the time required to carry out these procedures in this manner to be noted. This capability to be in addition to the normal pre-drydock operating procedures involving venting of diluted gases via a riser.

- A vent mast to be provided for each tank fitted with manual Nitrogen purging connection. Height and dimensions to be designed according to IGC and Classification requirements.

9.1. Containment Tests

The Cargo Containment System is to be fully approved by Classification for LNGC operations.

The following calculations to be performed by the Cargo Containment Designers and/or the Shipyard to verify the safety of the system:

- Thermal stress finite element analysis for each cargo containment system and each tank size, including the cargo piping system, considering expansion, contraction and vessel flexing, 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 dynamic cargo pressures 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.

- Any filling restrictions, in any or all the cargo tanks, must be clearly stated by the Shipyard and noted in the vessel's Loading Manual and Trim & Stability information.

- Strength, vibration and fatigue analyses of the Pump Tower

9.2 Other design specification:

Number of LNG Cargo Tanks	4 – Membrane / Moss type
Gross Capacity of LNG tanks at 100%	Approx. 174,000 m³
Partial loading/filling restrictions	As minimum as possible.
Vessel's cargo tanks cooling down from ambient	Maximum 15 to 16 hrs.
Loaded Boil-Off rate	< 0.11% of 98.5% cargo loaded volume.
Number of Cargo pumps per tank	Two units with 100% redundancy
Number of Spray (stripping) per tank	One unit (same manufacturer as cargo pump)
Fuel Gas Pumps	Two units with 100% redundancy. 1 pump in #2 Cargo tank and second in #3 Cargo tank.
Emergency Cargo pump	550 m³/hr. at 155 mlc (S.G. 0.5)
Heavy Duty vapour return compressors	Two units with 100% redundancy, equally sized electric motor driven centrifugal, located in Cargo compressor room; approx. 36,000 m³/hr. each at -140°C inlet temperature and 180 kPa pressure at Vapour manifold.
Fuel gas compressors	Two units with 100% redundancy, equally sized to meet MCR laden consumption, including 2 x Main engines and 3 x largest Auxiliary engines, and located in Cargo compressor room.

LNG Fuel Supply Pumps	Two units with 100% redundancy, equally sized to meet MCR laden consumption, including main and auxiliary engines and located in Cargo tanks 3 & 4.
Gas Heaters	Two units - One warm-up gas heater and other Fuel gas heater in Cargo compressor room.
Forcing Vaporizer	One unit of suitable capacity to match the propulsion needs at MCR for 100% gas burning systems. Approx. 4,200kg/hr. from -163^{o}C to -100^{o}C.
LNG Vaporizer	One direct steam heated shell and tube type in Cargo compressor room (Approx. 26000 kg/hr. from -163^{o}C to -140^{o}C) for gas filling.
Inert Gas Generator	One unit (16,000 m^{3}/hr. with max discharge pressure of 25 kPa. Inert gas or Dry air/Dew point -45^{o}C at atmospheric pressure)
Nitrogen Generator	Two units with 100% redundancy, each able to satisfy all normal service requirements. Approx. requirements - (160 m^{3}/hr. Discharge Pr. 10 bar; Dew Point -70^{o}C at atmospheric pressure)

- Fuel Compressors, and any other applicable equipment, to be suitable for their intended purpose. They shall be designed, fabricated and tested to ensure suitability for the use within marine environment including shipboard vibration and accelerations and effects of pitch, heave and roll motions.

9.3. Custody Transfer System

- An approved Custody Transfer System (CTS), together with Cargo volume, temperature and pressure measurement capabilities according to requirements of Owner, Cargo buyers and fiscal authorities to be fitted.

- Two independent level measuring systems, of different designs, to be installed for each tank. The primary level gauging system to use the latest proven technology and provide adjustable alarm level signals for low level and normal filling level. Maximum error tolerance of +/- 5.0 mm to be provided.

- The secondary system to be a radar or float gauge type subject to approval. Measuring tapes to be made of Invar.

- A cargo temperature measurements system to be provided in each tank for temperature measurement at five different locations, with a pair of temperature sensors acting as primary and stand-by sensors at each such location.

- An inclinometer with accuracy better than +/- 0.025^{o} for list and +/- 0.01^{o} for trim to be installed and integrated to CTS unit.

- Primary CTS system to be fully integrated with IAS, whereas the secondary system to have a stand-alone capability for information transfer to the IAS only.

- Additional to full flexible reporting feature, the CTS system shall have the capability to exclude up to 4 cargo tank(s) from the custody and survey at a particular load and discharge terminal. The system shall be as well as capable to generate at least 4 multi loading and discharge reports within a same voyage. The name of any loading or discharge terminal shall be editable from the workstation prior to conducting the CTMS opening operation.

9.4. Gas Detection System

- A fixed gas detection system to be fitted capable of detecting methane gas concentration. Both sampling type and infra-red gas detectors systems to be provided for barrier insulation spaces and cargo area. The system is to monitor on main gas detection panel, and interfaced with IAS for individual warning. Detection points will be 10% in excess of IMO gas carrier code.

- Infra-red gas detectors shall be provided in the Air Conditioning handling unit, Accommodation and Navigation Bridge inlet ventilation and access doors areas and integrated with the Gas detection system.

9.5. Ship Shore Communication System

- Ship-Shore Link to be designed and arranged using latest technology with full compatibility between all terminals.

- Following facilities to be provided for vessels alongside LNG berths for communication and ESD signal transfer:

    - Hotline telephone, PABX telephone, Public telephone in CCR
    - Fiber optic and Electrical connection on either Port and Starboard side of the vessel
    - Mooring line tension monitoring system in CCR

10.0 Ballast system

- The Ballast system to consist of a ring main with spurs to each ballast tank, with surge protection devices fitted to prevent rupture in the event of transient overpressure.

- Three identical electric driven Ballast pumps to be located in the Engine room. Each pump to be sized such that with any two running the ballast tanks can be filled or emptied within 14 hours.

- A water driven eductor (300 m^3/hr.) with a non-ferrous body to be installed for stripping the ballast tanks via the ballast main, without a separate stripping main.

- The Ballast system to exclude routine use of Peak tanks as ballast tanks at all times.

- An electro-pneumatic remote reading level measuring system to be installed for all Water ballast tanks, including Fore & Aft Peak.

- Ballast line material to be GRP with double ring bell and socket joints. GRP couplings may be employed if double ring and socket joint are not practically possible.

- Ballast Water Treatment system of slip stream electro chlorination technology meeting IMO and USCG Type approval requirements to be installed integral with the ballast system. Other technologies such as Ultraviolet can be proposed for Purchaser's review. The Aft Peak tank shall be designated salt water tank for holding slip stream supply when trading in fresh water ports.

- Ballast Water Treatment System shall comply with latest EU regulations for testing in service.

11.0 Automation system – General

- Remote and automatic controls and instrumentation to be provided for Safety, Propulsion plant and Cargo handling to follow the guidance in ISO document 17894, "Computer Applications – General principles for the development and use of programmable electronic systems in marine applications". It will comply with the requirements of the Class notation for unmanned machinery space operation and the rules for LNG carrier.

- All instrumentation and control system to be type approved by the Classification society and conform to IEC 60092 recommendations and requirements. The system arrangements to be designed to ABS ergonomics guide.

- The Cargo Control System to be designed following latest SIGTTO Recommendations.

- Integrated Automation System (IAS) to be provided for centralized control and monitoring of vessel's Machinery and Cargo systems from Engine Control Room (ECR) and Cargo Control Room (CCR). The interface between IAS and Navigation system to be for information exchange only. A fully redundant microprocessor based integrated control with redundant communication networks to consist of the following:

    - Two workstations, each with dual screen in CCR.
    - Two workstations, each with dual screen in ECR.
    - One workstation with dual screen in wheelhouse.
    - Data loggers and Printers
    - Data acquisition units.
    - 18 x alarm panels with Engineer call function

- All automation systems to include a self-diagnostic facility.

- The alarm system to be part of the IAS and meet the requirements of IMO resolution A686 (17), Code on alarms and indicators.

- A closed circuit television (CCTV) system to be installed with monitoring capabilities of the rudder position, stack emissions, and surveillance of main decks, (forward and aft), manifolds, overside (P&S), Engine room areas and Cargo Machinery spaces. Cameras with zoom/pan/tilt capabilities to be provided for with 32" monitors in Bridge, CCR and ECR.

12.0 Electric System – General

- The Electrical installation to be designed and provided for operating under tropical conditions according to the applicable rules, requirements and guidelines.

- Electrical equipment to be sited to minimum risk of damage due to excessive heat or leakages. No piping to be routed through dedicated electrical equipment spaces.

12.1. Electric Power Distribution

- The following voltage systems to be applied:
  - High Voltage AC 6.6kV, 60 Hz, 3 Ph.
  - Low Voltage AC 440V, 60 Hz, 3 Ph.
  - Light Distribution AC 220V, 60 Hz, 1 or 3 Ph.
  - Control voltage DC 24 V

- Switchboards will be of marine type with IP 23 or better enclosures, complete with self-ventilation, hinged doors, insulated handrails and construction to withstand ship's vibration. The High Voltage and Low Voltage switchboard to consist of two sections with interconnecting bus-tie circuit breakers.

- 6.6kV (HV) Main Switchboard to be divided into two sections with a bus-tie connection; each section consisting of:

  - 2 x Incoming power from two Main generators
  - 1 x Outgoing power to 440V Service transformer
  - 2 x Starter for large motors (Water Ballast pump, Water Spray pump)
  - 1 x Outgoing to 6.6kV (HV) Cargo Switchboard

- 6.6kV (HV) Cargo Switchboard to be divided into two sections with a bus-tie connection; each section consisting of:

  - 1 x Incoming panel from 6.6kV (HV) Main Switchboard
  - 1 x Outgoing power to 440V Service transformer
  - Starter panels for Cargo systems (Cargo pumps, HD Compressors)

- 440V (LV) Main Switchboard to be divided into two sections with a bus-tie connection; each section consisting of:

  - 1 x Incoming panel from 6.6kV (HV) Main Switchboard
  - 1 x Starter panels for Machinery systems.

- 1 x 440V Feeder panels
- 1 x 220V Feeder panels
- 1 x Emergency generator switchboard

- 440V (LV) Cargo Switchboard to be divided into two sections with a bus-tie connection; each section consisting of:

  - 1 x Incoming panel from 6.6kV (HV) Cargo Switchboard
  - 1 x Starter panels for Cargo systems.
  - 1 x 440V Feeder panels

- 440V Emergency Switchboard in accordance with Classification rules, consisting of:

  - 1 x Emergency generator feeder
  - 1 x 440V Feeder panel
  - 1 x 220V Feeder panel

- 24 VDC Switchboard
  - 1 x Battery switchboard for battery charging/discharging and distribution source for interior communication, navigation and transient lighting.
  - 1 x Battery switchboard for battery charging/discharging and distribution source for machinery systems.

- Shore Power connections to be provided within the construction of the Emergency Switchboard with a shore connection box capable of receiving 440V/60 Hz/1400 Amps.

- Equivalent Electrical architecture to the above will be considered if it meets Class approval.

12.2. Transformers, Starters and Motors

- Transformers to be self-ventilated, Class “H” insulated, though Class “F” insulation can be considered.

- All essential and critical system 440V starters will be located at the Switchboards and will be, as far as practicable, split between them, whilst remaining starters to be located near the consumer. Star-Delta or Auto transformer soft starters to be provided for large consumers.

- Motors to be totally enclosed type (IP44 TEFC) and those exposed to be weather to be weather type (IP 56). Insulation to be Class ‘F” with class “B” temperature rise and rated for 110% full load duty at an ambient conditions of 50^{o}C.

12.3. Cables

- The cable throughout the vessel to be of IEC 60092-3 series in compliance with IEC 60332-3A (flame retardant). In general, cables not to be installed above the sources of ignition.

- Power cables to Switchboards to have a current rating of 110% of the maximum rating. These will conform to NEK 606 latest revision and IEC 60332-1 & 60332-3 category C with halogen free type approved by Class.

13.0 Buyers' Furnished Equipment

- Following items to be arranged for supply in satisfactory condition by the Purchaser for either stowage or installation by the Shipyard, as appropriate. Shipyard will provide crane assistance and logistics within their facilities.

    - Navigation Charts, Paper and Electronic
    - Flags, Signals and Nautical equipment not mentioned.
    - Galley and Pantry utensils, including pans, glassware and crockery etc.
    - Chandlery like soaps, brooms, cleaning sprays, waste bins etc.
    - Bedding, Linen and Napery.
    - All medicines and medical equipment.
    - Hoses and Mooring ropes/wires in excess of Classification requirements or mentioned in the specification.
    - Portable gas detectors
    - Consumable items for Lifeboats.
    - Portable and loose items for Citadel.
    - Personal Protective equipment.
    - Personal computers including servers, hubs and other office machines not mentioned in the specification.
    - Stationary
    - Entertainment equipment like TV sets, radio receivers.
    - Hobby equipment including gymnasium or game equipment.
    - UHF onboard communication (walkie-talkies)
    - Lubricants, Greases, Hydraulic oils, Chemicals, consumable stores needed for voyages, excluding those consumed in sea trials.
    - Test kits for water, fuel and lube oils.
    - SOPEP technical information and equipment needed for oil removal & response.
    - Planned Maintenance System software and platform.

14.0 Optional Equipment

The following equipment is optional to the Outline specification and is to be quoted separately as part of Attachment C – Price Formula and Slots. These options are further categorised into:

a) Primary options
b) Secondary options.

All options shall be assessed on a case by case basis in order to refine the final specification.

Scaling up of Power generation units, additional utilities, infrastructure, safety zone maintenance and automation, and regulatory approvals from provision of the items to be all accounted for under each option, and not in the base specification above.

14.1 Primary Options

The following options are Purchaser's preferred options that shall be assessed for operational and cost benefit. In all cases, Shipyard shall provide, as part of their bid submission, full details and calculations on how these are achieved.

14.1.1 Reliquefaction Plant

- Provide a suitable Reliquefaction plant for cooling and condensation of BOG generated during voyage. Cargo and Fuel gas handling system to operate under "Capacity Control" i.e. the available BOG at each mode and speed is as much as needed to keep the pressure in the cargo tanks constant at its recommended set point value.

- The preferred Reliq systems are Mixed Refrigerant System (and its variants), the Joule Thomson (JT) systems either in Partial Reliq system (PRS) or Full Reliq system (FRS) mode, or the Turbo Brayton sub-cooling systems.

- Alternative Reliq systems including hybrids may only be considered on a case by case basis.

- The Reliq system capacity is to be chosen for the following two sub-options, and have to priced separately:

    - Vessel can achieve 12 knots minimum BOG speed in fully laden condition i.e. no BOG is burnt at the GCU. Shipyard to guarantee Reliq system's capacity to return 110% of the remaining BOGR, after consumption in the Main engines at 12 knots speed with normal electrical load on Diesel generators including the load of the Reliq system. Capacity measurement shall be based on LNG returned to the Cargo tanks.
    - Vessel can achieve zero GCU usage in any condition i.e. no BOG is burnt at the GCU. Shipyard to guarantee Reliq system's capacity to return 110% of the remaining BOGR, after consumption with normal electrical load on Diesel generators including the load of the Reliq system. Capacity measurement shall be based on LNG returned to the Cargo tanks.

- All necessary cooling requirements to be provided by a dedicated FW cooling system. All rotating equipment shall have 100% redundancy and where appropriate, Variable Frequency Drive (VFD) shall be incorporated.

- During Gas Trials the commissioning of the reliquefaction plant shall be performed including capacity test.

- Shipyard to indicate the total Power requirements, and revised capacity of Generator engines and other ancillary equipment. Class notation shall be upgraded to Lloyd's Register RMC (LG) or equivalent. Revised Electric Load Analysis to include conditions such as 1) Seagoing Laden, 2)

Seagoing laden with Reliquefaction, 3) Seagoing ballast, 4) Seagoing ballast with cool down, 5) Port in-loaded, 6) Port out-loaded, 7) Cargo loading, 8) Cargo discharge, 9) Port idle with Cargo and 10) Port idle without cargo.

14.1.2 NOx Compliance

- Provide a suitable nitrogen abatement technology for deployment on Main engines, Generator engines and boilers to curtail the nitrogen emissions. The treatment unit shall be selected based on 100% MCR. EIAPP certificate or State of Compliance for IMO NOx limit Tier III shall be provided.

- Either Selective Catalytic Reduction (SCR) or Exhaust Gas Recirculation (EGR) to be considered. Scaling up of Power generation units, additional utilities, infrastructure and automation, and regulatory approvals etc. to be all accounted for under this item.

    - SCR unit to consist of the Reactor with a soot blowing unit and the catalyst elements, Reactor trace heating, complete with Power Distribution Unit, Urea pump unit and dosing unit. A bypass system for system has to be provided. The catalyst element shall have a lifetime of 10 years based on 800 hours annual operation. Shipyard shall follow the guidelines for urea handling and storage as prescribed in ISO 18622-3:2014.

    - EGR unit to consist of the Pre-scrubber, Distribution chamber, Cooler, Blower, EGR scrubber, mist catcher unit, Sludge tank and EGR control unit.

- Exhaust system back pressure calculations shall be reviewed by the Purchaser and the Engine Maker, and shouldn't exceed 500 mmWC for a LPSCR.

- The compliance with Tier III levels shall be verified during the shop tests in accordance with Scheme A in compliance with Regulatory body, whereas onboard verification of NOx emissions from main engines shall be carried out by means of engine parameter check, only if modification of the engine component modification affecting NOx emissions is made onboard.

- Shipyard to indicate the total Power requirements, and revised capacity of Generator engines and other ancillary equipment. Class notation shall be upgraded to Lloyd's Register ShipRight (NO3) or equivalent. Revised Electric Load Analysis to include conditions in ECA controlled areas such as 1) Seagoing Laden, 2) Seagoing laden with Reliquefaction, 3) Seagoing ballast, 4) Seagoing ballast with cool down, 5) Port in-loaded, 6) Port out-loaded, 7) Cargo loading, 8) Cargo discharge, 9) Port idle with Cargo and 10) Port idle without cargo.

14.2 Secondary Options

In no specific order, the below mentioned options shall be assessed for operational and cost benefit.

14.2.1 Air Lubrication System

- Provide a suitable Air Lubrication system with automation to regulate compressors according to draught and speed. Design of the Air Release Units (ARU) to be hydrodynamically shaped and fit

within the double bottom. Care has to be taken not to introduce oil from the compressed air released from the ARUs.

- CFD to be performed to confirm minimal effect on the flow to the propellers and not cause cavitation.

- Shipyard to indicate the total Power requirements, and revised capacity of Generator engines and other ancillary equipment.

14.2.2 Bow Thruster Unit

- Provide a suitable Bow Thruster unit e.g. 4-bladed, skewed, Controllable Pitch type Bow thruster unit of 2500 KW producing approx. 380 MT of thrust complete with an electro-hydraulic follow-up remote control system.

- Vertical type motor, squirrel cage, induction motor with auto transformer starting method.

- Shipyard to indicate the total Power requirements, and revised capacity of Generator engines and other ancillary equipment

14.2.3 Enhanced Cargo Tank Design Pressure

- Maximum tank design pressure rating of 50 kPaG, and Minimum Temperature -163^{o}C, whilst minimum permissible vacuum pressure not to be lower than 1 kPa below atmospheric pressure. Dual MARV pressure setting of 25 kPaG and 40 kPaG to be provided.

14.2.4 FSRU Ready

- LNGC hull structure, Containment systems and Machinery spaces to be designed for and constructed for an FSRU ready deployment that conforms to classification notation (LNG)R of ABS. This implies that LNGC will be a Ship type 2G (Membrane or Moss type, Maximum pressure 70 kPaG and Minimum Temperature -163^{o}C) capable of a full range of loaded conditions from full to empty.

- Accommodation to be scaled up to 48 persons, plus 6 Suez Canal workers, with necessary facilities for both male and female crew.

- Decks to be strengthened to accommodate the Regasification Equipment such as Gas Processing Units, Suction Drum, Recondenser, Transfer manifolds, Emergency Shutdowns etc. at a later date. This is to include Scantlings and details of foundation drawing in way of regasification and power generation modules, Strength analysis document in way of regasification and power generation module and Cargo containment and Pump Tower strength analysis (sloshing)

- Mooring arrangements, upsizing of Power requirements, Fire and Gas detection system, Fire extinguishing and Ventilation of new spaces will not be part of this proposal yet. However, a modular approach to accommodate the FSRU process equipment with relation to spaces and scaling has to be agreed, which is to include the following at least:

- Forward hull structure to contain a Pump Room and Forward Electrical Room (FER), for future installation of associated sea water pumps, sea water filters, water glycol circulation pumps and sea water/water glycol heat exchangers, for provision of heating to the regasification system.

- Provisions for LNG feed pumps in the emergency pump wells of each cargo tank, for supply of LNG to the regasification plant.

- Installation of additional Nitrogen (N2) generator capacity.

- Installation of new Power Generation Module with high voltage switchboards and transformers in new steel structure above the poop deck.

- Extending existing 6.6kV switchboard and the bus-tie breakers for receiving/feeding of power to the new 6.6 kV switchboard located in the Power module.

- Installation of new maintenance crane in regasification area, as well as upgrade of existing midship hose handling crane for personnel transfer between FSRU and LNGC.

14.2.5 Power Take-off

- Provide suitable Power Take-off system(s), mounted in the propulsion shaft line each, such that they deliver full power required in fully laden condition at all rpms' corresponding to Half Ahead speed and above. The installed power from independent Diesel Generators is expected to be reduced to three generating units maximum.

- Frequency converter, designed on modern pulse-width modulation (PWM) technology and power switches, synchronous or induction machine with a top mounted rectifier and water cooler are preferred, however other comparative options to be favourably assessed.

- Ideally, Power Take-off output to be of 440V / 60Hz to feed the propulsion needs only, however if the Fuel gas Compressor or a proposed Reliq system requires higher voltage, then Shipyard offering to propose a 6.6 kV system.

14.2.6 Shaft Clutch

- Provide for a suitable shaft clutch arrangement for engagement/disengagement of propeller from the Engine. A Renk unit suitably rated for Engine capacity (such as PSC-225 or equivalent0 complete with its hydraulic motive to be offered.

14.2.7 Waste Heat Recovery for Diesel Generators

- Waste heat recovery system installed to extend to Diesel generators besides recovering thermal energy from Main engine exhaust only.