Final Engineering Project of a Tugboat powered by LNG (Valencia)

D3.7

CORE LNGas
hive

Core Network Corridors and Liquefied Natural Gas

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More Information

Public CORE LNGas HIVE reports and additional information related with the project execution and results are available through CORE LNGas Hive public website at www.corelngashive.eu

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Glossary of abbreviations

LNG	Liquified Natural Gas
STS	Ship to Ship
HFO	Heavy Fuel Oil
MGO	Marine Gas Oil
SOW	Scope of Work
LOA	Length Overall
LPP	Length Between Perpendiculars
IMO	International Maritime Organization
COG	Centre of Gravity
MARPOL	International Convention for the Prevention of Pollution from Ships
NOx	Nitrogen Oxides
SOx	Sulphur Oxides
PM	Atmosphere Particulate Matter
IGF	International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels
IGC	International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
BOG	Boil of gas
GVU	Gas Valve Unit
LCG	Longitudinal Centre of Gravity
TCG	Transversal Centre of Gravity
VCG	Vertical Centre of Gravity
CL	Centre Line
BL	Base Line
GZ	Metacentric Height
GT	Gross Tonnage
NT	Net Tonnage
EN	Equipment Number
BV	Bureau Veritas
NG	Natural Gas
CTMS	Custody Transfer System
FiFi	Fight Fighting
UF	Use Factor
SART	Search And Rescue Transmitter
EPIRB	Emergency Position Indicating Radiobeacon Station
EEBD	Emergency Escape Breathing Device
SOW	Scope of Work
AiP	Approval in Principle
KR	Korean Register of Shipping
DNV·GL	Det Norske Veritas
ABS	American Bureau of Shipping
DGMM	Dirección General de la Marina Mercante
ESD	Emergency Shutdown

0 EXECUTIVE SUMMARY

The present document describes the technical documentation jointly developed by FUNDACIÓN VALENCIA PORT, SEAPLACE, BOLUDA CORPORACIÓN MARÍTIMA y BUREAU VERITAS,on the Sub-activity EV6 included in the CORE LNGas hive project.

This work involves the basic engineering of a LNG fuelled tug boat including Bureau Veritas approval.

The basic parameters of the development, defined together with Boluda, are as follows:

- GT<500
- Pure Gas Propulsion
- Minimum 65 tons Bollard Pull
- People on board 8

This document begins describes the scope of the sub-activity and an initial evaluation of the project. NOx and SOx emissions fulfilment are analysed as well as the rules and regulations applying to a gas fuelled tugboat. The different LNG tank alternatives along with a state of art with the existing gas fuelled tugs are presented.

The projected vessel object of the present report is an escort tug powered by LNG. The fuel is stored in a LNG type C tank with a volume for approximately 10 days, inside the Tank Room. Class notation: BV, I+HULL, +MACH, Escort Tug, FIFI1 Water Spray, AUT-UMS, Comf-Noise1, Gasfuel, Inwater Survey. Vessel characteristics, such as main dimensions, bollard and operating profile are defined.

The basic design development has been carried out on a set of different documents that the present report outlines.

General Arrangement shows the subdivision of the vessel and arrangement of spaces, superstructures, deck houses, hold space, accommodation and machinery spaces.

Naval architecture calculation are developed to ensure stability requirements fulfilment. Hydrostatic calculations have been carried out as well as an estimation of the lightship weight distribution and tonnage. LNG tug complies with BV regulations regarding Intact stability, two different loading conditions are defined.

The tugboat is designed with transversal steel structure. Structural basic design package has been developed including Midship drawings, Main deck, shel expansion, aft Peak, Forepeak, Hold space and Machinery room. The superstructure, wheelhouse and different structures that compose the topside are also calculated and designed.

Arrangement of the engine room and definition of the piping systems has been developed.

To fulfil all the operational requirement, electrical load calculations and a one-line diagram are carried out. Consumers are defined according with the electrical network and the corresponding switchboard which are connected.

The vessel, in terms of safety and security, must comply with rules and regulations of Classification Society, and the requirements of SOLAS and the class notation. Therefore, lifesaving and firefighting equipment, escape route and dangerous areas plans are done, as well as, a system for gas detection and the vessel fire divisions. Navigations lights comply with COLREG.

1 DESCRIPTION OF THE PROJECT

The Tugboat powered by LNG is the Sub-activity EV6 included in the CORE LNGas hive project, which is constituted by 16 engineering studies and 11 pilots and implementation elements in total.

CORE LNGas hive is a proposal focused mainly on LNG deployment for maritime transport and ports along the Spanish and Portuguese sections of the Atlantic and Mediterranean core corridors of the Transeuropean Transport Network aiming at support the implementation of Directive 2014/94 on the deployment of alternative fuels infrastructure besides the monitoring of Directive 2012/33 regarding Sulphur content of marine fuel.

The objective of EV6 is to design a LNG fuelled tug boat. The ship also implements other innovative technologies addressed to improve her optimal use of power. The scope of this study will only cover the basic engineering with Bureau Veritas approval.

The participants, in the feasibility study, are Fundación Valenciaport, Autoridad Portuaria de Valencia, Bureau Veritas, Boluda Corporación Marítima and Seaplace. Fundación Valenciaport is the leader of the Consortium.

Tugs are usually fueled by marine diesel oil. However, this fuel produces a number of polluting emissions. This new vessels is designed by the Spanish tug owner Boluda and Engineering company Seaplace. This is one of the first tugs to be fueled by the much more environmentally friendly liquefied natural gas (LNG) to eliminate sulphur emissions, bring particulate matter emissions down close to zero and reduce the discharge of CO2 and NOx by 26 per cent and 80- 90 per cent respectively.

The new tug is powered by lean-burn gas engines. These powerful gas engines are particularly robust, with a high degree of reliability and long intervals between overhaul. The lean-burn principle delivers high efficiency coupled with reduced exhaust emissions and low specific energy consumption.

Gas engine technology is not new having been proven in both land-based and large ship installations but the LNG fuelled tugs are trailblazers in this sector of the marine market demanding a significant step-forward in technical know-how above that of the average tug building yard. Always at the forefront of innovation and technological advance, Boluda is aimed to lead on all other specialist tug operators in the search for more eco-friendly and economic tug operation.

The systems have had to meet the International Code of Safety for Gas Fuelled ships and the Bureau Veritas Classification Society rules. These involve such requirements as engine room spaces with ventilation of 30 air changes per hour, gas detection, automatic shutdown of gas supply and disconnection of electrical equipment, excess flow shutdown, ventilated double (sheathed) piping. Other special knowledge will be incorporated into the installation of the capacity double walled tank, cold boxes and gas heating systems.

Whenever required, innovative solutions are applied to deal with specific challenges in a safe and cost-efficient manner.

1.1 PROJECT SCHEDULE

The CORE LNGas hive project schedule comprises from January 2014 until December 2019. During this period of time the Project will be developed through several activities.

Considering the Tugboat Powered by LNG as a part as the CORE LNGas hive and taking into account the Activity 2, during this period, all the basic engineering documents were carried out and submitted.

During the Project, a Communication Plan was carried out to ensure that the aims of the project, its ongoing development and its results were publicized among all the actors and stakeholders in the maritime and port industry and more widely among different European regions.

1.2 INITIAL EVALUATION OF THE PROJECT

Concern over vessel´s emissions into the atmosphere of greenhouse gases has led the IMO to create and implement increasingly stringent regulations on emissions through MARPOL convention.

The implementation of new emissions regulations has been implemented globally and locally. Initially the SECA zones (Sulphur Emissions Control Areas) were established, where the percentage of SOx emitted into the atmosphere by marine engines was regulated. Finally, these areas evolved into ECA zones (Emission Control Area), where not only the percentage of SOx emitted is regulated, but also regulate the levels of NOx, CO2 and particulate emissions.

FIGURE 1: ECA WORLD WIDE

The Environmental Protection Agency (EPA) of the United States has modified the usual nomenclature of the IMO, keeping overall maximum emission levels but modifying dates of application in the ECA zones around their coasts.

FIGURE 2 : ECA EEUU

1.2.1 SOx Emissions

According to IMO SOx Regulation 14, from 1 January 2015, ships operating in ECA zone and European ports must use fuels with a sulphur content of less than 0.1%. From 1 January 2020 all ships operating worldwide must use fuels with a sulphur content of less than 0.5%.

The next table and graphic summarize the maximum sulphur content of fuel used onboard inside and outside ECA:

Outside an ECA established to limit SO_x and particulate matter emissions	Inside an ECA established to limit SO_x and particulate matter emissions
4.50% m/m prior to 1 January 2012	1.50% m/m prior to 1 July 2010
3.50% m/m on and after 1 January 2012	1.00% m/m on and after 1 July 2010
0.50% m/m on and after 1 January 2020*	0.10% m/m on and after 1 January 2015

TABLE 1 - SOX EMISSIONS

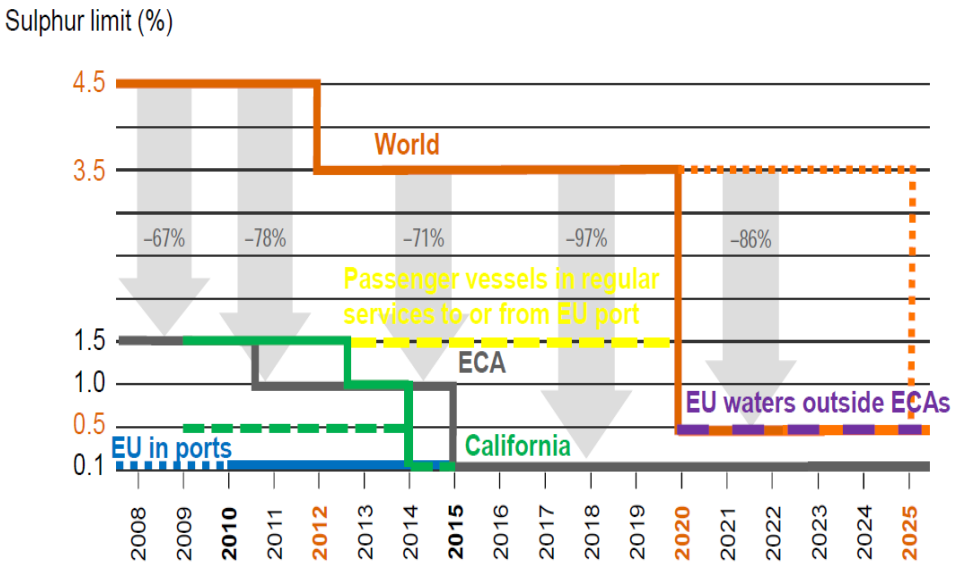


FIGURE 3 : SOX EMISSIONS

1.2.2 NOx Emissions

According to IMO NOx Regulation 13, the NOx regulations set a NOx limit depending on the building date of the vessel and the operation area.

The next table and graphic show the NOx emission limits:

Tier	Ship construction date on or after	Total weighted cycle emission limit (g/kWh) n = engine's rated speed (rpm)		
		n < 130	n = 130 - 1999	n ≥ 2000
I	1 January 2000	17.0	$45 \cdot n^{(-0.2)}$ e.g., 720 rpm – 12.1	9.8
II	1 January 2011	14.4	$44 \cdot n^{(-0.23)}$ e.g., 720 rpm – 9.7	7.7
III	1 January 2016	3.4	$9 \cdot n^{(-0.2)}$ e.g., 720 rpm – 2.4	2.0

TABLE 2 NOX EMISSIONS

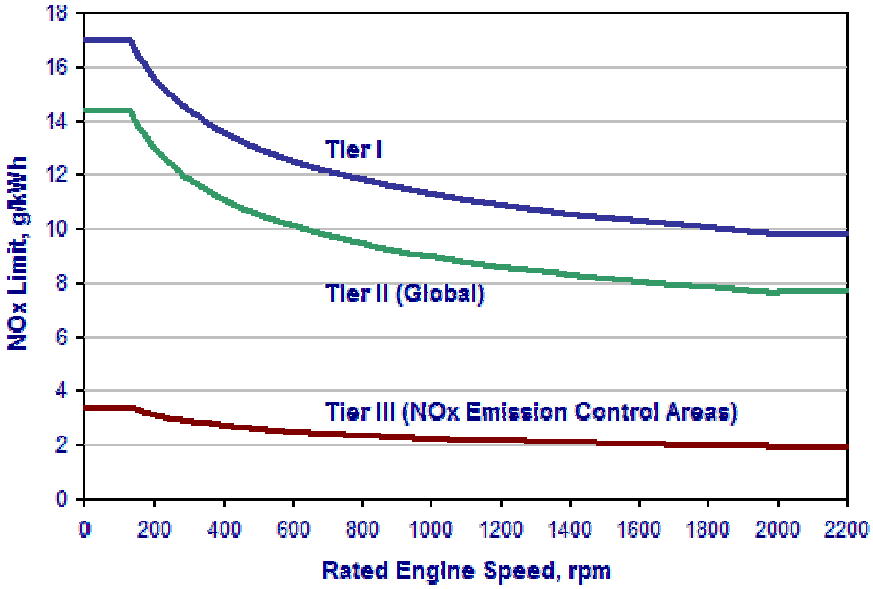
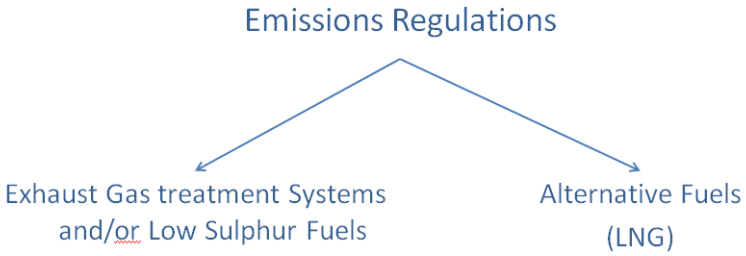


FIGURE 4 : NOX EMISSIONS

According to regulations Tier III will apply at the NOx Emission Control Areas (North American ECA and the United States Caribbean Sea ECA) and Tier II applies globally for vessel built in 2016.

Compliance with those NOx and SOx regulations requires the use of expensive exhaust gas treatment systems and / or the use of fuels with low sulphur content or the use of alternative fuels as Natural Gas.



The use of natural gas as a fuel can meet emission standards without installing any exhaust gas treatment system (no Sulphur content on natural gas and NOx emission reduction) and reduce emissions of CO2 and particulates compared to HFO and MDO.

The next graphic summarize the emissions comparison of a marine diesel engine using HFO-MDO and LNGas fuel:

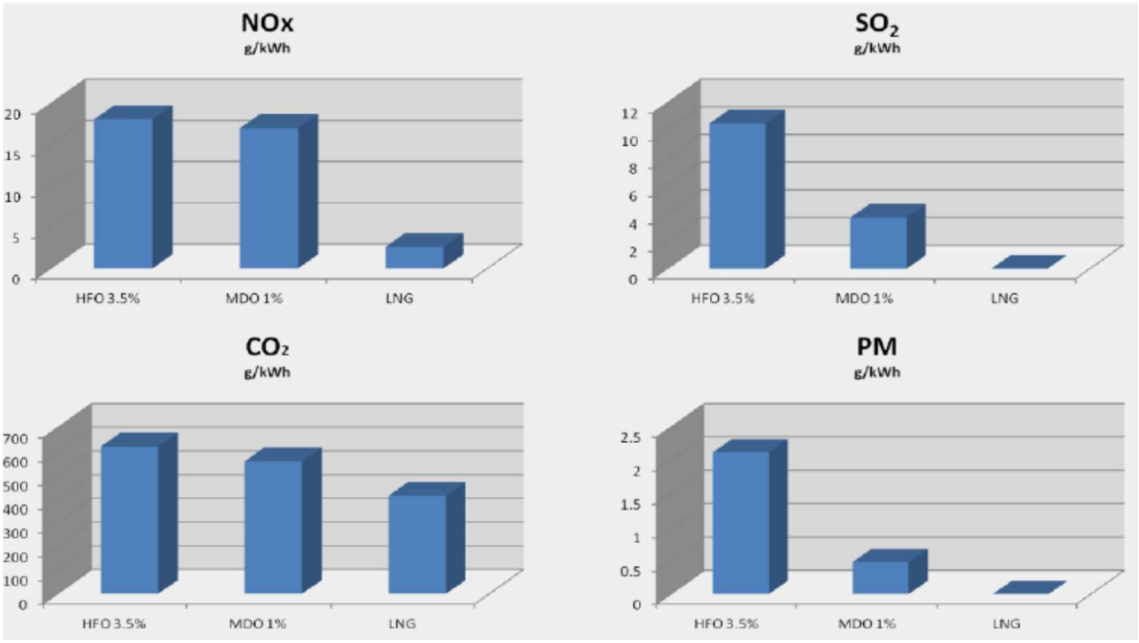


FIGURE 5: EMISSIONS COMPARISON

Add to the environmental benefits, the use of natural gas as fuel has economic advantages due to gas prices. Absence of an LNG maritime distribution network in the cost of natural gas can be increased by the distribution costs that can represent a high percentage of the final price of gas.

1.2.3 Gas fuelled Tug Regulation

Apart from general rules and classification society rules, it is necessary to comply with the regulation for gas fuelled vessels as well as the rules of each classification society for ships powered by gas.

The vessel shall comply with these gas regulations:

International Code of safety for ships using gases or other low-flashpoint fuels (IGF Code):

The purpose of this Code is to provide an international standard for ships using low-flashpoint fuels, other than ships covered by the IGC Code.

This Code provides a mandatory provisions for the arrangement, installation, control and monitoring of machinery, equipment and systems using low-flashpoint fuels minimizing the risk to the ship, its crew and the environment, having regard to the nature of the fuels involved.

Unless expressly provided otherwise this Code applies to ships to which part A of Solas chapter II-1 applies.

Classification Society Gas fuelled vessels rules:

The vessel will be certified by the classification society Bureau Veritas and shall comply with all gas fuelled class notations.

According to BV Steel ships regulation, part A, Ch 1, Art 4, the vessel shall comply with the service notation gasfuel, created for vessels propelled by gas engines. This service notation is completed by the additional rule NR529 Safety Rules for Gas-Fuelled Engines installations in ships.

1.2.4 LNG Tank alternatives

The liquefied natural gas storage tank on board is the first step in the fuel gas supply system. The selection of the type of tank to be used on board as well as its main characteristics as size and shape is defined by the operation of the vessel (autonomy / fuel consumption) and the space available on board.

The autonomy of the vessel set by the project requirements indicates the need to store the LNG for a large period of time. Usual operation of a tugboat has large peaks in gas demand and others in which gas demand is virtually zero. The gas consumption of the engine depends on the hours of operation and the engine load during operation.

The following graphic shows the average engine load based on similar tugs in operation:

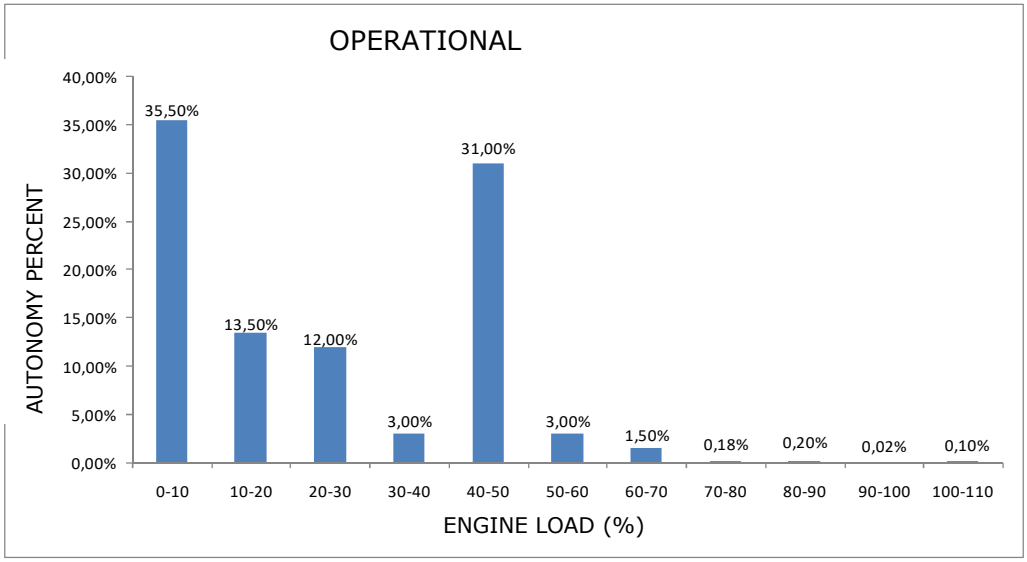


FIGURE 6: OPERATIONAL PROFILE

According to the operational profile the average load of the engine is 24.8 %. Therefore it is necessary a tank capable of withstanding the pressure generated by the evaporation of gas inside the tank in those periods where the ship is operating in low demand of gas.

Currently the only tanks capable of withstanding pressure (up 10barg) are type C tanks. Two types of C tanks are commercialized: cylindrical and prismatic type. Some variations of the cylindrical type are the bi-lobed tanks.

Cylindrical type C tanks have a low volumetric efficiency and integration onboard in tank spaces below deck is complex.

FIGURE 7: TYPE C TANKS

LNG tank facilities under the main deck, where space is limited, the net volumetric efficiency of cylindrical tanks is very low. The result is a large loss of space under the main deck for this type of LNG tank.

This problem is solved by installing prismatic tanks. Prismatic tanks have been proved by several society classes and several project ongoing plan to use them on board.

Type	Cylindrical (Type C)	Type B	LPV (Type C)
Fluid Volume (m^3)	15,870	15,120	15,120
Installation Volume (m^3)	50,046	15,998	15,998
Volume efficiency (%)	32	95	95
No. of tanks	15	1	1
No. of lost containers	1,317	421	421
BOG compression system	Not required	Required	Not required
BOG loss	None	Intermittent at low load	None
Insulation for tank	Simple	Complicated	Simple
Secondary barrier	Not required	Required	Not required
Insulation for hull	Not required	Required	Not required
Productivity	High (Simple geometry)	Low	High (Repeated structure)

FIGURE 8 ATS PRISMATIC TANK TYPE C VS CONVENTIONAL TANKS

1.2.5 Gas fuelled tugs

Nowadays gas is increasing its popularity as marine fuel. Environmental friendly combined with lower costs are the main reasons for many operators to consider it over traditional fuels across a wide range of ship types. There are ferries, inland barges, chemical tankers, supply vessels and others propelled by gas.

M/V Seagas bunkering Viking Grace.


Lady Viking

Argonon.


Francisco


Fiord 1 MRF.

The number of powered by gas vessels built in the last 10 years has undergone a significant increase. In July 2015 the DNV-GL updated its estimations of LNG fuelled fleet excluding Gas carriers and inland waterways vessels. DNV-GL estimated a gas fuelled fleet of 1000 vessel classified by DNV-GL by 2020. The estimation has been updated several times, at the submission of the present report, DNV-GL has estimated that probably 500 ships will be gas fuelled by 2020.

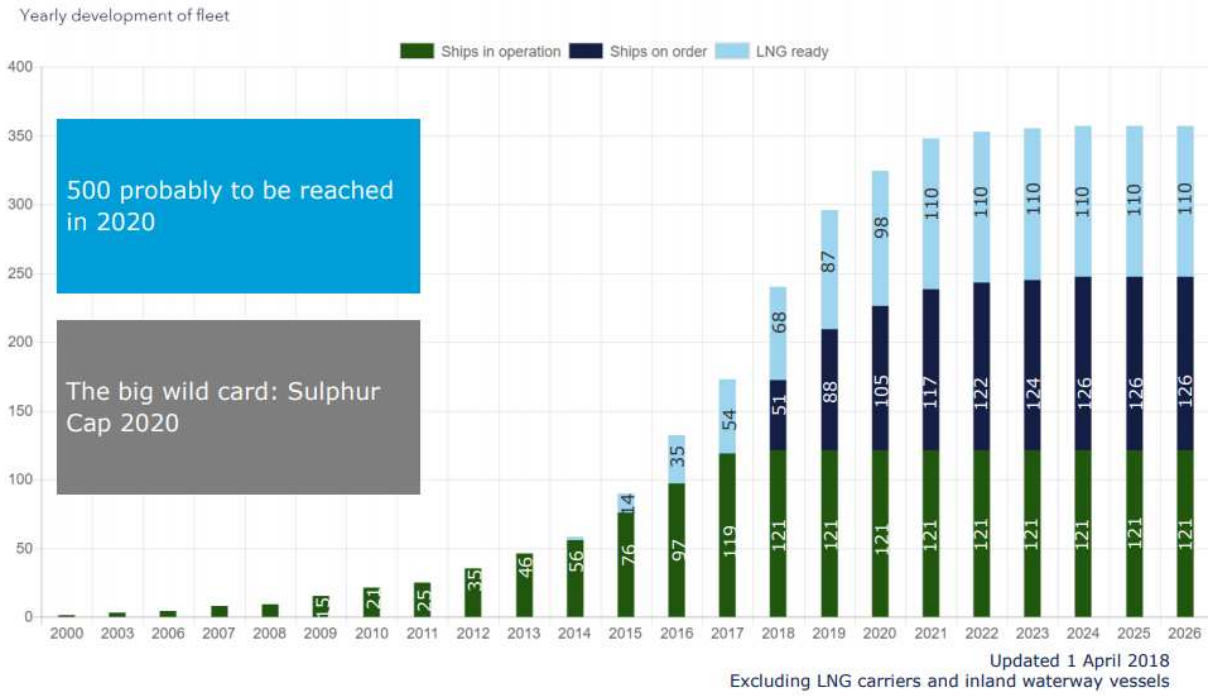


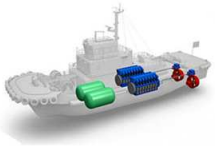
FIGURE 9: DNV-GL LNG FUELLED FLEET ESTIMATION

The operation area of tugs makes them conducive to the use of gas as fuel. Most tugs operate near to shore where the emissions reductions are most significant and as the LNG marine supply network is getting further developed so it is expected that more major ports will also choose natural gas as tugs fuel to reduce emissions, reduce cost and eliminate smoke.

Currently there are several tugs propelled by gas in operation in the world and some more in design / construction stages.

1.2.5.1 Sakigake (ASIA)

REMOLCADORES JAPONÉS (2016)



- L= 33.50 m
- B= 10.20 m
- T= 4,37 m
- Escolta/Fifi 1/Oil Rec.
- Niigata 28AHX-DF- Dual
- ASD- Azimuthing Stern Drive
- ClassNK
- Propulsor:Wärtsila Steerable ThrusterWST-18
- Astillero Keihin Dock(Japón)
- Armador: NYK-Nippon Yusen Kaisha

The new tug Sakigake was delivered in 2015 by Keihin Dock Co. Ltd. This is the first tug propelled by LNG to operate in Japanese waters. The tug has been delivered to the company Nippon Yussen Kaisha (NYK) Line. It has been chartered to the Wing Maritime Service Corporation. The vessel will operate at the Yokohama and Kawasaki ports.

The project has received subsidies from Japan's Ministry of Economy, Trade and Industry and the Ministry of Land, Infrastructure and Transport.

The tug is propelled by two dual fuel engines. The Sakigake is equipped with twin Niigata 6L28AHX-DF dual-fuel engines, each developing 1618 kW. Engines are the prime movers for a 360-degree steerable Niigata Z-Peller propulsion system. The engines can run on either liquefied natural gas or diesel oil. The engine running on gas will consume a small amount of diesel oil. On gas mode the emissions are reduced by a 30% of CO_2 and 80% of NO_2.

LNG bunkering will be done by truck at a pier in Yokohama port. The company Tokyo Gas Co. will supply LNG fuel for the vessel.

In July 2015 a trial fueling of the vessel from a truck was successfully carried out for the first time in Japan.

FIGURE 10: SAKIGAKE

1.2.5.2 Hai Yang Shi You 525 (ASIA)

REMOLCADOR CHINO: HAI YANG SHI YOU 525

- L= 38,6 m
- B= 11,6 m
- T= 4,1 m
- Rolls-Royce C26:33L9PG- Gas
- 2430kW
- Propulsor: Rolls-Royce US 205 CP
- ASD- Azimuthing Stern Drive
- Astillero Jiangsu Zhenjiang
- Armador: CNOOC

Zhenjiang shipyard has delivered in 2015 the first tugboat, *Hai Yang Shi You 525*, propelled by liquefied natural gas solely for the China National Offshore Oil Corporation (CNOOC). CNOOC, Shanghai Bestway Engineering, Zhenjiang Shipyard and Rolls-Royce have been involved in the development of the project.

The decision to design a vessel propelled by LNG follows the Chinese government's 2011 plan. This plan tries to strengthen its maritime base with the manufacture of high-end, ecologically-efficient ships and technology.

Rolls-Royce has provided a propulsion package based on twin Rolls-Royce Bergen C26:33L9PG engines directly couple to a Rolls-Royce US 205 CP azimuth thrusters ensuring rapid manoeuvring and strong bollard pull capabilities to the tug.

Usage of LNG in this tugboat eliminates sulphur emissions, reduce particulate matter emissions close to zero and reduce the discharge of CO_2 and NOx by 25 per cent and 80-90 percent respectively. Rolls-Royce gas fuelled Bergen engines meet IMO Tier II and Tier III regulations as well as US Environmental Protection Agency rules on NOx.

FIGURE 11: HAI YANG SHI YOU 525

1.2.5.3 Hai Yang Shi You 521 (CHINA) and Hai Yang Shi You 522 (CHINA)

REMOLCADORES CHINOS: HAI YANG SHI YOU 521, HAI YANG SHI YOU 522

- L= 38,6 m
- B= 11,6 m
- T= 4,1 m
- Escolta/Remolque/Fifi
- Wärtsilä 34DF- Dual
- 25 m3 GNL
- Potencia: 6500 hp
- ASD- Azimuthing Stern Drive
- CCS- China Classification Society
- Astillero CSSC Guangzhou Haungpu
- Armador: CNOOC

In 2013 the Chinese port of Gaolan (near Hong Kong) was the first to feature the world's first tugs powered by liquefied natural gas. These LNG tugs are the first in a series and will be the first tugs in China ever to be propelled by gas. The tugs are intended for towing duties, escort and firefighting. Both tugs built for CNOOC Energy Technology & Services Limited (CETS).

CNOOC works with the philosophy and strategy of achieving more clean energy in its operations. The low emission levels is particularly beneficial for Vessels operating close to population centers are more sensible to air pollution, as tugs frequently are. These tugs will operate along China's coastline, bunkering from the company's own bunkering terminals. Tugs will each be powered by two 6-cylinder Wärtsilä 34DF in line dual-fuel engines with a total output of 3000kW each one. These engines when operating in gas mode, the nitrogen oxide (NOx) emissions are at least 85 percent below those specified in the current IMO regulations, and CO_2 emissions are some 25 percent less than those of a conventional marine engine running on diesel fuel.

FIGURE 12: HAI YANG SHI YOU 522

1.2.5.4 Borgøy and Bokn (EUROPE)

FIGURE 13: BORGΦY Y BOKN

The Borgøy and the Bokn were born with the idea of designing and building the world's first LNG fuelled escort tug. Each with fire-fighting and oil recovery capability were intended to be the world's most environmentally friendly tugs. This innovative project became a reality when the Borgøy was handed over for sea trials in January of 2014.

The vessels were designed by Norway's Buksèrog Berging and Marine Design AS, and built by Sanmar's Istanbul shipyard. The tugs will be operated by Buksèrog Berging at Statoil's Kårstø gas Terminal in northern Norway.

Kårstø gas Terminal is the largest one in exports facility of LNG in Europe and the third largest one in the world. LNG tankers, LPG carriers and chemical tankers operate 24 hours per day and 365 days a year. Escorts tugs must be available for the safe handling and manoeuvring of these vessels.

Usage of LNG in this tugboat eliminates sulphur emissions, reduce particulate matter emissions close to zero and reduce the discharge of CO_2 by 25% and NOx by 80-90 percent. Rolls-Royce gas fuelled Bergen engines meet IMO Tier II and Tier III regulations as well as US Environmental Protection Agency rules on NOx.

The engines, propulsion package and LNG system has been delivered by Rolls-Royce. Both vessels are powered by two (2) Rolls-Royce Bergen C26:33L6PG lean-burn gas engines with a total power output t of 3240 kW at 1000 rpm. The engines are directly coupled to Rolls-Royce US35 azimuth thrusters, each fitted with a 3m CP propeller in a nozzle. A Schottel 333kW bow thruster is set onboard to provide extra maneuverability.

The LNG tank provided by Rolls Royce is an Aga Cryro AB type C tank mounted in vertical with an approx. capacity of 80 m^3. The tank C type is selected to withstand pressure. The fuel gas supply system is designed to work without pumps, using the LNG tank pressure. The gas tank provides autonomy of 4-5 days operation at 10 knots. All fuel gas supply systems are duplicated (one at each side) according to meet the International Code of Safety for Gas Fuelled ships and the DNV Classification Society rules for single gas fuelled propulsion applications. In case of failure the system includes a crossover valve to allow

both engines to keep running in the event of a problem with the tank connection space on one side.

As safety issues, the tugs include double-walled gas supply pipes between the tank and combustion chamber, gas detectors and external gas detection system above the engine are fitted in accordance with class requirements. In the event of a leakage from any inner pipe, the gas is collected and ventilated to the mast.

FIGURE 14: BORGΦY

1.2.5.5 DUX, PAX and AUDAX (EUROPE)

FIGURE 15 – DUX, PAX AND AUDAX DUAL FUEL TUGBOATS

The Dual fuel tugs where built in Astilleros Gondán (Spain) for Østensjo Rederi A/S, the last one was delivered in 2017 and all of them are operating in Norway

The main particulars are:

- LOA: 40.2 m
- Beam: 16 m
- Depth: 6.3 m
- Max. Draft: 6.7 m
- FIFI-1
- Oil Recovery
- Dual Fuel
- LNG Tank capacity: 30 m³
- Crew: 8
- Main engines: Wärtsilä 2 x 6L34DF / 3000kW
- Azimuth: Schottel SRP3030CP
- BP: 110 t

2 VESSEL CONCEPT

From the beginning of Project, Seaplace has developed different works with the objective of establishing a solid foundation for further developments.

Early works have been focused on defining the basic parameters of the Tugboat. The basic parameters, defined together with Boluda, are as follows.

- GT<500
- Pure Gas Propulsion
- 65 tons Bollard Pull

Based on these requirements, five different Tugboat configurations were developed:

- ASD Prismatic tank
- ASD Cylindrical tank 1
- ASD Cylindrical tank 2
- ATD Prismatic tank
- ATD Vertical cylindrical tank

In parallel to the development of conceptual tugboat, and directly linked to them, the operating profile of the tug has been analyzed in order to determinate the capacity of the LNG tank. The operating profile was indicated in the document "*DC-801-PO-001-Operation Profile*".

Moreover, in collaboration with Bureau Veritas, the class notation was defined in order to meet the regulatory requirements.

For the development of the project, several meetings have been held with the partners of the project. Meetings have been held in Valencia and in Madrid where all partners have participated jointly: DGMM, Valenciaport Foundation, BV, Boluda and Seaplace.

2.1 INTENDED SERVICE OF THE VESSEL, CLASS AND TYPE

2.1.1 VESSEL FUCTION

The vessel shall be an escort tug powered by LNG. The fuel is stored in a LNG type C tank with a volume for approximately 10 days, inside the Tank Room. The specific gravity of the cargo is 0.45 t/m3.

The propulsion is a gas plant conformed by two main gas engines which feed two azimuth thrusters located forward, and a harbour diesel engine. Each main engine will have one gearbox in order to feed the FiFi pumps and the shaft generators.

The vessel is designed to be fire-fighting, FiFi 1, with two fire monitors located above accommodation deck, and two FiFi pumps located in the engine room and coupled to the gearboxes according to the Class Rules.

The vessel is intended to operate at the Mediterranean Coast Ports as an escort tug. The vessel will be fitted with two bunker stations on board, and the bunkering of LNG will be as Truck to Ship (TTS) considering the present status of the LNG bunkering facilities.

The vessel will have a steel hull and superstructure, fully welded.

All the materials and equipment fitted in the vessel shall be new and of good quality. The construction shall be carried out according to Class Requirements and good International ship building practice. The ship Builder will apply its own construction standards, subject to Class Approval.

The vessel will be an escort tug with a bollard pull of 65 tons and an accommodation designed for 8 people. The vessel will have less than 500 Gross Tonnage and will be also intended for firefighting service.

2.1.2 OPERATION AREA

The vessel is designed to operate in the Spanish Mediterranean Coast in the following climate conditions:

- Ambient temperature -5°C / +35°C
- Sea water temperature 0°C / +32°C
- Engine Room +5ºC to +45ºC.
- Humidity 30%-70%

2.1.3 CLASSIFICATION

The vessel is designed and built on the basis of Classification Rules of BV:

- I+HULL
- + MACH
- Escort Tug
- Fire Fighting ship 1 water spray
- AUT-UMS
- COMF-NOISE 1
- INWATERSURVEY
- GasFuel

2.1.4 RULES AND CONVENTIONS AND CERTIFICATES

The vessel has to comply, but not limited to, the following rules and regulations:

1) Rules and Regulations of the Country of Registry (Spain)
2) Rules and Regulations of Classification Society (BV)
3) Rules and Regulations of the proposed Loading and Discharging Terminals
4) International Convention on Load Lines
5) International Convention for the Safety of Life at Sea (SOLAS)
6) International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF-Code)
7) Convention on the International Regulations for Preventing Collisions at Sea (COLREG)
8) International Convention on Tonnage Measurements of Ships
9) ILO Maritime Labour Convention, 2006
10) ILO Convention concerning crew accommodation on board ships, No. 92 and 133
11) IMO Resolution MSC 137 (76) Standards for Ship Manoeuvrability, as applicable
12) IMO Resolution A343 (IX) "Recommendations on Methods measuring Noise Levels at listening Posts" as amended
13) IMO Resolution A468 (XII) "Code on Noise Levels on board Ships"
14) IMO Resolution A708 (17) "Navigation Bridge Visibility and Function"
15) IMO Resolution A686 (17) Code on Alarms and Indicators"
16) IMO Publication No. 978 "Performance Standards for Navigational Equipment"
17) IMO Regulation on Ballast Water Management (BWM)
18) IEC International Electro-technical Commission (IEC), Publication No.60092 for Electrical Installations on Ships
19) International Ship and Port Facility Security Code (ISPS-Code)
20) International Convention for the Prevention of Pollution from Ships MARPOL including Annex I, IV, V and VI, incl. Ch.4 (EEDI)
21) Spanish Gas System Regulations, including NGTS Regulations

All certificates will be issued without restrictions unless otherwise stated and effective in a date close to date of vessel delivery.

2.2 VESSEL CHARACTERISTICS

2.2.1 MAIN DIMENSIONS

- Length overall 29,5 m
- Length between perpendiculars 28,6 m
- Breath moulded 12,8 m
- Depth Main deck 5,3 m
- Design Draft 3,5 m
- Crew 8p

2.2.2 TONNAGE

The designed tug fulfil the GT requirements with Gross Tonnage less than 499 GT. Tonnage calculation is calculated according to 1969 Convention and validated by Flag and BV.

2.2.3 BOLLARD PULL

The bollard pull for the vessel at 100% Maximum Continuous Rating (MCR) under standard tropical conditions and design draught shall be of 65 metric tons.

Bollard pull is has been carried out according to the Classification Society procedure and certified by Classification Society.

2.2.4 CAPACITIES

- LNG Approx. 68 m3
- Fuel Oil Approx. 4 m3
- Fresh water Approx. 15 m3

2.2.1 RANGE

About 10 days at service speed on design draft.

2.2.2 SPEED AND POWERING

Two gas engines will supply the power demand and the shaft generators are mainly used for power supply at deck machinery and service operations.

- Total power installed (MCR): 4860kW
- Service speed at design draft: 12 knots
- Specific energy consumption: 7500 KJ/KWh

2.2.3 OPERATING PROFILE

The following operating profile has been obtained from a database of similar vessels:

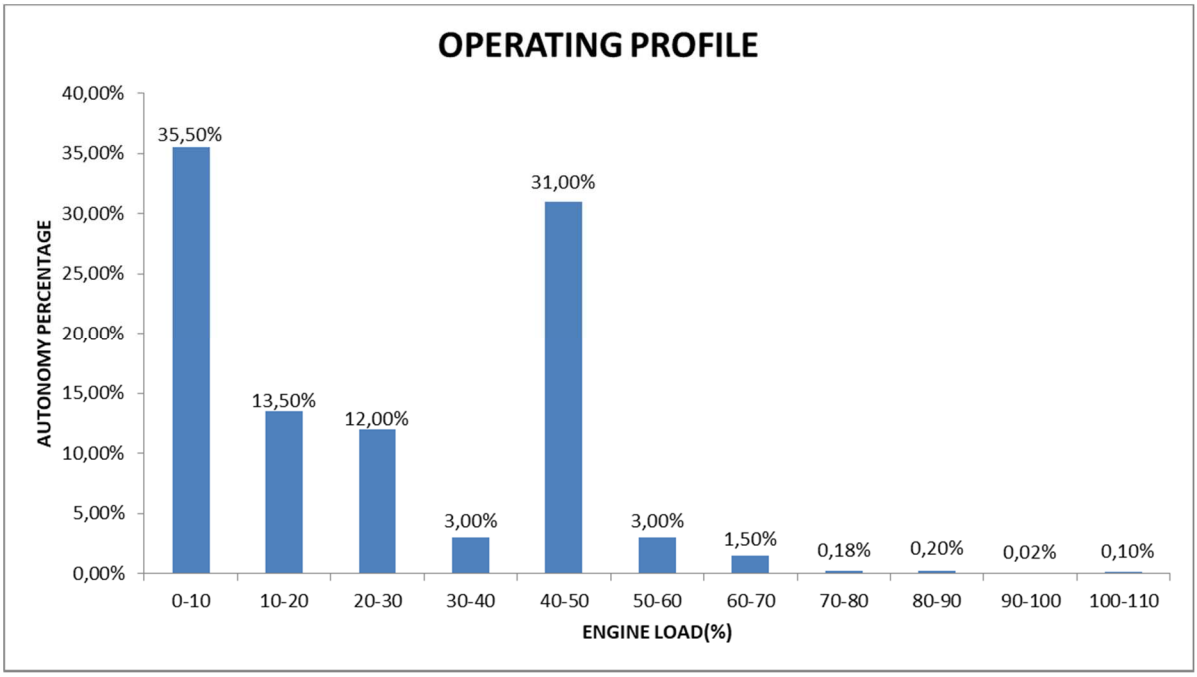


FIGURE 16 OPERATING PROFILE

According to this data, the engine main load is 24.8%. This load is considered for the tugboat activity periods, 12 hours a day.

2.2.4 CONSUMPTION CALCULATIONS

With and operating profile of 24.8%, 12 working hours a day and taking into account the engine power and GNL properties, a GNL consumption estimation is made.

The consumption is expressed in m^3 and depending on the tugboat autonomy in days.

INITIAL DATA				
MAIN LOAD	BKW	Specific Energy Consumption (Kj/KWh)	HHV (Kj/Kg)	Density (kg/m3)
24,8	4860	7550	49700	450

TABLE 1 INITIAL DATA

CONSUMPTION				
Autonomy (DAYS)	POWER (KW)	Consumption (Kj)	Consumption (Kg)	Consumption (m3)
14	1205,28	1,53E+09	30760	68,356
13	1205,28	1,42E+09	28563	63,473
12	1205,28	1,31E+09	26366	58,591
11	1205,28	1,20E+09	24169	53,708
10	1205,28	1,09E+09	21972	48,826

TABLE 2 CONSUMPTION

3 BASIC DESIGN DEVELOPMENT

3.1 GENERAL ARRANGEMENT

The General Arrangement has been developed fulfilling the requirements noted from Boluda. An initial assessment from Bureau Veritas has been done.

FIGURE 17 TUGBOAT 3D MODEL

3.1.1 ANALYSIS OF THE DIFFERENT TUGBOAT CONFIGURATIONS

To comply with the requirements, five different Tugboat configurations were developed by Seaplace. Theses configurations vary mainly due to the utilised LNG tank. The studied options are: ASD prismatic tank, ASD horizontal tank, ASD horizontal tank, ATD prismatic tank and ATD vertical tank.

The different configurations are depicted in the documents:

- *"GE-801-SK-001 ASD PRISMATIC TANK"*
- *"GE-801-SK-002 ASD HORIZONTAL TANK"*
- *"GE-801-SK-003 ASD HORIZONTAL TANK"*
- *"GE-801-SK-004 ATD PRISMATIC TANK"*
- *"GE-801-SK-005 ATD VERTICAL TANK"*

3.1.1.1 ASD Prismatic tank

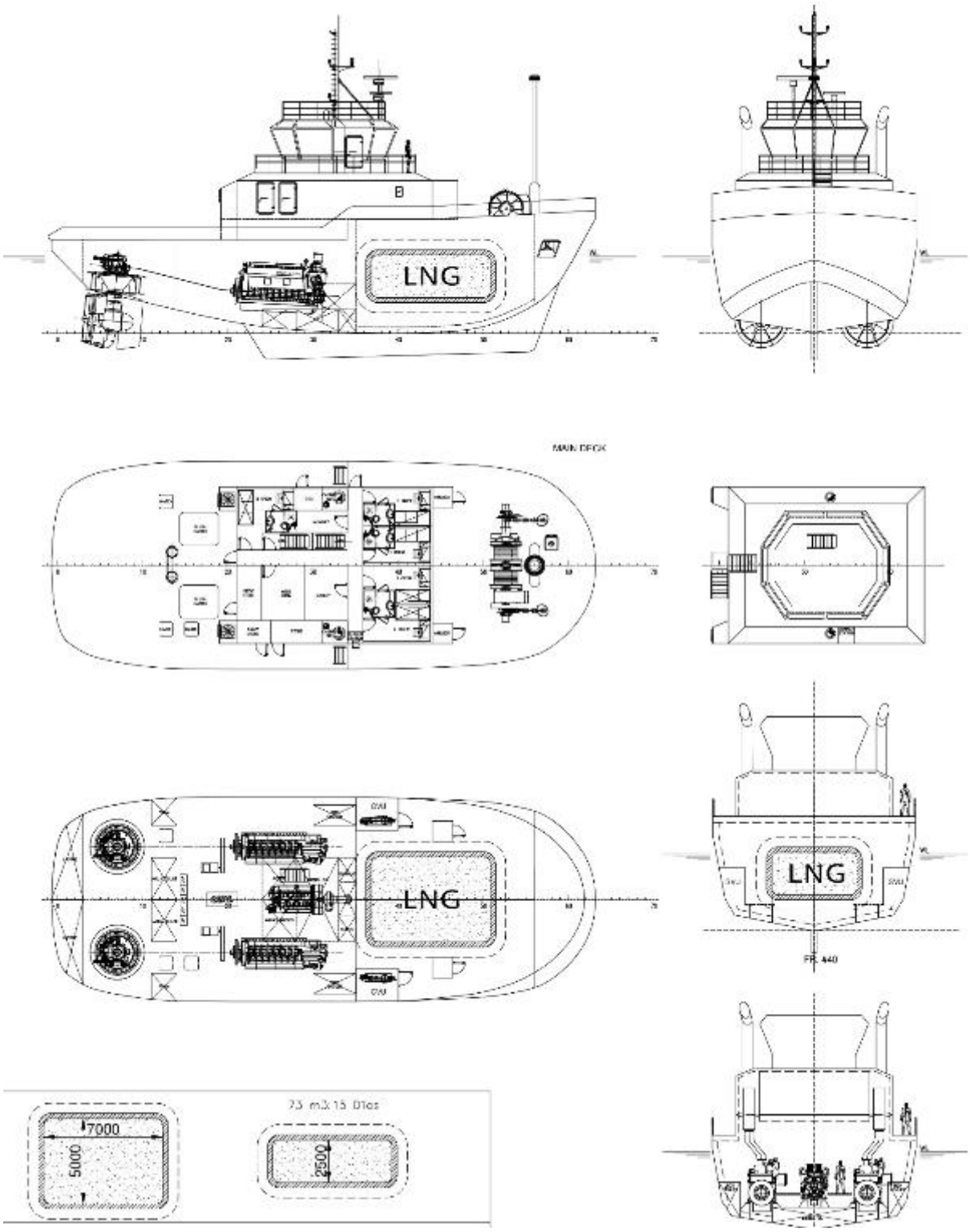


FIGURE 18 ASD PRISMATIC TANK

3.1.1.2 ASD Cylindrical tank 1

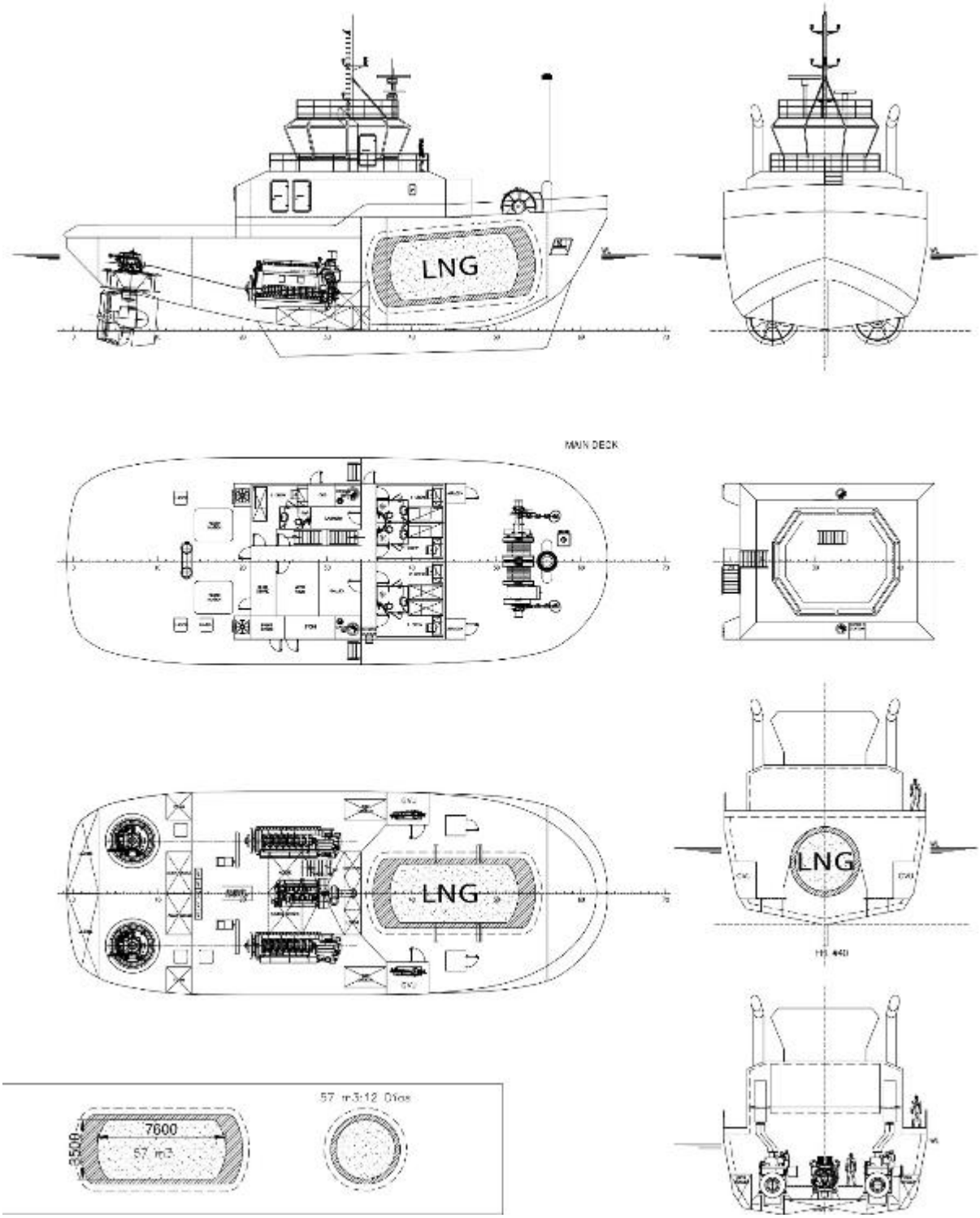


FIGURE 19 ASD CYLINDRICAL TANK 1

3.1.1.3 ASD Cylindrical tank 2

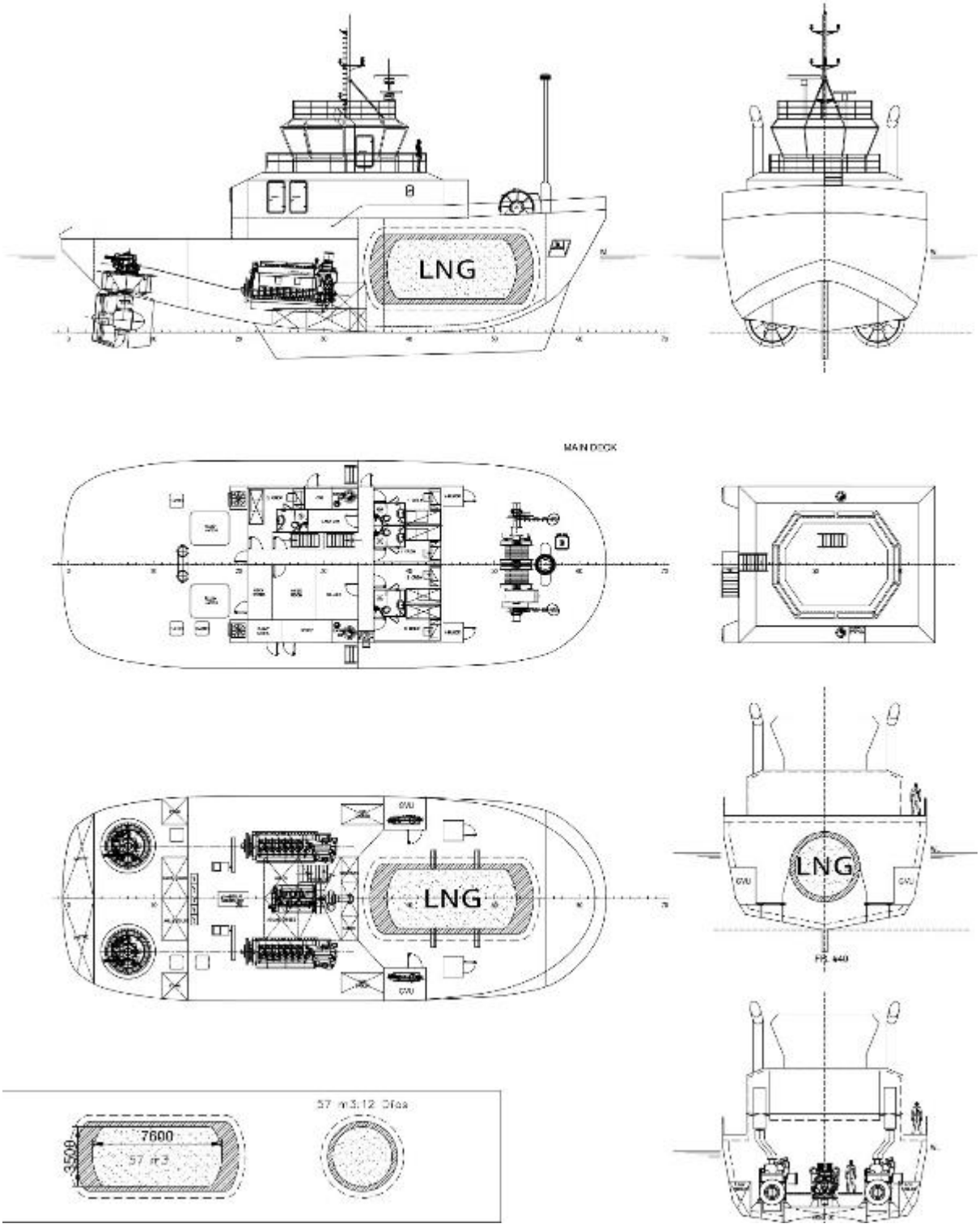


FIGURE 20 ASD CYLINDRICAL TANK 2

3.1.1.4 ATD Prismatic tank

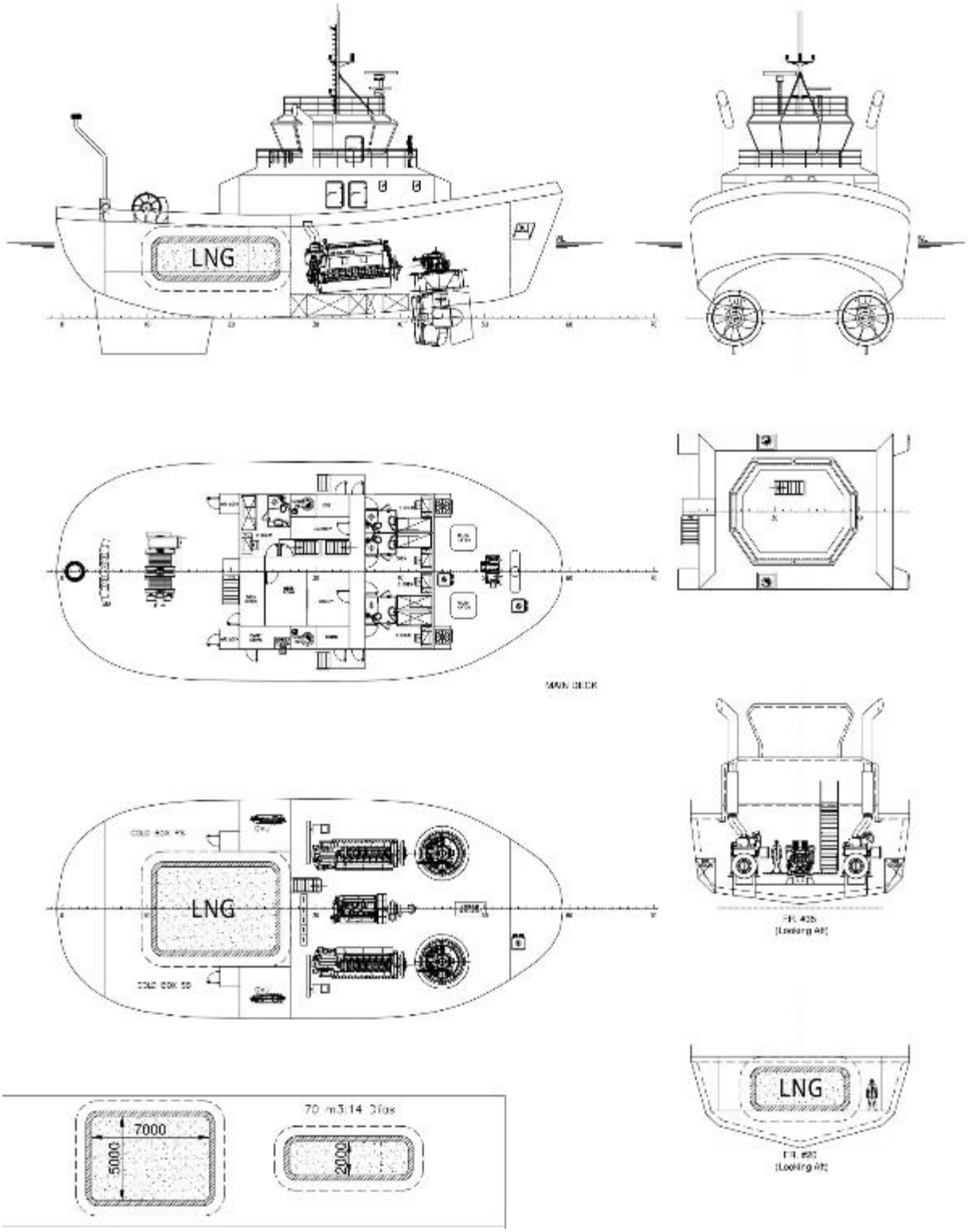


FIGURE 21 ATD PRISMATIC TANK

3.1.1.5 ATD Vertical cylindrical tank

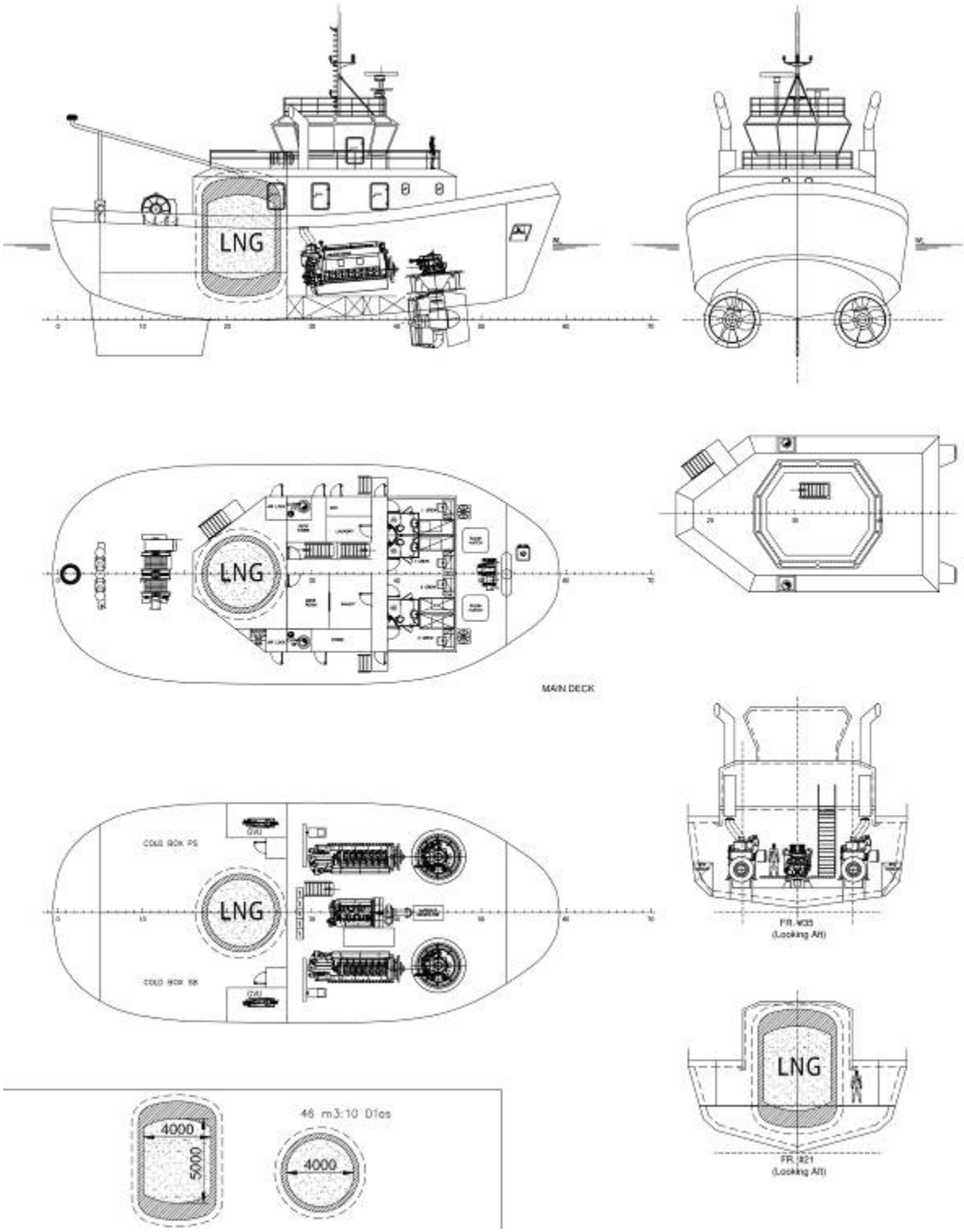


FIGURE 22 ATD VERTICAL CYLINDRICAL TANK

3.1.2 GENERAL ARRANGEMENT

After analysing all the possible configurations, the ATD Prismatic tank distribution is chosen due to the better compliance with the requirements and usability of the vessel.

The different configurations assessed have different requirements and impacts on the existing deck. In order to properly evaluate the impact, once the final configuration of the LNG tanks is set, the analysis of the location of existing main elements on deck was done.

Considering the intended service of the Tugboat and its class notation, the main deck, bridge deck and spaces bellow main deck are fully provided with all the necessary equipment to fulfil their normal operation.

All drawings have been approved and stamped by Bureau Veritas

General Arrangement spaces distribution is as follows:

Below main deck:

- Aft peak tank.
- Tank room with LNG tank.
- Cold Box Portside with Airlock.
- Cold Box Starboard Side with Airlock.
- Box coolers.
- F.W. tanks.
- Engine room with engine tanks (bilge, waste oil, sludge…).
- Chain lockers.
- Fore peak tank.
- Void spaces.
- Sea chests.

On main deck:

- Casing.
- Galley.
- Mess room.
- Laundry.
- Stores.
- N2/Dry powder room
- Bunker Stations.
- Three double cabins with toilet.
- Two single cabins with toilet (Captain and Chief Engineer cabins).
- Deck machinery.
- FiFi Monitors.

On bridge Deck:

- Wheelhouse.

Subdivision of the vessel and arrangement of spaces, superstructures, deck houses, hold space, accommodation etc..., as shown on drawing *"GE-801-GA-001-02_General Arrangement"*.

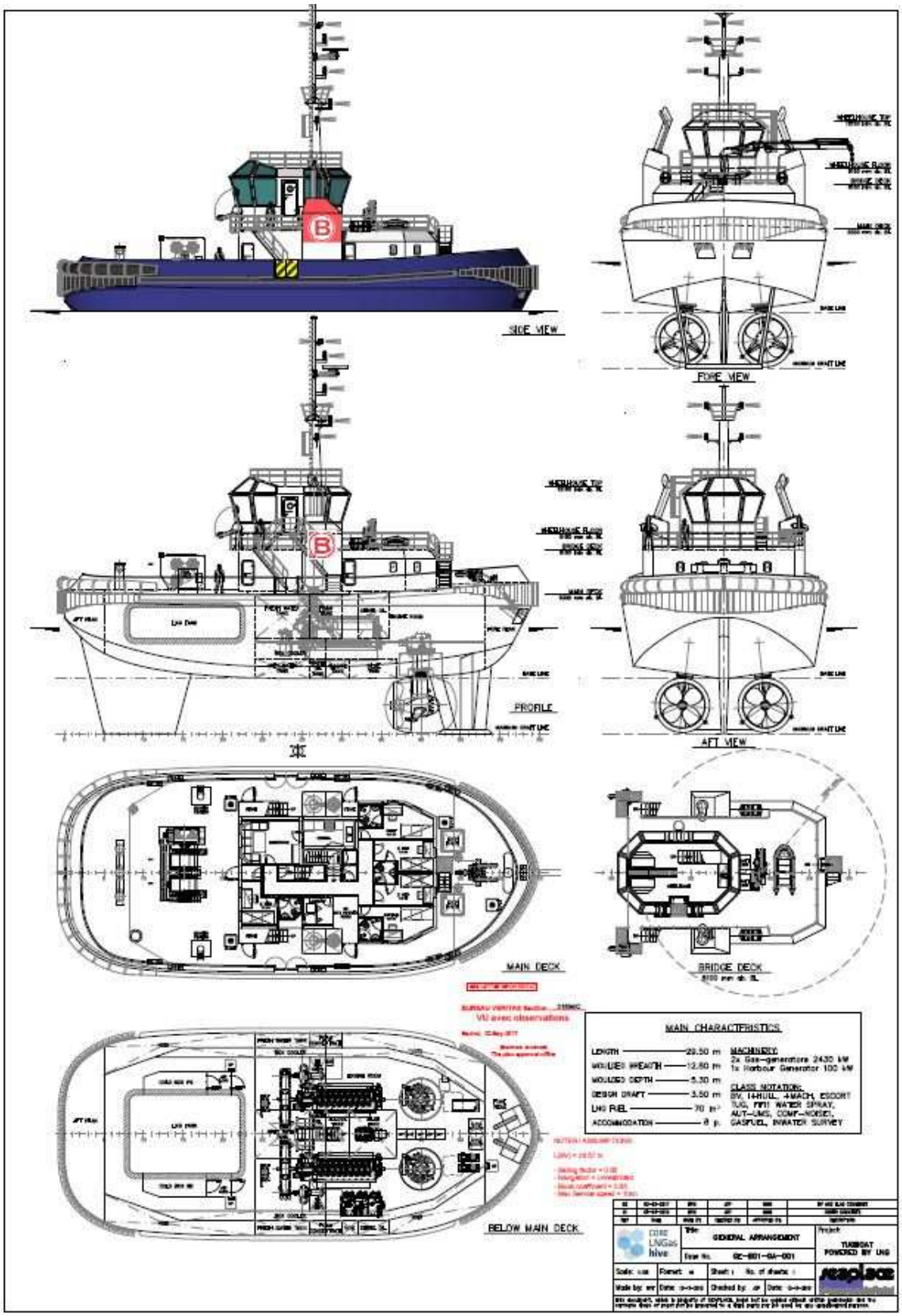


FIGURE 23 GENERAL ARRANGEMENT

3.2 NAVAL ARCHITECTURE

3.2.1 BODY PLAN

The drawing of the body plan can be found in the document *"NA-801-BP-001-00_Body Plan"*

The vessel's lines is designed to be optimum for the principal dimensions, based on proven design and approved by propulsion system manufacturer.

Frame spacing is 500 mm being the origin on the frame system the aft most point of the structure.

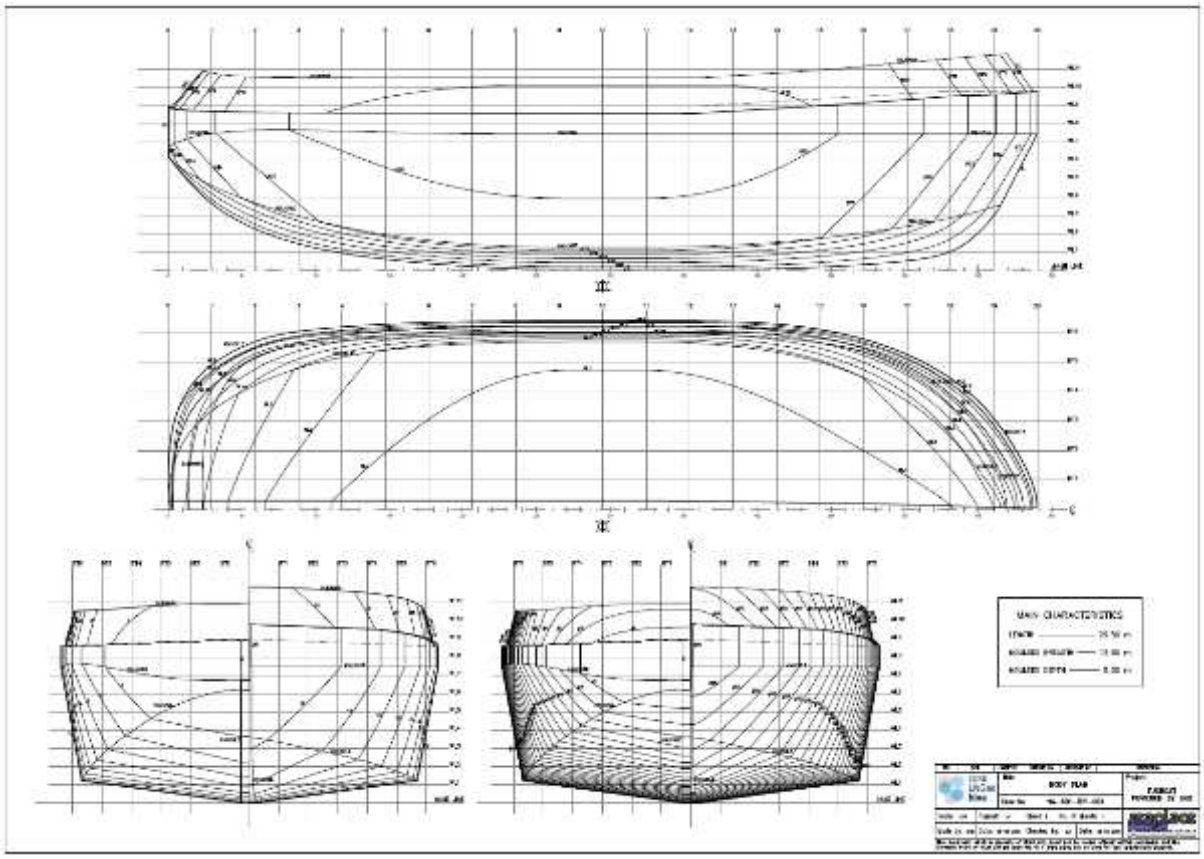


FIGURE 24 BODY PLAN

3.2.2 BONJEAN AND SECTIONAL AREAS CURVES

The calculation of the Bonjean and sectional areas curves are contained in the document *"NA-801-CS-001-00_Bonjean Curves"*

The Bonjean curves and sectional areas curve are calculated

Here are represented the Bonjean curves from a draught of 0.2 to 5.2 m with intervals equally spaced 0.2 m.

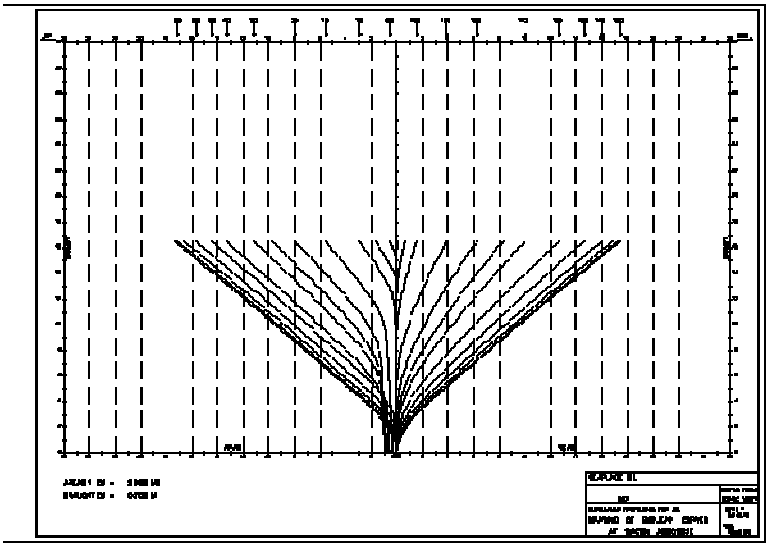


FIGURE 25 BONJEAN CURVES

The curve of sectional areas at the design draught of 3.3 m comparing the percentage of maximum halfbreath with the percentage of maximum section area.

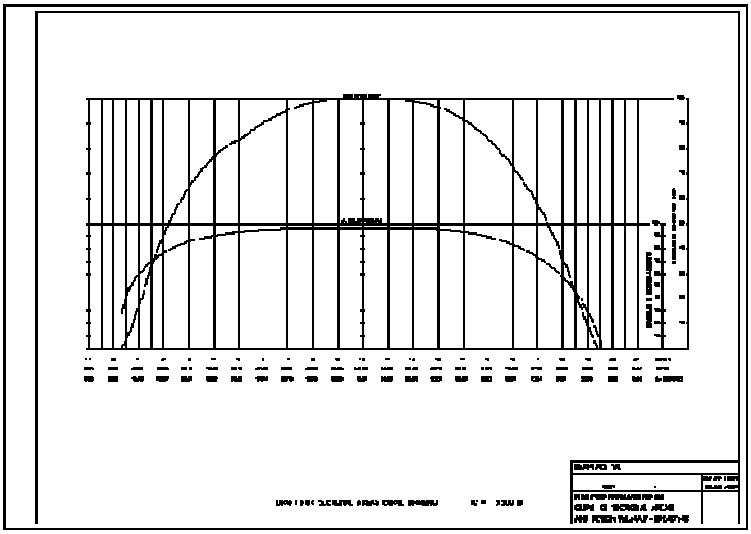


FIGURE 26 SECTIONAL AREAS CURVE

3.2.3 HYDROSTATIC CALCULATIONS

The document *"NA-801-CS-002_00_Hydrostatic Calculations"* contains the hydrostatic calculations

The most common hydrostatic parameters of the tugboat for draughts equally spaced from 0.1 m to 5.0 m are calculated.

The hydrostatic parameters included in the document are:

(TA) Aft draft
(TF) Fore draft
(DISFA) Displacement
(DISV) Moulded volume
(XCB) X.C.B.
(XCBA) X.C.B. with App.
(HCB) H.C.B.
(AW) Waterline area
(AX) Max. Tran. section
(ZBM) Tran. metacentric radius
(ZBML) Long. metacentric radius
(CB) Block coefficient
(CP) Prismatic coefficient
(CM) Maximum section coefficient
(MTC) Moment trim 1 cm
(TCI) Tons. immersion 1 cm
(S) Wet surface area
(CW) Waterline coefficient
(XCF) X.C.F.

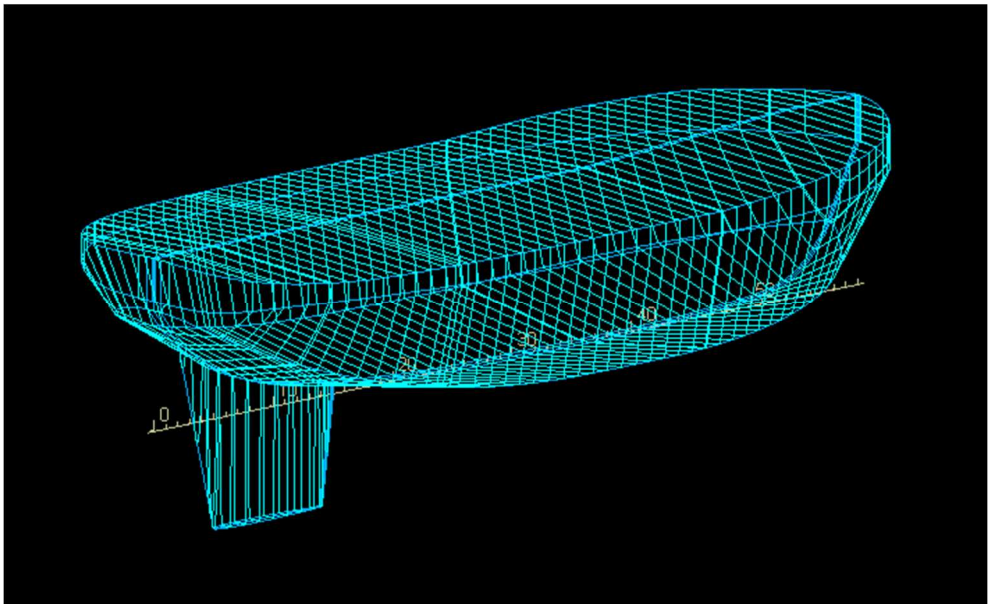


FIGURE 27 HULL TRANSVERSAL SECTIONS

3.2.4 STABILITY CROSS CURVES

Stability Cross Curves have also been calculated numerical and graphically. The software used for the calculations is FORAN v70.

Trims of 0.00 and 0.50 m are considered, as these values cover all the operational trims expected in a preliminary stability analysis.

Displacements covering the operational draught range are considered, and these are 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200 and 1300 tons.

The **heeling angles** used for the calculations are 5, 10, 15, 20, 25, 30, 35, 40, 50 and 60 degrees. Only portside heeling angles are considered, as the tugboat watertight hull is symmetrical.

The stability cross curves calculation is reflected on document *"NA-801-CS-003_Stability Cross Curves"*

Trim	0.000 M
Heel angle (grad.)	**Displ (T)**
5	1202.972
10	1017.393
15	839.481
20	670.28
25	521.759
30	405.279
35	311.618
40	234.922
50	129.968
60	74.482

TABLE 3 DECK INMERSION TABLE

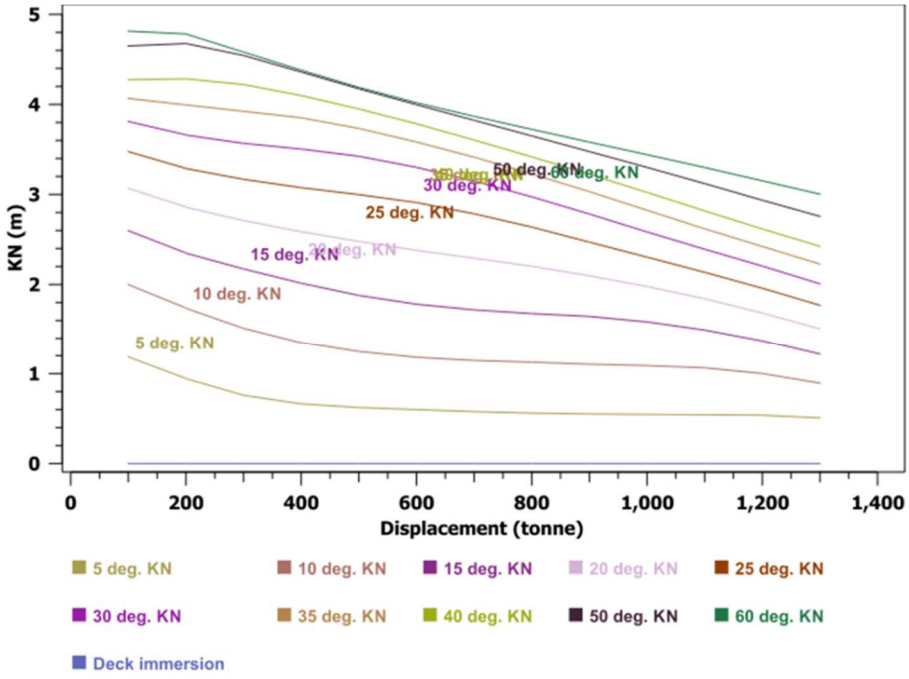


FIGURE 28 STABILITY CROSS CURVES TRIM 0M

3.2.5 INTACT STABILITY AND LOADING CONDITIONS

The Intact Stability and Loading Conditions document *"NA-801-CS-005-00_Loading Conditions"* analyses the intact stability of the vessel.

For this analysis, the vessel has been considered as a tugboat and according to this, the stability requirements established by BV for tugboats have been applied.

As this vessel is also equipped with FIFI monitors, the requirements established by BV for fire-fighting vessels have been applied.

For all the stability calculations it has been assumed a KG value of the lightship weight of 3.5 m, having a margin from the value 3.39 m obtained from the preliminary lightship weight calculation.

For all the calculations, FORAN V70 has been used.

According with this document and calculations carried out, the lightship distribution of the vessel, fulfil the requirements as per IS 2008 Code and the IMO wither criteria, through the loading conditions considered.

3.2.5.1 INTACT STABILITY CRITERIA

The intact stability criteria this vessel has to fulfil are the general requirements established in **IS2008 Code**. These requirements are:

1. The area under the curve of righting levers (GZ curve) should not be less than 0.055 m·rad up to an angle of 30º and should not be less than 0.09 m·rad up to an angle of 40º or up to θf if this angle is less than 40º. The area under the righting lever curve between the angles of heel of 30º and 40º, or between 30º and θf if this angle is less than 40º, should be not less than 0.03 m*rad.

2. The righting lever should be at least 0.2 m at an angle of heel equal to or greater than 30º.

3. The maximum righting lever should occur at an angle of heel not less than 25º

4. The initial transverse metacentric height should not be less than 0.15 m.

Additionally, the IMO weather criterion has been evaluated for all loading conditions. The wind profile used is the following:

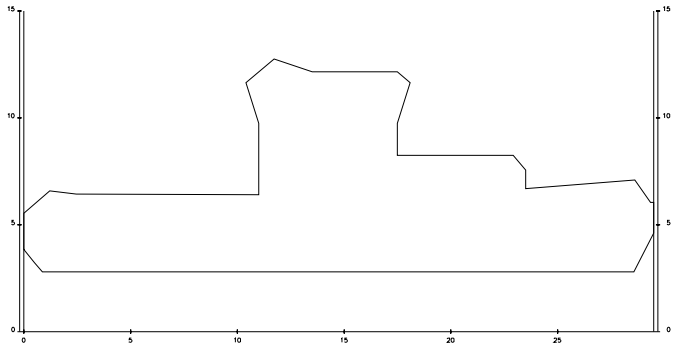


FIGURE 29 WIND PROFILE

As this vessel is a **TUGBOAT**, the stability requirement established in the BV Rules for tugboats (PtD, Ch14, Sec2) are also to be evaluated. These requirement is the following:

A tug may be considered as having sufficient stability, according to the effect of the towing force in the beam direction, if the following condition is complied with:

$$A \geq 0.011$$

Where:

A: Area, in m·rad, contained between the righting lever and the heeling arm curves, measured from the heeling angle θ_C to the heeling angle θ_D

θ_C : Heeling angle of equilibrium, corresponding to the first intersection between heeling and righting arms

θ_D : Heeling angle, to be taken as the lowest of the angle θM, corresponding to the position of GZmax, the angle of downflooding or 40°

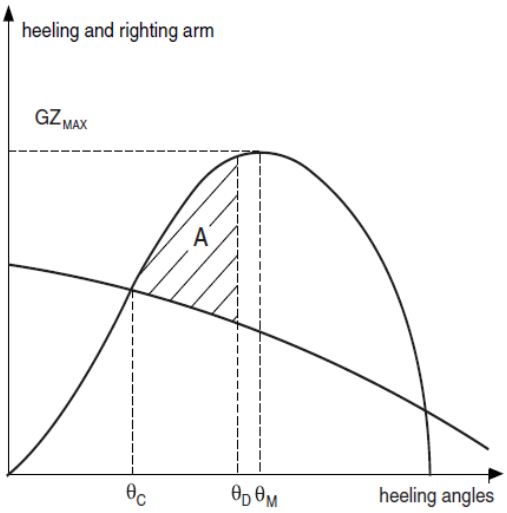


FIGURE 30 HEELING ARM CURVE

For the calculation of the Tugboat criteria, the following data is considered:

- Maximum bollard pull = 80 tons = 784.8 kN
- Vertical distance between the towing hook and maximum draft line = 10.4 m
- c = 1, as the vessel has azimuth propulsion

This vessel is also equipped with FIFI monitors, so the requirements established by BV for **FIRE FIGHTING VESSELS** (PtD, Ch16, Sec2) are also to be complied.

A fire-fighting ship may be considered as having sufficient stability, according to the effect of the reaction force of the water jet in the beam direction due to the monitors fitted on board, if the heeling angle of static equilibrium θ0, corresponding to the first intersection between heeling and righting arms, is less than 5°.

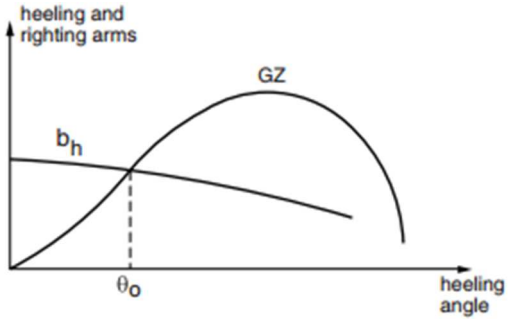


FIGURE 31 HEELING ARM CURVE FOR FI-FI

For the calculation of the FIFI criteria, the following data is considered (taken from the thrusters and monitors specifications and the general arrangement):

- Reaction force (in kN) of the water jet of each monitor fitted on board = 21 kN
- Thrust (in kN) relevant to manoeuvring thrusters = 2*370.5 = 741.0 kN
- Vertical distance between the manoeuvring thrusters axis and keel = 1.80 m
- Location of monitors = 13.0 m from maximum draft line

3.2.5.2 LOADING CONDITIONS

The loading conditions analysed in this document are the following:

- LC00 – Lightship condition
- LC01 – Port departure
- LC02 – Port arrival

Additionally, the following weights have been considerate for the calculations:

- Crew and effects = 0.8 tons
- Provisions = 1 ton

3.2.5.3 INTACT STABILITY ANALYSIS

In the following table it is attached a summary of some parameters from the results of the loading conditions study and the evaluation of the criteria to be fulfilled, showing fully compliance.

	Condition	D (tons)	Xg (m)	KG (m)	KGc (m)	GMc (m)	Tm (m)	Trim (m)
LC00	**Lightship condition**	667.1	14.82	3.50	3.50	3.18	3.10	-0.33
LC01	**Port departure**	728.2	14.50	3.52	3.57	2.97	3.30	0.05
LC02	**Port arrival**	674.1	14.79	3.50	3.55	3.11	3.13	-0.30
	Positive portside							

	Condition	DN 0º-30º (mm*rad)	DN 0º-40º (mm*rad)	DN 30º-40º (mm*rad)	GZ 30º (m)	Angle GZm	GM0 (m)
LC00	**Lightship condition**	417.8	669.6	251.8	1.46	33.1	3.18
LC01	**Port departure**	395.0	625.8	230.8	1.34	32.6	2.97
LC02	**Port arrival**	413.5	662.3	248.8	1.44	33.0	3.11
	Rules required values	**55**	**90**	**30**	**0.20**	**25º**	**0.15**

TABLE 4 EVALUATION OF THE LOADING CONDITION CRITERIA

The GZ stability curves for each loading condition show compliance with the criteria.

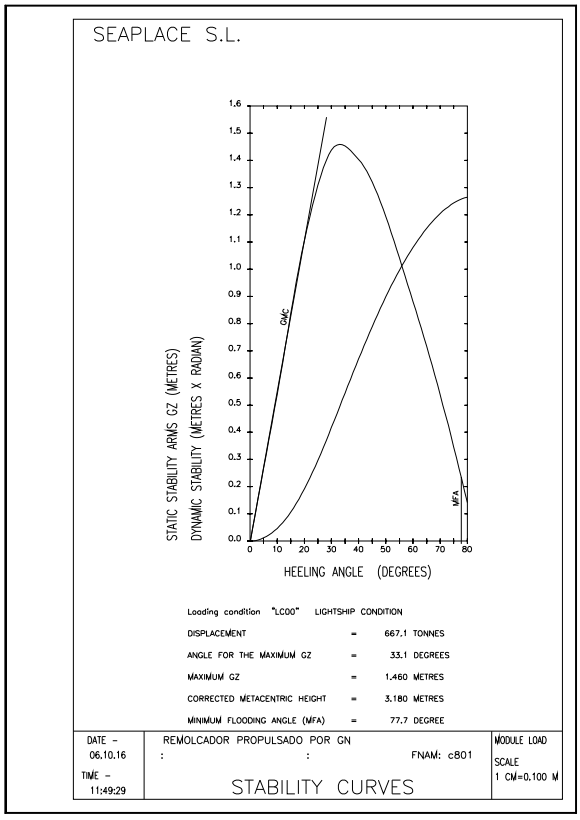


TABLE 5 LC00 STABILITY CURVE

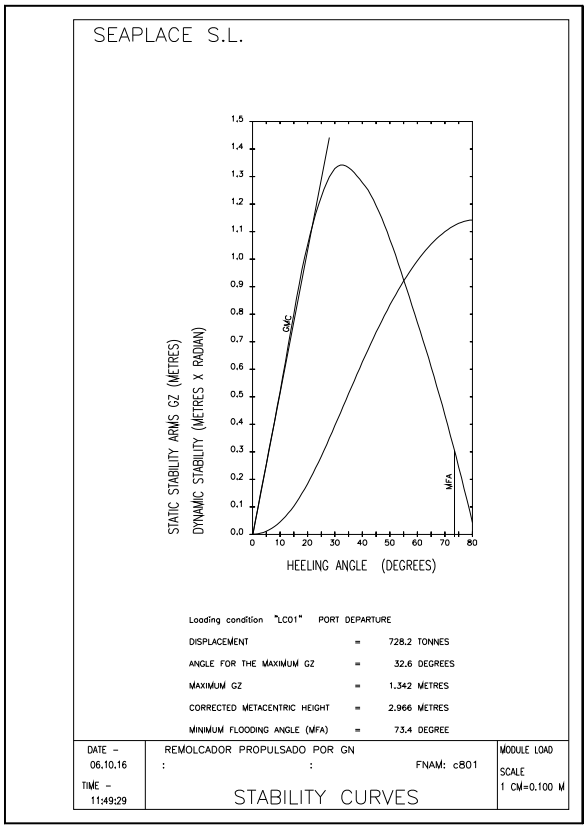


TABLE 6 LC01 STABILITY CURVE

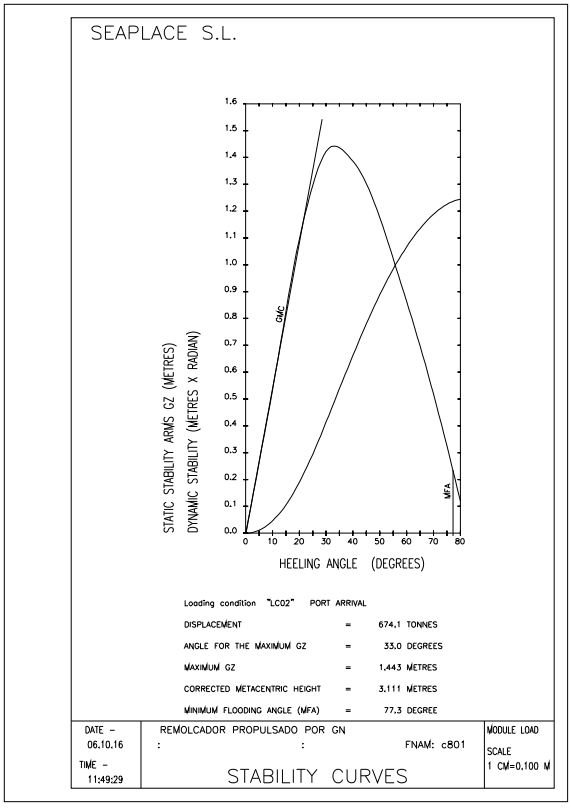


TABLE 7 LC02 STABILITY CURVE

3.2.6 FREEBOARD CALCULATION, MINIMUM BOW HEIGHT AND BUOYANCY RESERVE

The document *"NA-801-CS-008-00_Freeboard Calculation"* contains the freeboard calculation, minimum bow height and extra reserve buoyancy

These parameters are calculated according to International Convention on Load Lines 1966. This vessel can be classified as a type "B" ship.

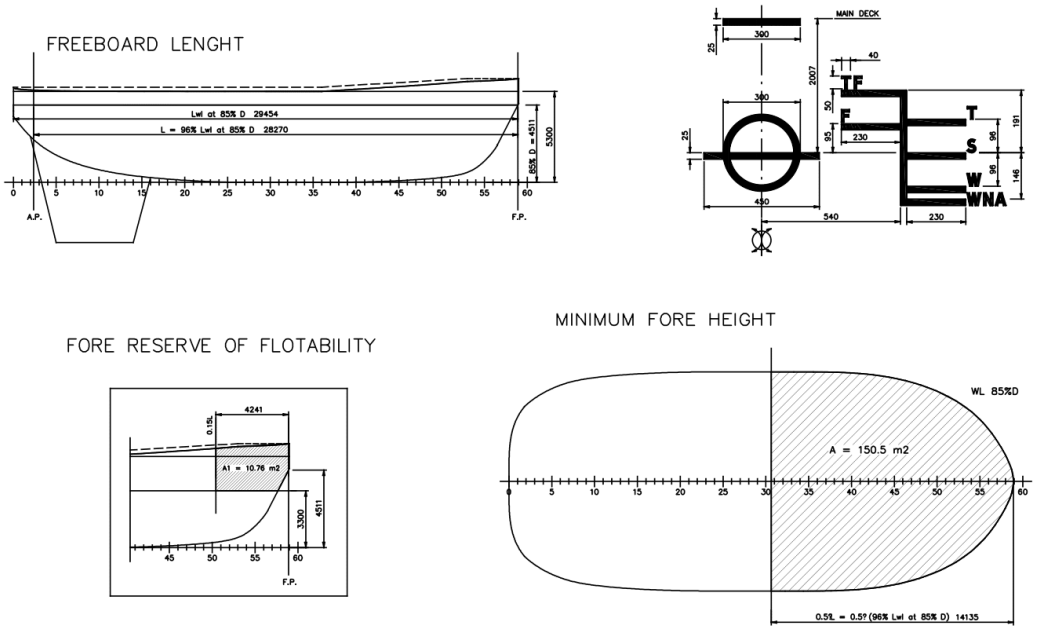


FIGURE 32 FREEBOARD CALCULATION, MINIMUM BOW HEIGHT AND EXTRA RESERVE BUOYANCY

3.2.7 SPEED POWER CURVE PREDICTION

The preliminary speed – power curves are calculated in order to predict the free sailing smooth water speed of the designed LNG Tugboat and can be found on document: "*HY-801-CS-001-00_Speed Power Curve Prediction*".

3.2.7.1 FRICTIONAL RESISTANCE

The hull appendages geometry add to the advance resistance of the ship.

The aft skeg and the propellers fender will cause an additional frictional resistance. On this purpose, a conventional approach has been applied based on the ITTC-57 friction line as well as on the proper estimation of a form factor.

Due to their different geometry, the resistance of the fender foot has been computed separately of the one of the fender vertical struts.

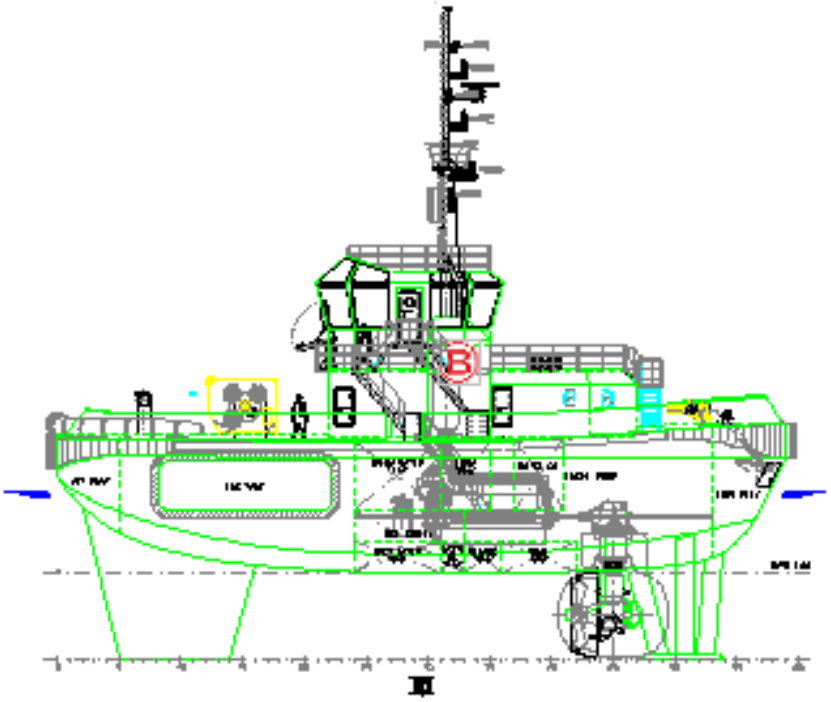


FIGURE 33 MAIN HULL APPENDAGES

The total frictional resistance has been computed for different speeds. Table 2 shows the corresponding results before applying any kind of margin:

	RF (kN)	RF (kN)	RF (kN)
V (knot)	Hull & Skeg	Prop. Fender	Total
10.5	139.2	5.6	144.8
11.0	163.2	6.2	169.4
11.5	190.7	6.7	197.4
12.0	221.0	7.3	228.3
12.5	254.4	7.9	262.2
13.0	290.8	8.5	299.3
13.5	331.7	9.1	340.8
14.0	375.0	9.8	384.8
14.5	423.2	10.4	433.6

TABLE 8 FRICTIONAL RESISTANCE OF BARE HULL, SKEG AND PROPELLER FENDER

3.2.7.2 RESIDUARY RESISTANCE

The adopted estimates of the residuary resistance coefficients are presented for a range of speeds:

V (knot)	FN	1000·CR
10.5	0.322	17.4
11.0	0.337	18.8
11.5	0.353	20.3
12.0	0.368	21.8
12.5	0.384	23.3
13.0	0.399	24.8
13.5	0.414	26.4
14.0	0.430	27.9
14.5	0.445	29.5

TABLE 9 RESIDUARY RESISTANCE COEFFICIENTS

3.2.7.3 TOTAL RESISTANCE

As recommended by ITTC, a non dimensional correlation allowance coefficient of 0.80·10-3 has been applied in order to obtain the ship total resistance

							with design
	frictional	residuary	appendages	correlation			margin
V (knot)	RF (kN)	RR (kN)	RAPP (kN)	RC (kN)	RT (kN)	RR/RT	RT (kN)
10.5	13.8	119.8	5.6	5.5	144.8	0.83	156.4
11.0	15.1	142.1	6.2	6.0	169.4	0.84	182.9
11.5	16.4	167.7	6.7	6.6	197.4	0.85	213.2
12.0	17.7	196.1	7.3	7.2	228.3	0.86	246.5
12.5	19.1	227.4	7.9	7.8	262.2	0.87	283.2
13.0	20.5	261.8	8.5	8.4	299.3	0.87	323.2
13.5	22.0	300.6	9.1	9.1	340.8	0.88	368.1
14.0	23.6	341.6	9.8	9.8	384.7	0.89	415.5
14.5	25.2	387.5	10.4	10.5	433.6	0.89	468.2

TABLE 10 VESSEL RESISTANCE VERSUS SHIP SPEED

3.2.7.4 PROPULSIVE POWER

The ship propulsion plant consists in two gas fuelled engines Rolls-Royce C26:33L9PG, delivering 2430 BKW at 1000 RPM each.and two controllable pitch azimuthal thruster US 255 CP type, manufactured by Rolls Royce.

Taking into account the shape of the body lines, as well as the location of main thrusters the following propulsive coefficients have been selected on the basis of previous Seaplace experience with similar hulls sailing at equivalent speeds:

- Wake fraction (w): 0.05
- Thrust deduction (t): 0.08
- Relative – rotative coefficient (□RR): 1.00

The mechanical losses in shaft lines and gearboxes are estimated to be 4 % of the transmitted power.

3.2.7.5 SPEED – POWER - RPM CURVES

The total mechanical power to be delivered to the propeller to push the ship at different speeds, both under sea trials and service conditions, are obtained considering the total advance ship resistance as well as all the aforementioned coefficients and efficiencies.

The speed – power curves both, for trials conditions as well as for service conditions are shown.

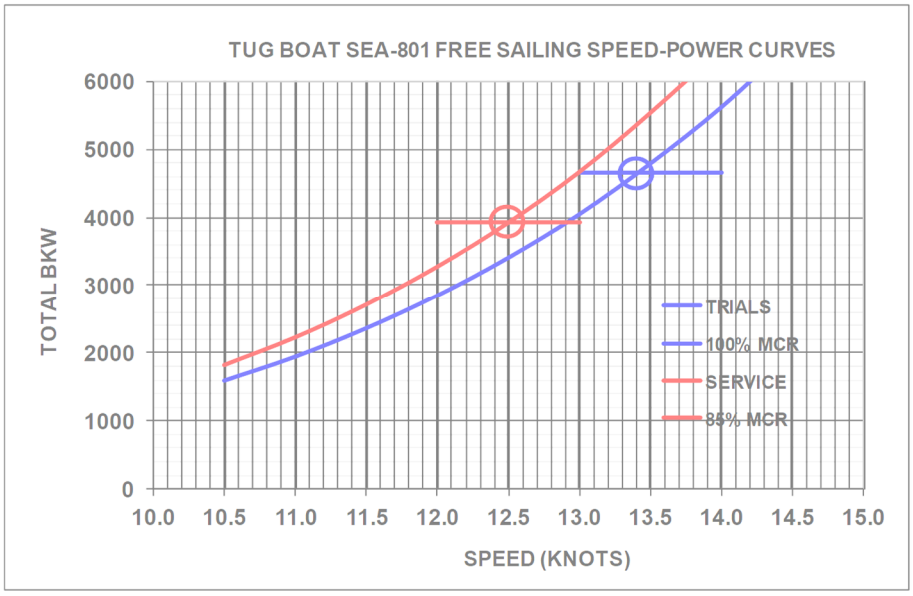


FIGURE 34 SPEED – POWER CURVES

Assuming that it is feasible adapting inside the thruster body a gear with a reduction ratio of about 5.1 : 1.0, the RPM - POWER curves are obtained considering the pitch/diameter and the blade area ratios.

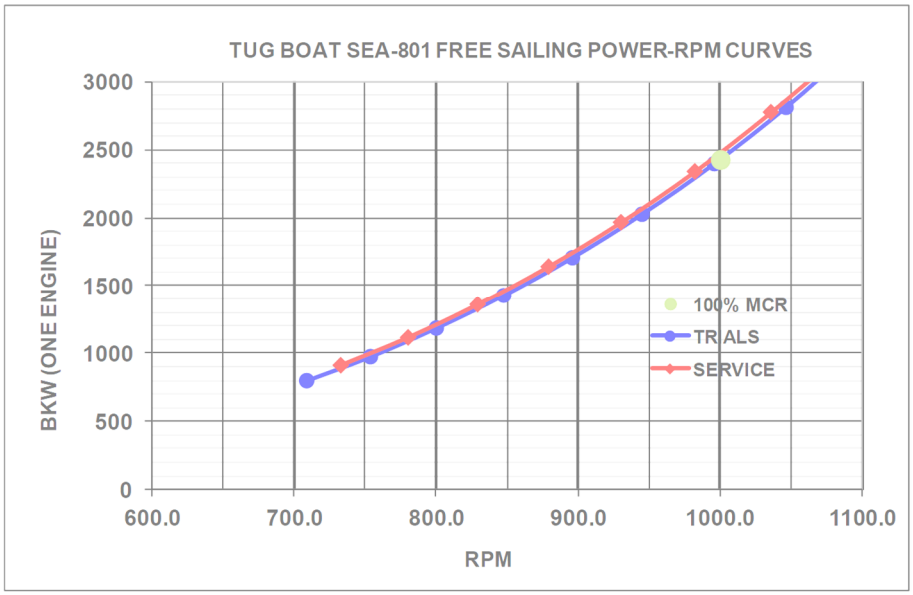


FIGURE 35 RPM – POWER CURVES

3.2.8 TONNAGE CALCULATION

Document "*NA-801-CS-007_01_Tonnage Calculation*" depicts all calculations referring to tonnage.

3.2.8.1 VOLUME CALCULATION

The enclosed spaces considered for the tonnage calculations are all the spaces bounded by the hull up to the main deck, casings and the accommodation spaces.

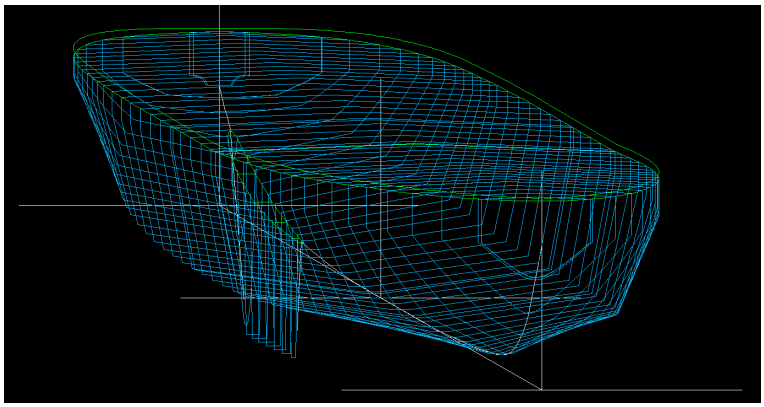


FIGURE 36 VOLUME UNDER MAIN DECK

Space	VOLUME m3
Bounded by ship's hull	1453
Box cooler PS	8,143
Box cooler SB	8,143
FIFI Sea chest PS	1,513
FIFI sea chest SB	1,513
Under Main Deck	**1433,688**

TABLE 11: VOLUME UNDER MAIN DECK

Deck	Space Name	Aft m	Fore m	Length	Breadth	Depth	Horizontal Area m2	Volume m3
Main Deck	Bunker Station PS	8	9,2	1,2	1,1	1,4	1,320	1,848
	Bunker Station SB	8	9,2	1,2	1,1	1,4	1,320	1,848
	Hatch 1	10,1	10,9	0,8	0,8	0,6	0,640	0,384
	Hatch 2	10,1	10,9	0,8	0,8	0,6	0,640	0,384
	Hatch 3	23,6	24,4	0,8	0,8	0,6	0,640	0,384
	Hatch 4	26,6	27,4	0,8	0,8	0,6	0,640	0,384
	Accomodation	11	23,5	12,5	10,5	2,65	110,500	283,588
Bridge Deck	Casings	15	17,5	2,5	1,6	2,2	4,000	13,697
	Wheelhouse	11	17,5	6,5	4	4,6	23,591	111,037
Total Volume over Main Deck								413,554

TABLE 12: TOTAL VOLUME OVER MAIN DECK

3.2.8.2 TONNAGE CALCULATION

The gross and net tonnage have been calculated according to Regulations 3 and 4 included in the Annex I of the International Convention on Tonnage Measurement of Ships, 1969.

The moulded depth of the vessel is 5.3 meters. The moulded draught is 3.5 meters.

Taking all this in consideration, the calculation of the gross and net tonnage of this vessel can be exposed as follows:

Gross Tonnage

V =	1847	m^3	Total volume of all enclosed spaces
K1 =	0,265		$K_1 = 0.2 + 0.02 \cdot log_{10} V$
GT =	**490**		$GT = K_1 \cdot V$

Net Tonnage

Vc =	0	m^3	Total volume of cargo spaces
K2 =	0,265		$K_2 = 0.2 + 0.02 \cdot log_{10} Vc$
d =	3,50	m	Moulded draught amidships
D =	5,30	m	Moulded depth amidships
K3 =	1,31		$K_3 = [1.25 \cdot (GT + 10\,000)]/10\,000$
N1 =	0		Number of passengers in cabins with no more than 8 berths
N2 =	0		Number of other passengers
$(4d/3D)^2$ =	0,78		Shall not be taken as greater than unity
$K_2V_c(4d/3D)^2$ =	123		Shall not be taken as less than 0.25·GT
NT =	**147**		Shall not be taken as less than 0.30·GT

$$NT = K_2 \cdot Vc \cdot \left(\frac{4d}{3D}\right)^2 + K_3 \cdot \left[N_1 + \left(\frac{N_2}{10}\right)\right]$$

TABLE 13: GROSS AND NET TONNAGE CALCULATION

3.2.9 CAPACITY PLAN

The capacity plan is designed to comply with the requirements and the values before calculated and is contained in the document *"NA-801-CP-001-01_Capacity Plan"*

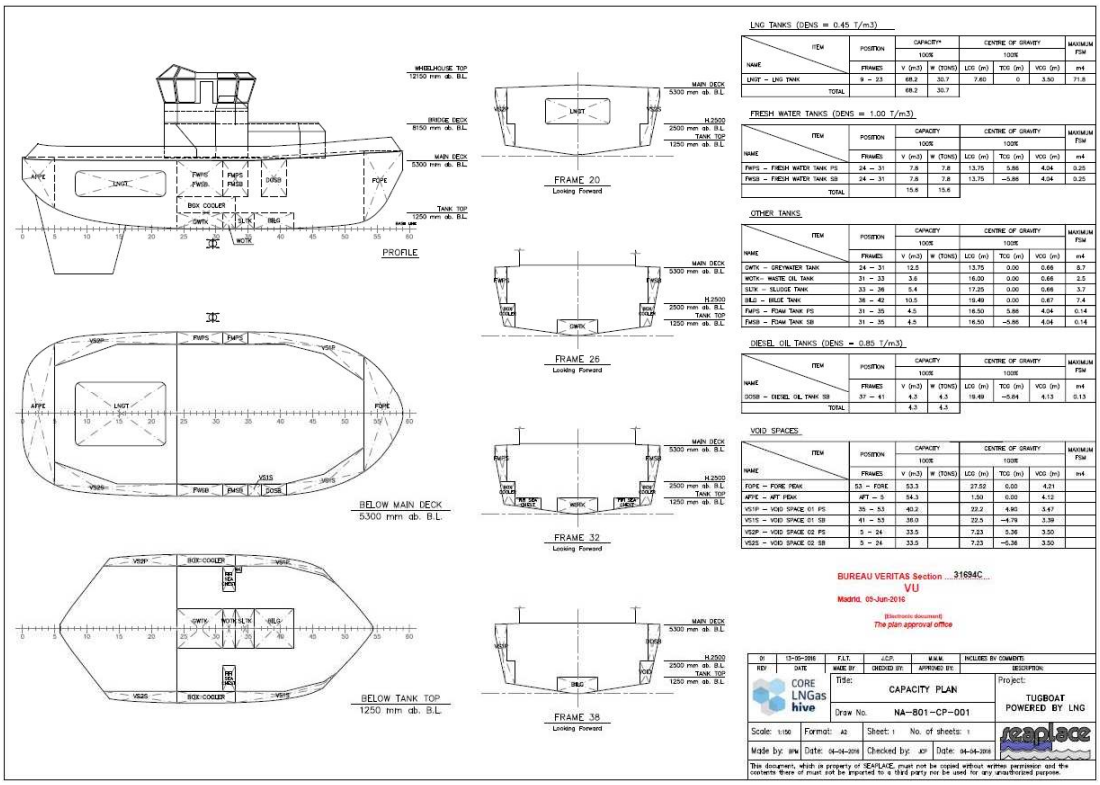


FIGURE 37 CAPACITY PLAN

3.2.10 SOUNDING TABLES

All the sounding lines have been defined as straight lines from the lowest part to the top of each tank. The calculations are included in the document "*NA-801-CS-009_Sounding Tables*".

The tanks of which the sounding line has been calculated are:

- Diesel Oil Tanks
- Fresh Water Tanks
- LNG Tanks
- Aftpeak
- Forepeak
- Bilge Tanks
- Foam Tanks
- Greywater Tank
- Sludge Tanks
- Waste oil Tanks

3.3 STRUCTURE

The structure is calculated and designing following Bureau Veritas rules as well as the Class Notation guidelines.

All drawings have been approved and stamped by Bureau Veritas

The midship section is designed with single bottom and transversal structure.

3.3.1 TRANSVERSAL STRUCTURE

3.3.1.1 MIDSHIP SECTION

The tugboat main structure is transversal. Midship section is design according to BV regulations and can be found on document *"ST-801-BS-001-01_Midship Section".*

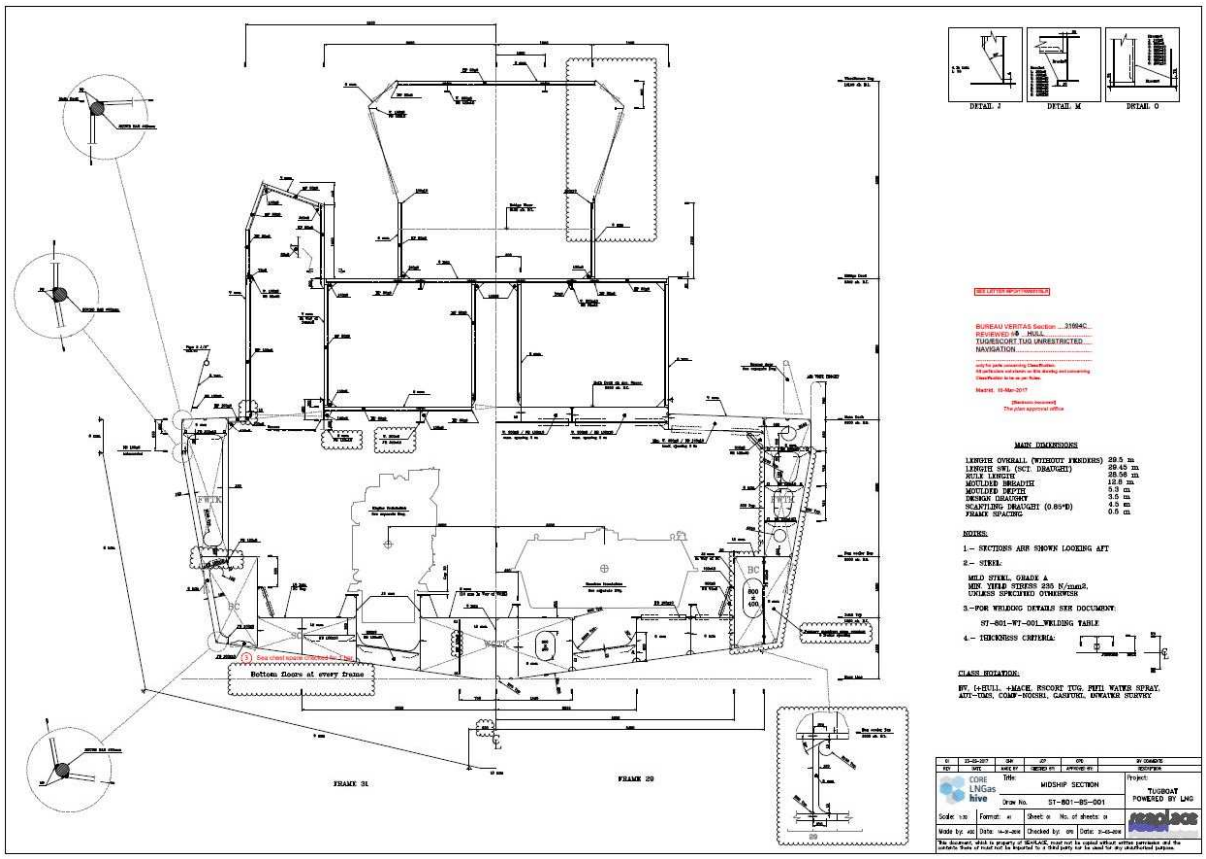


FIGURE 38 MIDSHIP SECTION

3.3.1.2 BULKHEAD SECTION

The bulkhead, located on frame 24, according to drawing *"GE-801-GA-001-02_General Arrangement",* will divide the hull into two watertight compartments.

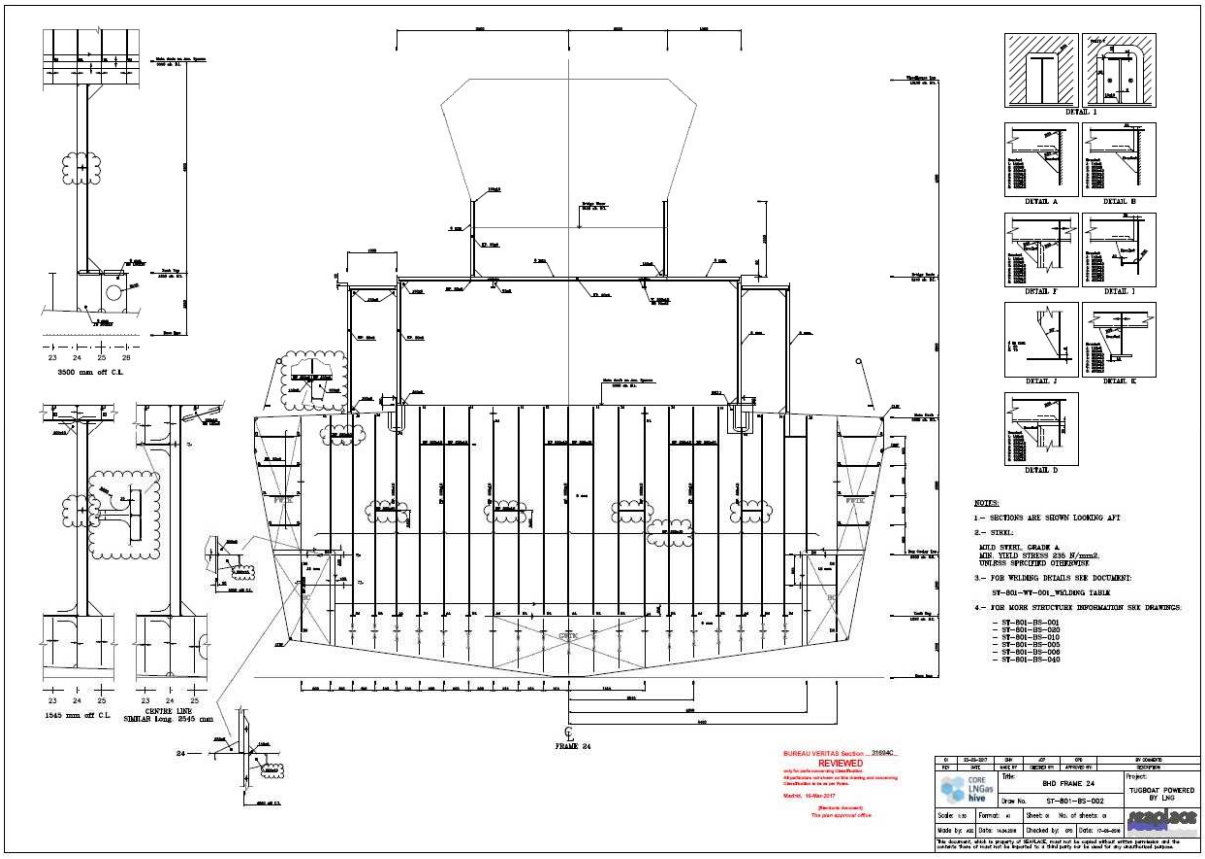


FIGURE 39 BULKHEAD SECTION

The bulkhead section is designed as shown in drawing *"ST-801-BS-002-01_BHD Frame 24".*

3.3.2 LONGITUDINAL STRUCTURE

Once the transversal structure is defined, the main deck and shell expansion are designed.

3.3.2.1 MAIN DECK

The main deck is cambered so it has a recese so the superstructure does not lie directly on the deck but on a flat structure.

Designed as shown in drawing *"ST-801-BS-020-01_Main Deck".*

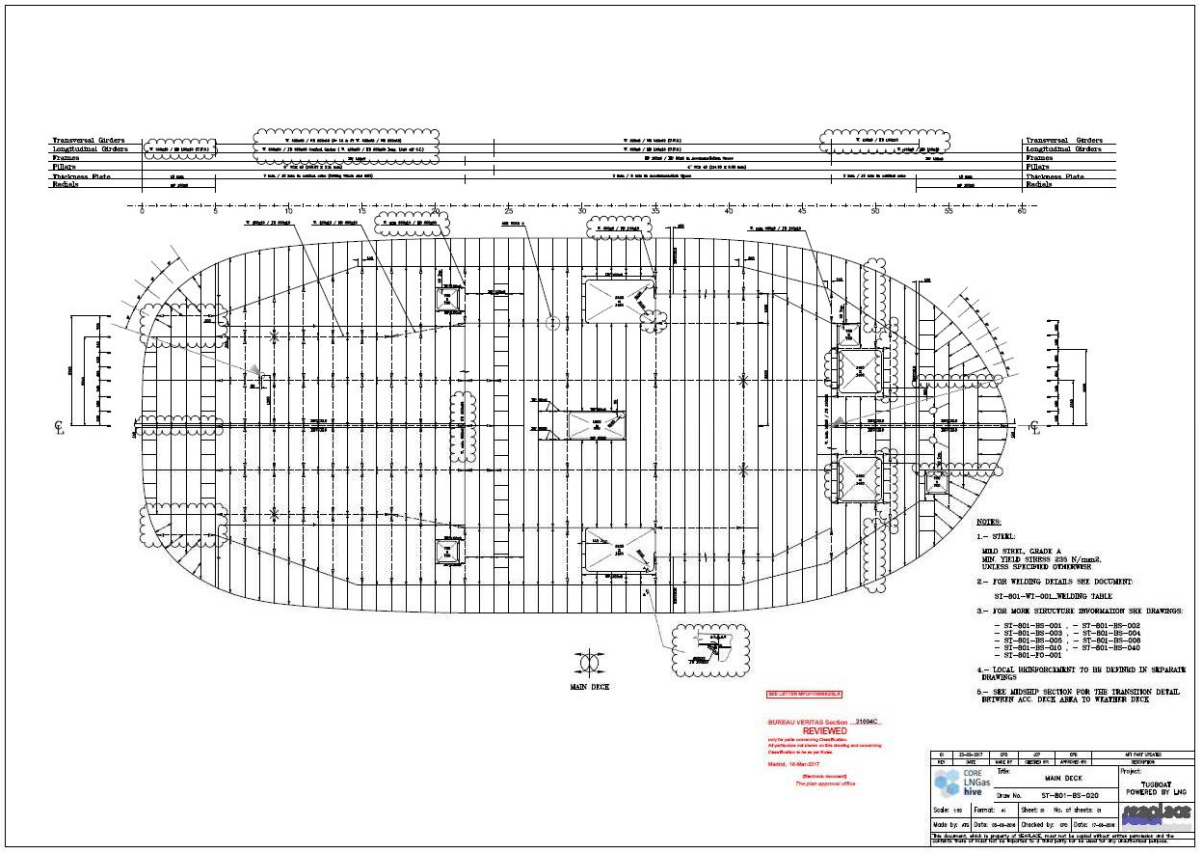


FIGURE 40 MAIN DECK

3.3.2.2 SHELL EXPANSION

The shell expansion is designed as shown in drawing "*ST-801-BS-010-01_Shell Expansion".*

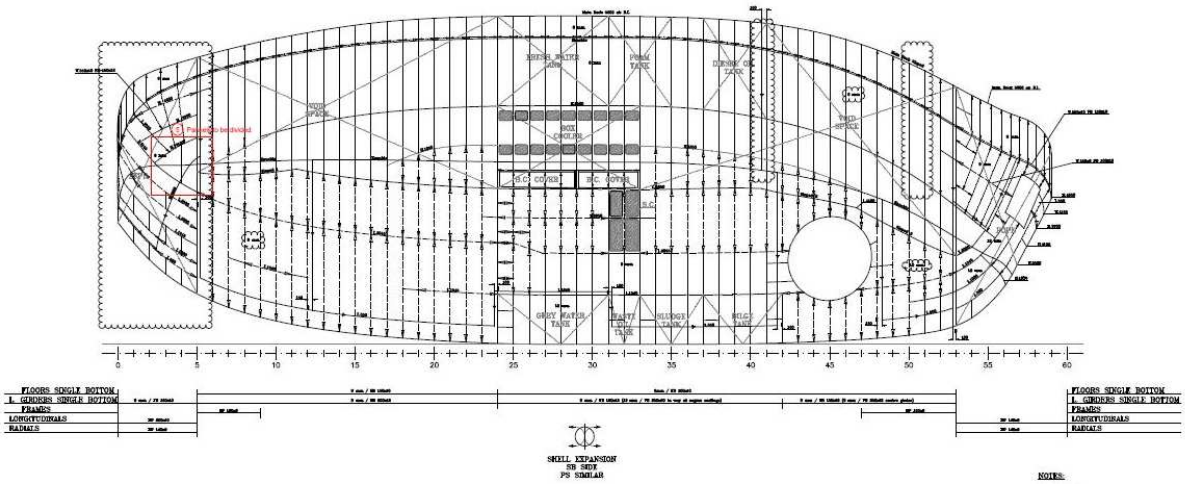


FIGURE 41 SHELL EXPANSION

3.3.3 MAIN AREAS STRUCTURE

Once the hull structure is designed, the rest of the structure can now be calculated.

Four main areas are chosen as to perfectly define all areas bellow mainDECK:

- Fore Peak
- Aft peak
- Engine room
- Hold space

3.3.3.1 FORE PEAK

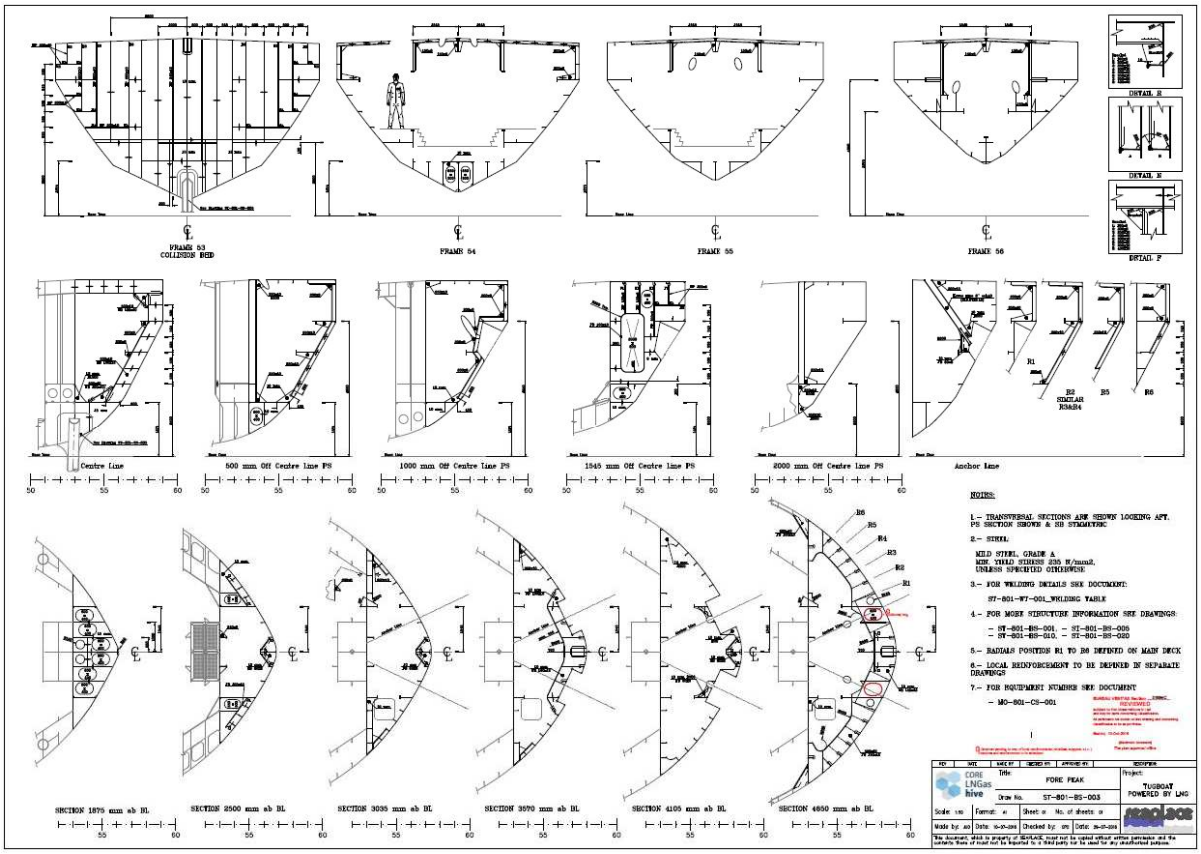


FIGURE 42 FORE PEAK

The forepeak is designed as shown in drawing *"ST-801-BS-003-00_Fore Peak".*

3.3.3.2 AFT PEAK

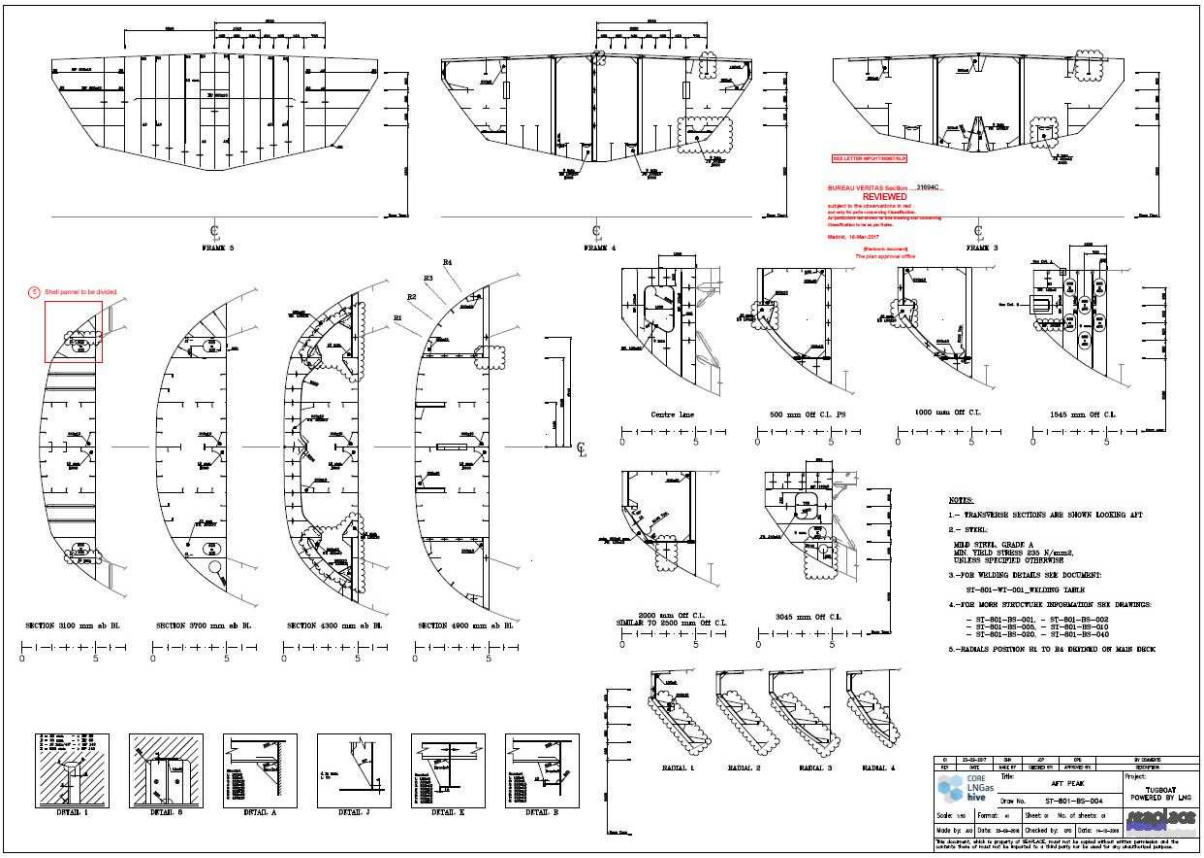


FIGURE 43 AFT PEAK

The aftpeak is designed as shown in drawing *"ST-801-BS-004-01_Aft Peak".*

3.3.3.3 ENGINE ROOM

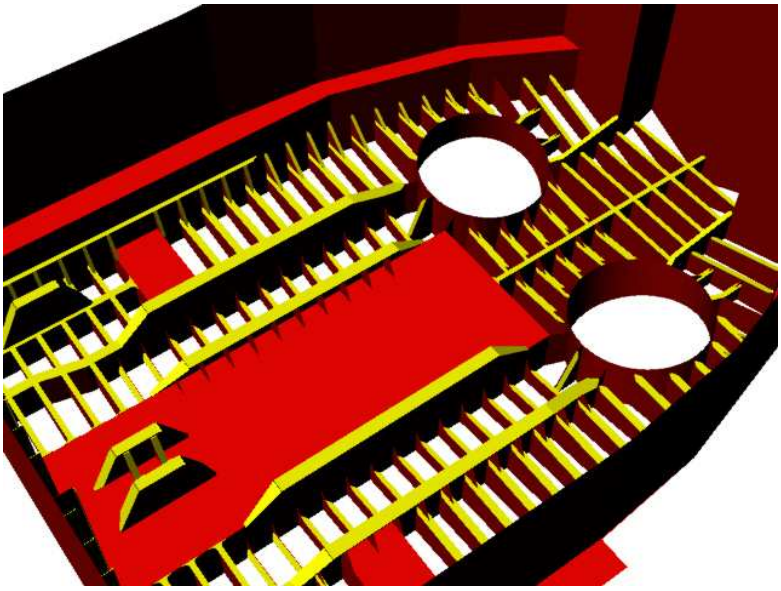


FIGURE 44 ENGINE ROOM RENDER

The engine room is designed as shown in drawing "*ST-801-BS-005-01_Engine Room".*

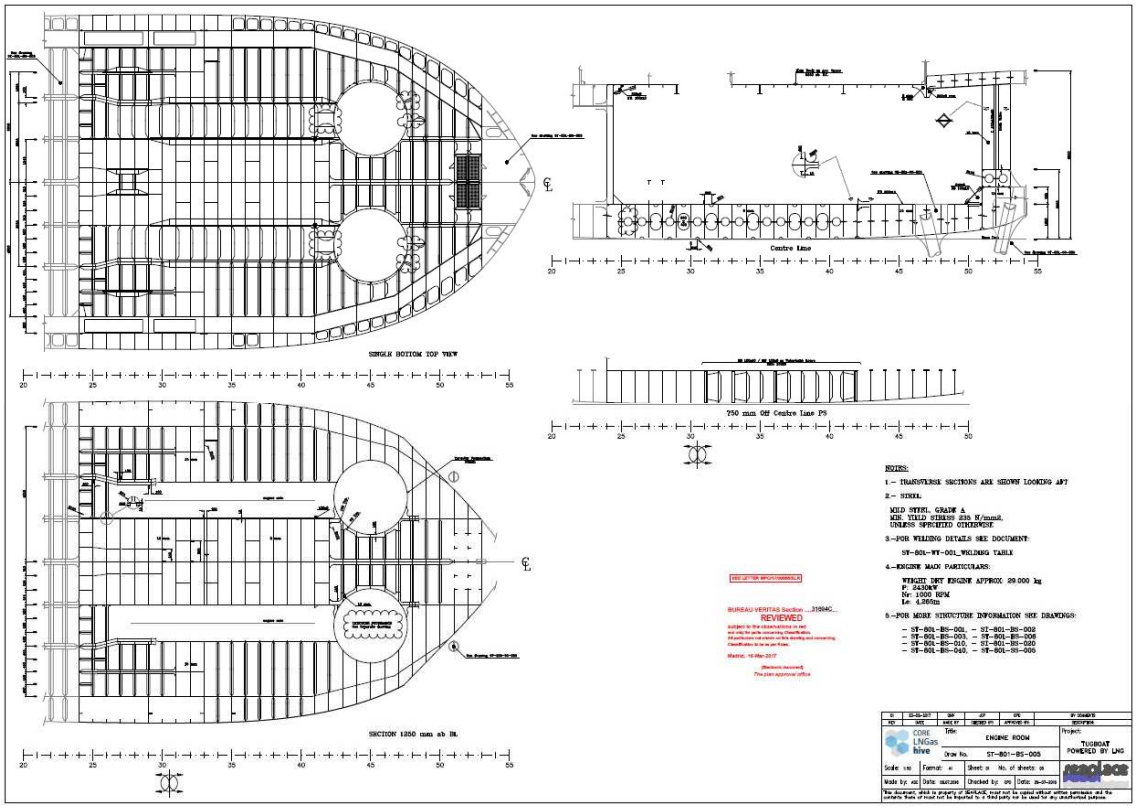


FIGURE 45 ENGINE ROOM 1/5

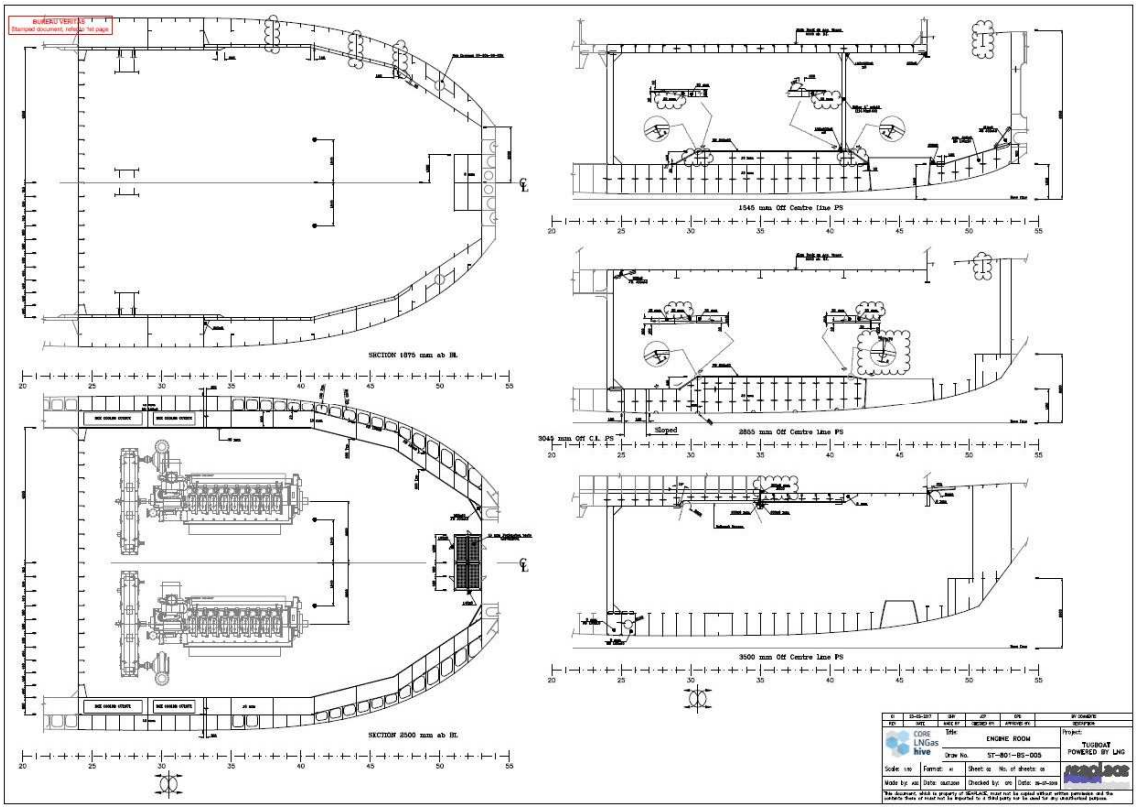


FIGURE 46 ENGINE ROOM 2/5

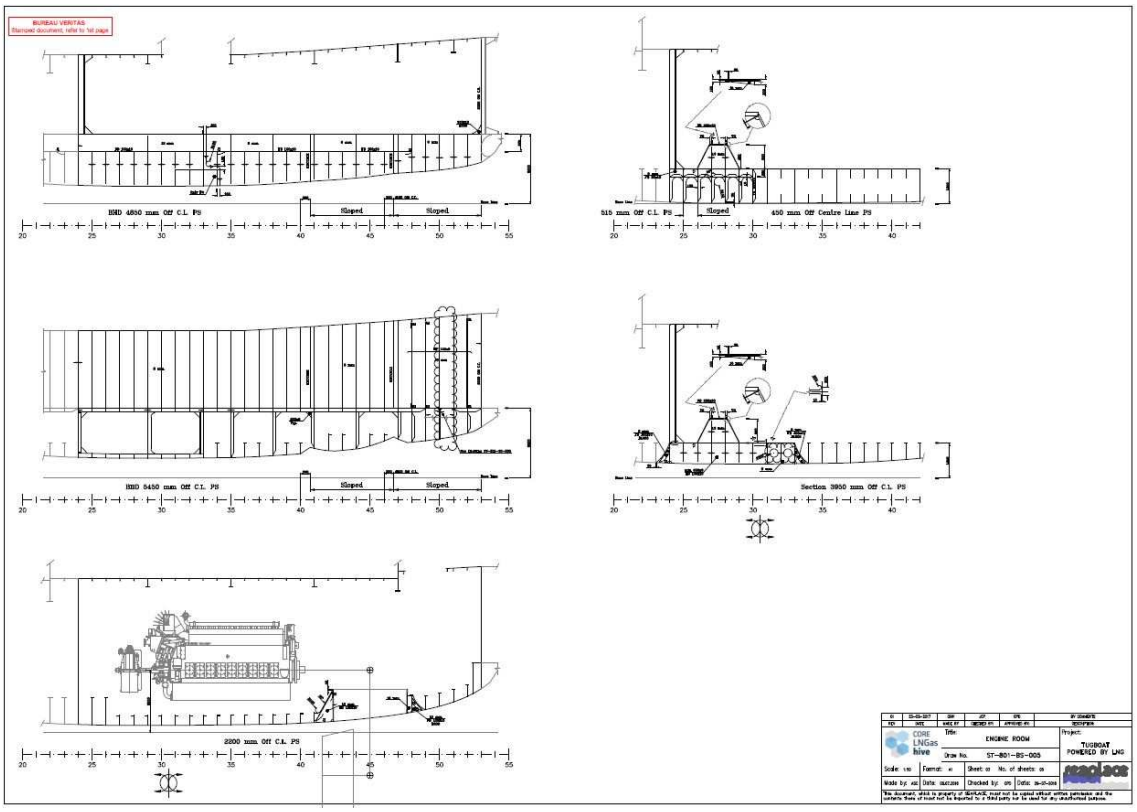


FIGURE 47 ENGINE ROOM 3/5

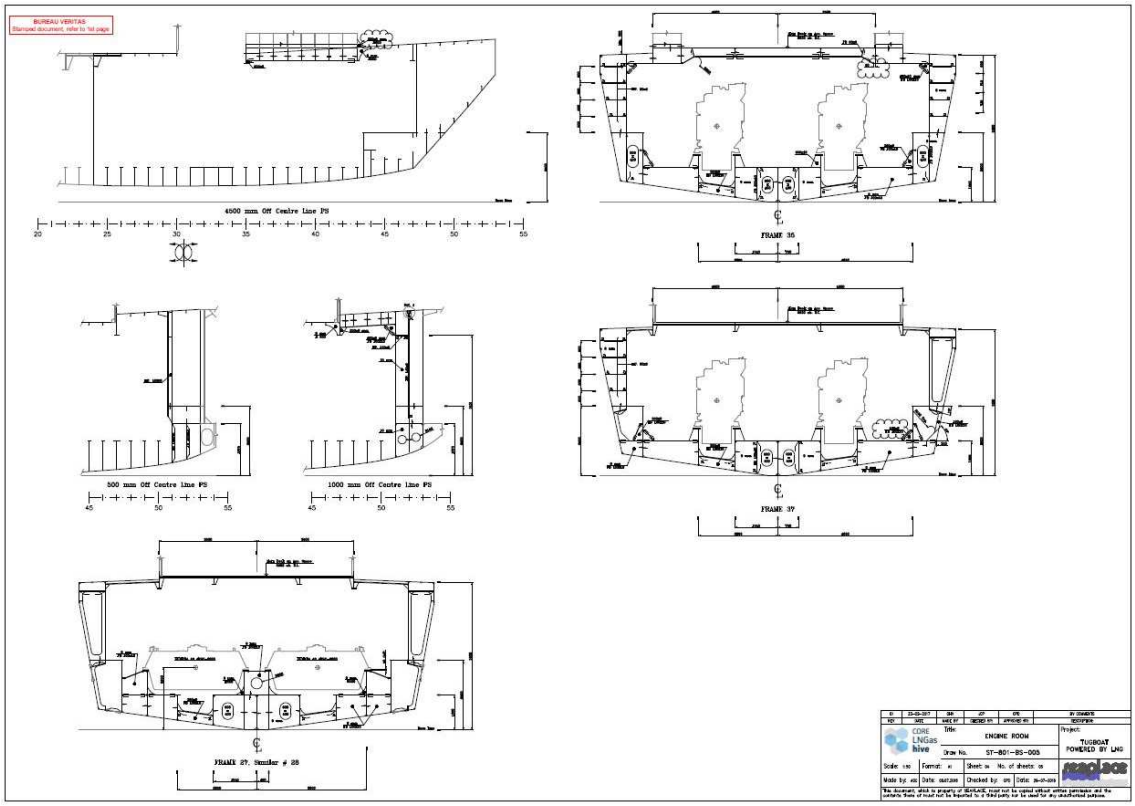


FIGURE 48 ENGINE ROOM 4/5

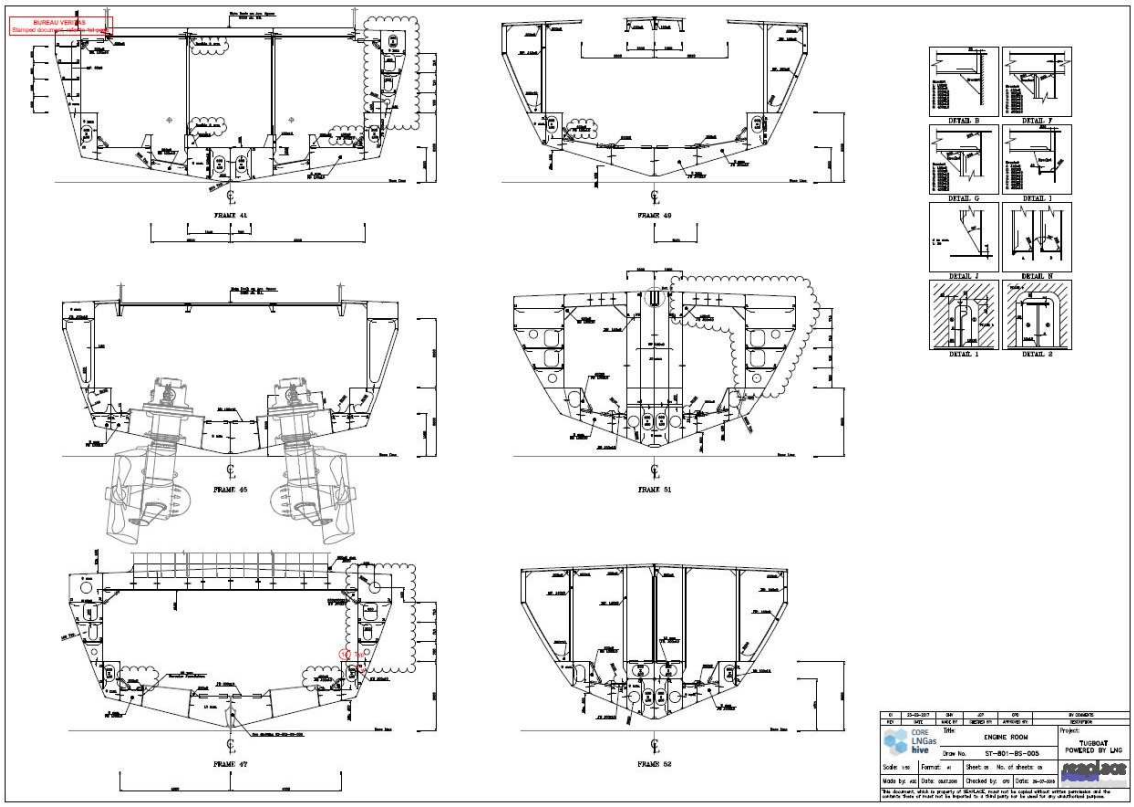


FIGURE 49 ENGINE ROOM 5/5

3.3.3.4 AFT HOLD LNG TANK

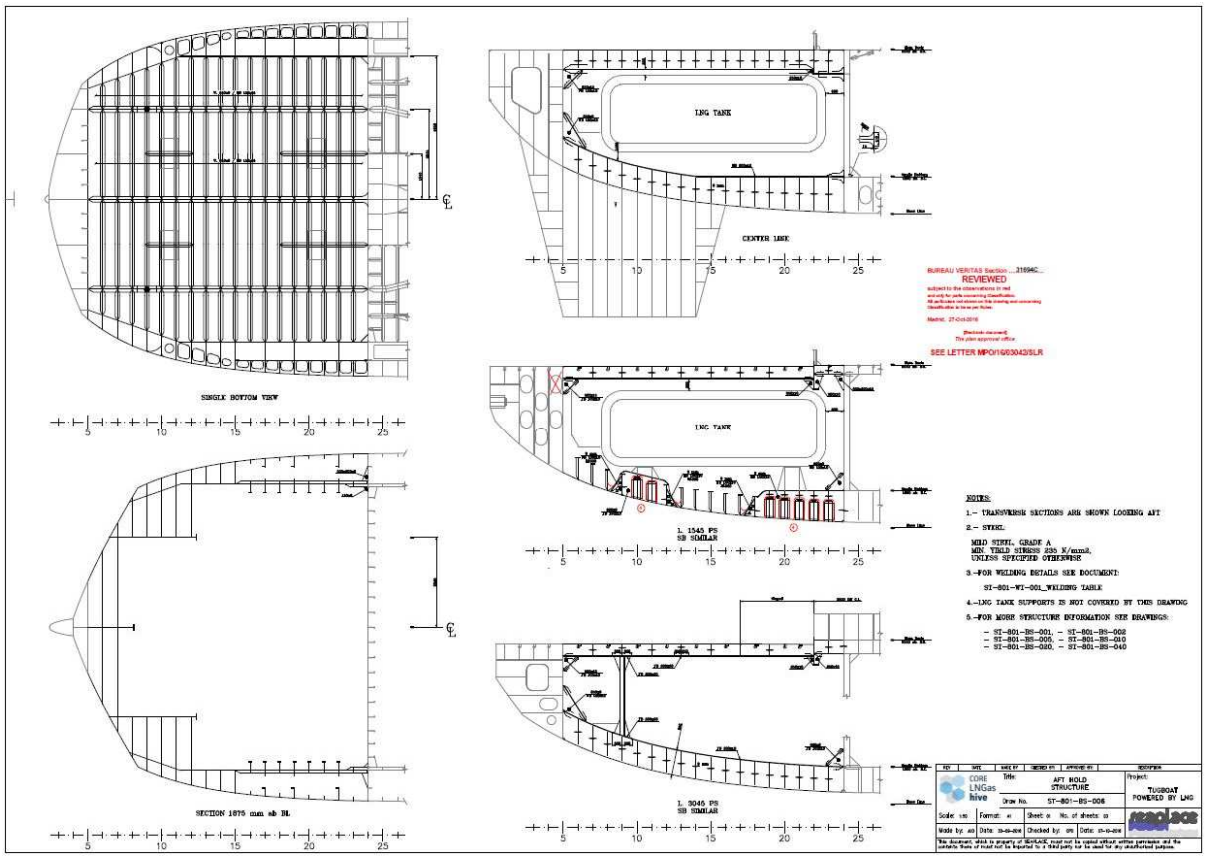


FIGURE 50 AFT HOLD ESTRUCTURE

The aft hold LNG tank is designed as shown in drawing *"ST-801-BS-006-01_Aft Hold Structure".*

3.3.4 SUPERSTRUCTURE

After defining the hull structure, Superstructure are designed.

3.3.4.1 SUPERSTRUCTURE

The superstructure is located forward, over the recese on main deck, as per drawing "*GE-801-GA-001_General Arrangement*" shows.

The superstructure is designed with one floor and including the lateral funnels, as shown in drawing *"ST-801-BS-040-00_Superstructure".*

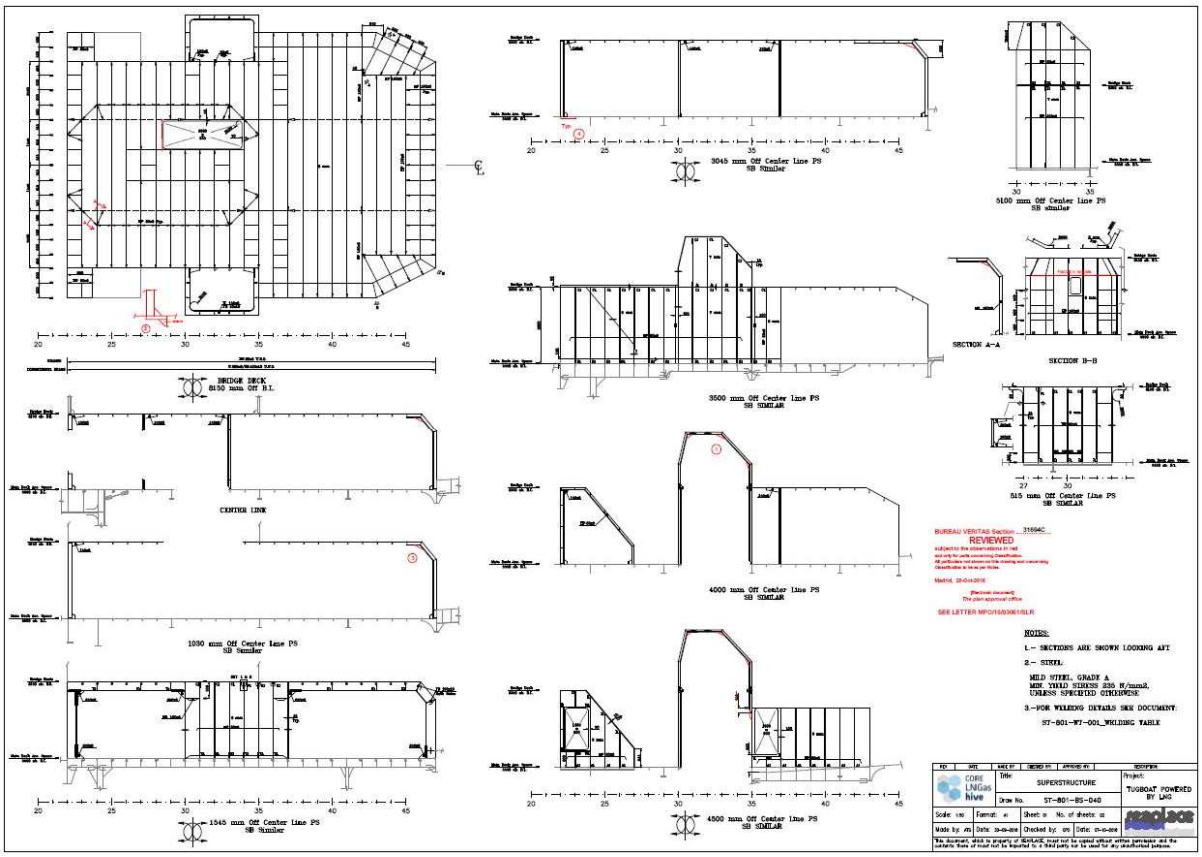


FIGURE 51 SUPERSTRUCTURE ½

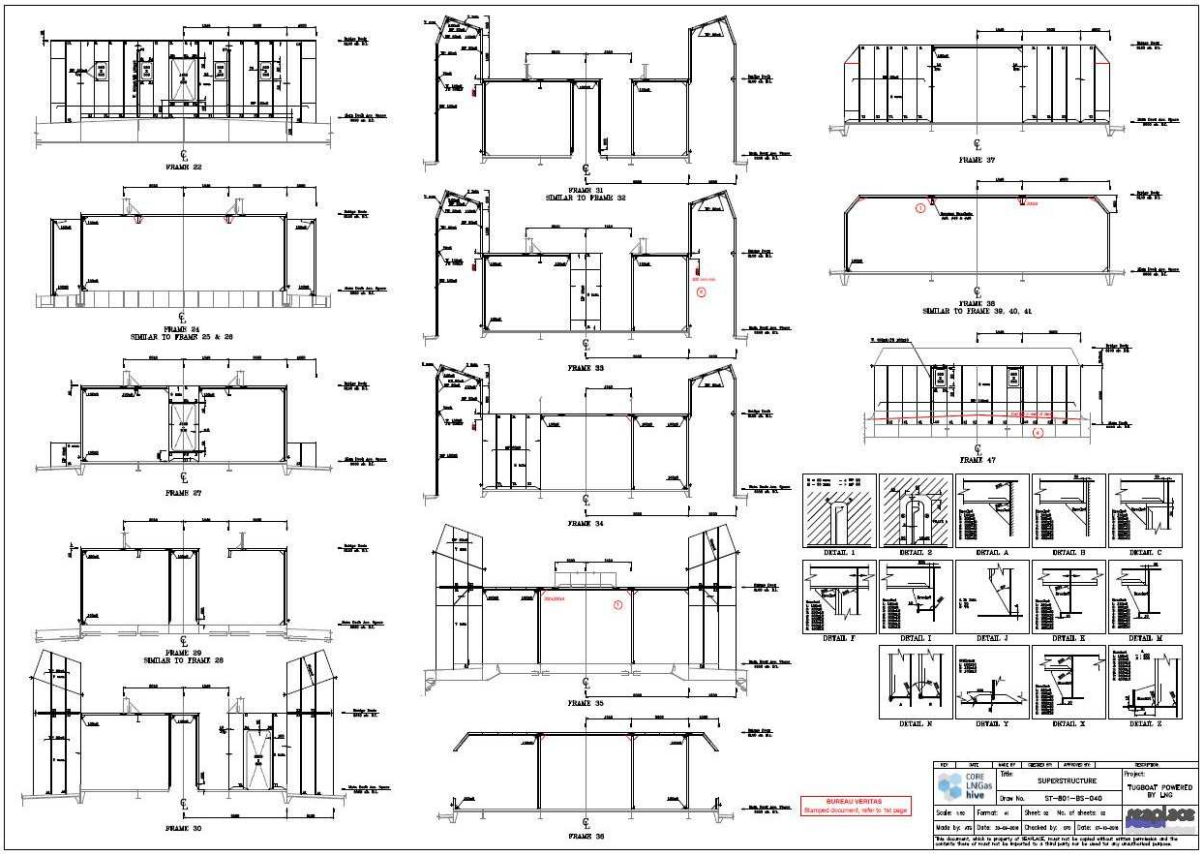


FIGURE 52 SUPERSTRUCTURE 2/2

3.3.4.2 WHEELHOUSE STRUCTURE

The wheelhouse superstructure is built of steel with windows as large as possible around the wheelhouse.

There is full visibility for the bow area, sides, and aft as far as practicable, including all towing winch area. Proper drainage from wheelhouse top is provided.

Drawing *"ST-801-BS-070-00_Wheelhouse Structure".*

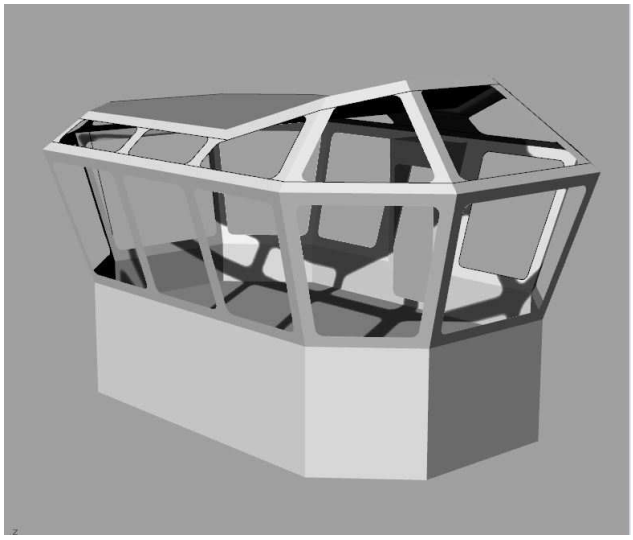


FIGURE 53 WHEELHOUSE 3D

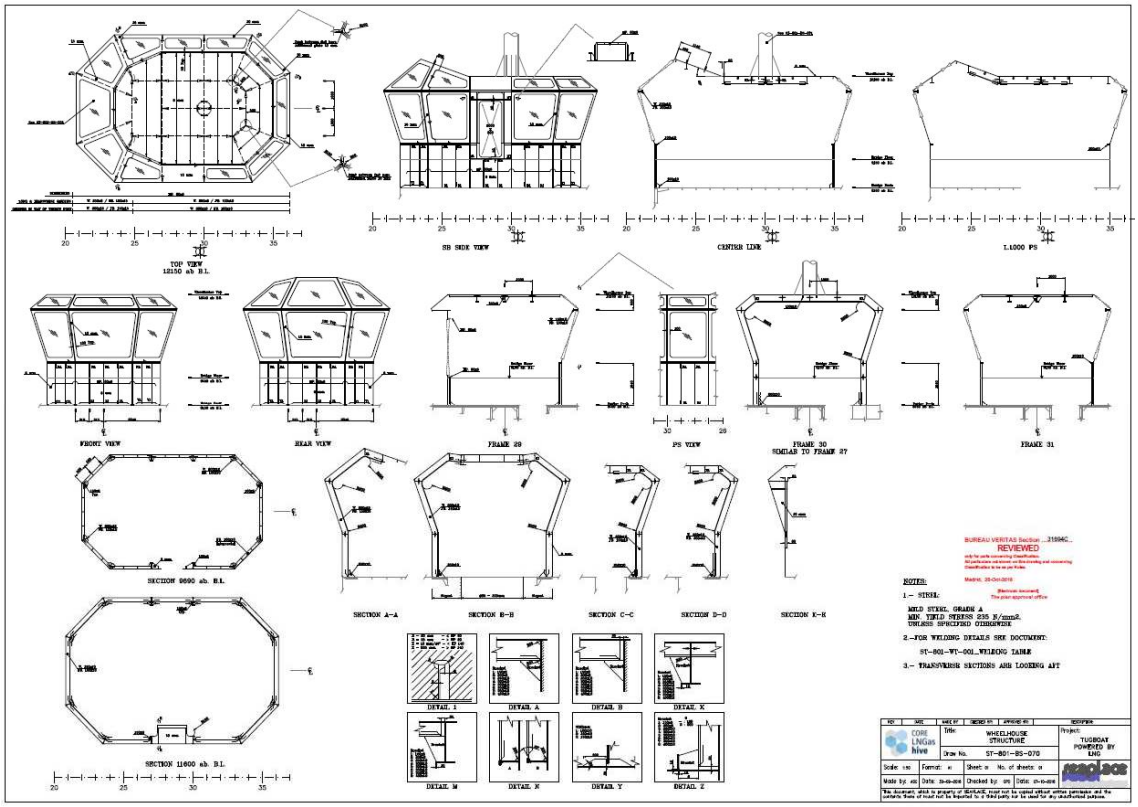


FIGURE 54 WHEELHOUSE

3.3.5 OTHER STRUCTURES

3.3.5.1 SKEG

A skeg is fitted amidships aft to improve the directional stability of the vessel.

The skeg is designed and reinforced as suitable docking support as shown in drawing "*ST-801-SS-002-00_Skeg".*

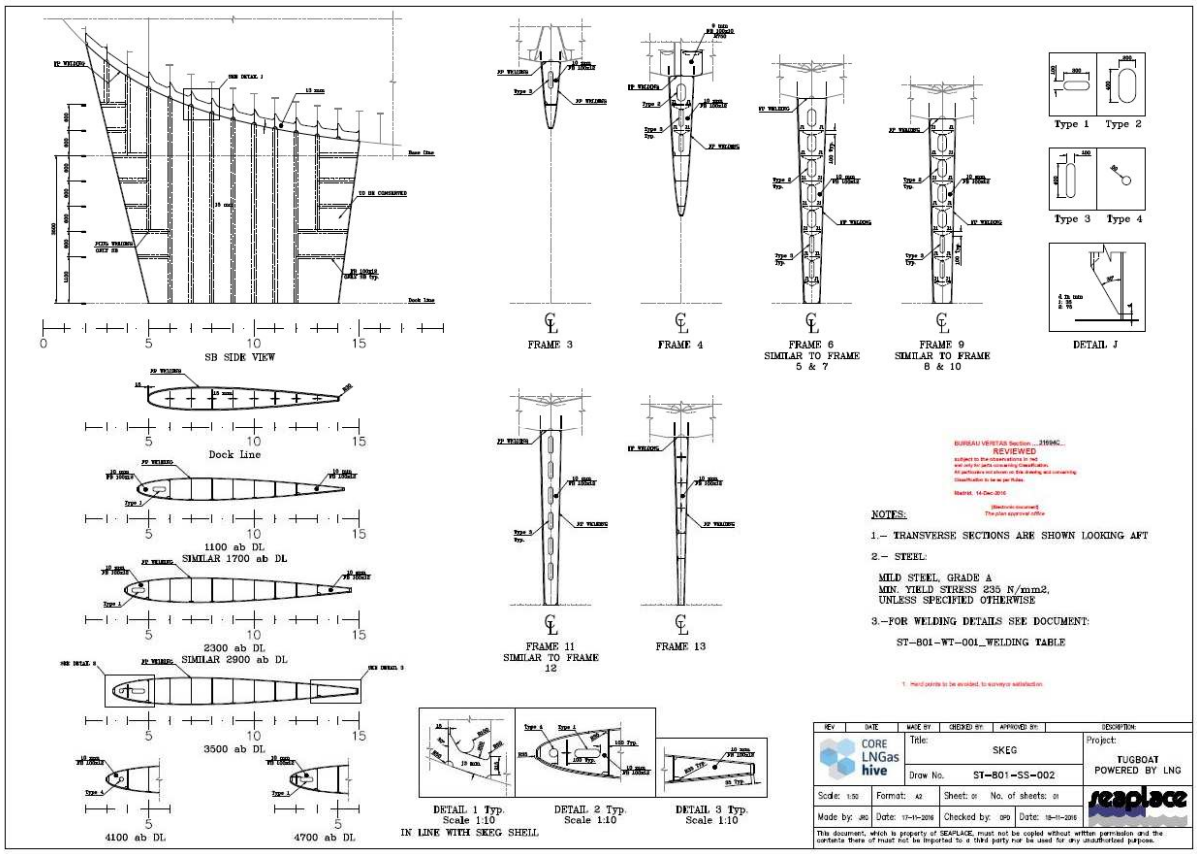


FIGURE 55 SKEG

3.3.5.2 FORWARD DOCKING SUPPORT

Forward docking support is needed to protect the thrusters in event of collision or grounding. It is designed as shown in drawing *"ST-801-SS-005-00_Forward Docking Support".*

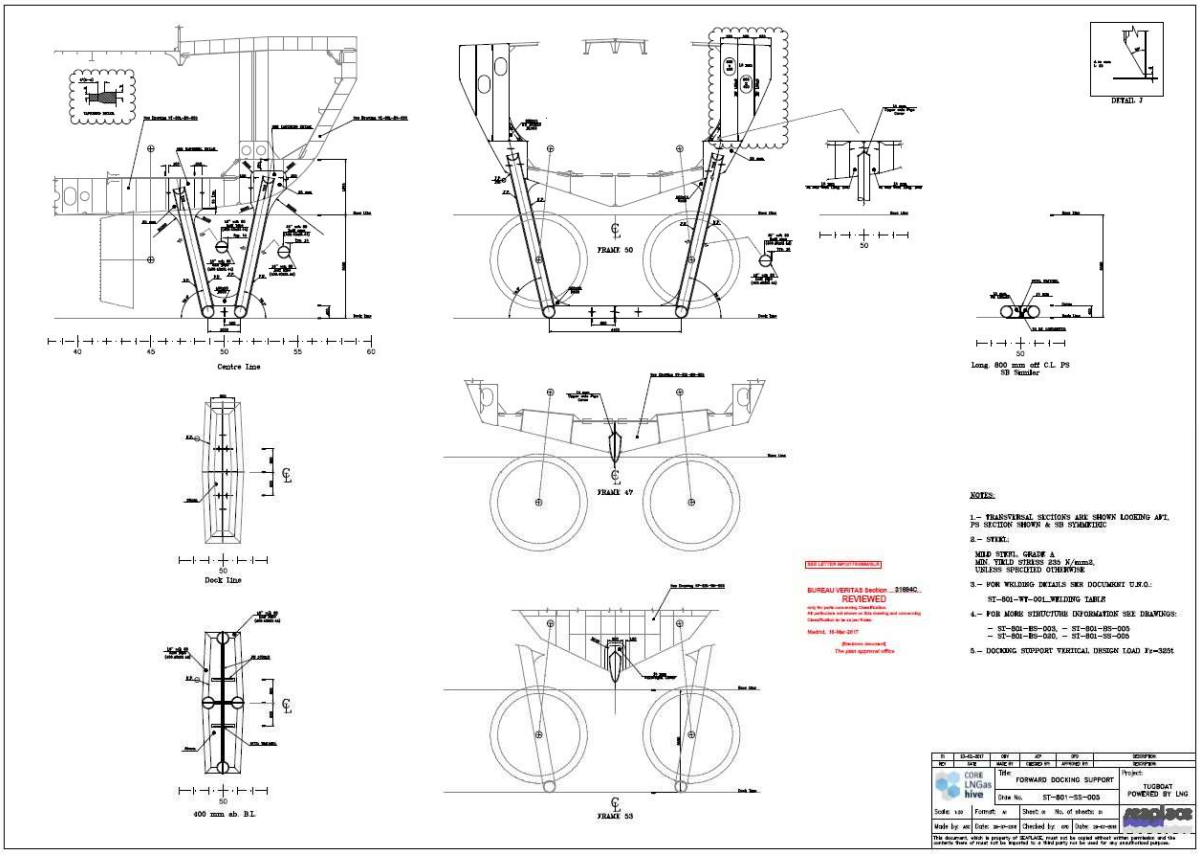


FIGURE 56 FORWARD DOCKING SUPPORT

3.3.5.3 BULWARK

The freeing port and bulkwark structure are calculated and design and can be found on document *"ST-801-SS-006-00_Freeing Port and Bulwark Structure".*

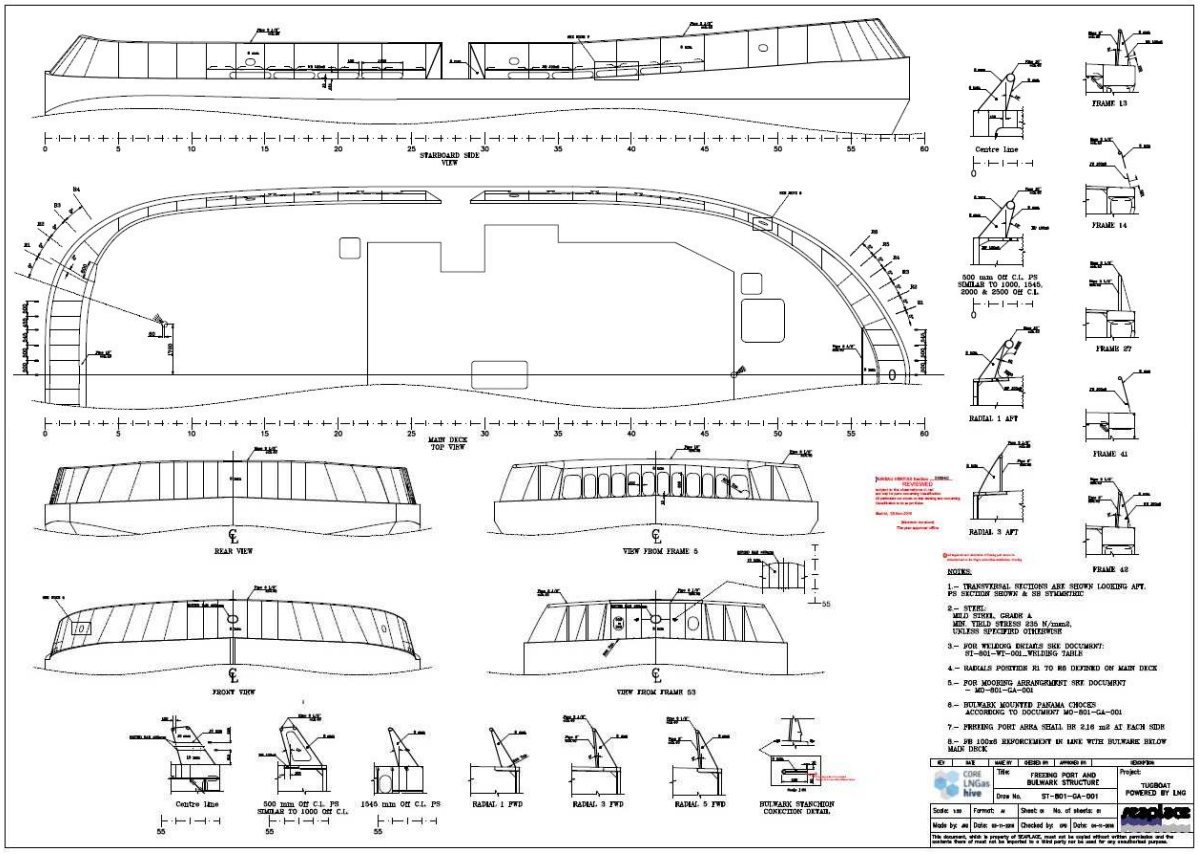


FIGURE 57 FREEING PORT AND BULWARK STRUCTURE

3.3.5.4 DECK EQUIPMENT LOCAL REINFORCEMENT

The towing winch needs an structural foundation. Local reinforcements are included on main deck as shown in drawing *"ST-801-FO-001-00_Towing Winch Foundation".*

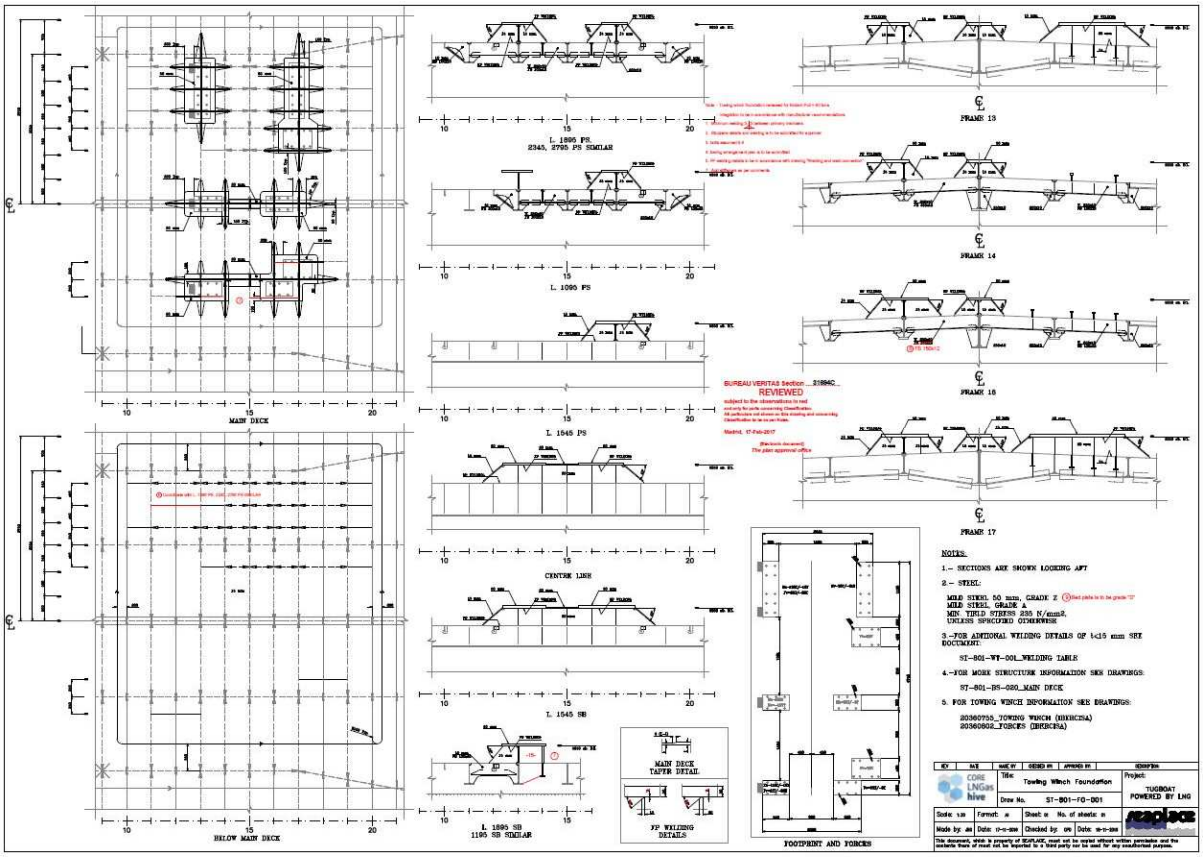


FIGURE 58 TOWING WINCH FOUNDATION

3.3.5.5 BRIDGE MAST

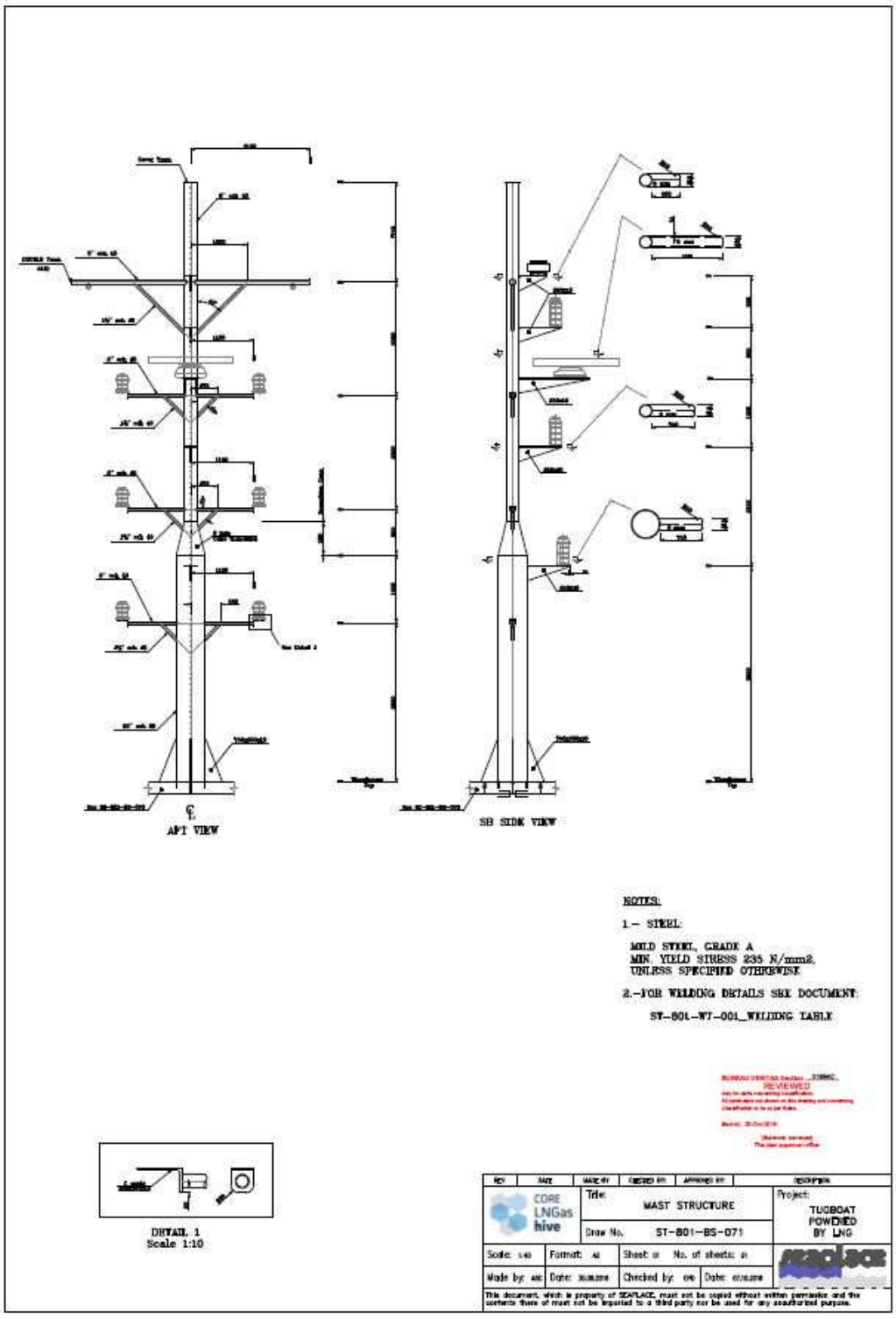


FIGURE 59 MAST STRUCTURE

The main deck is designed as shown in drawing *"ST-801-BS-071-00_Mast Structure".*

3.4 ENGINE ROOM

3.4.1 ENGINE ROOM ARRANGEMENT

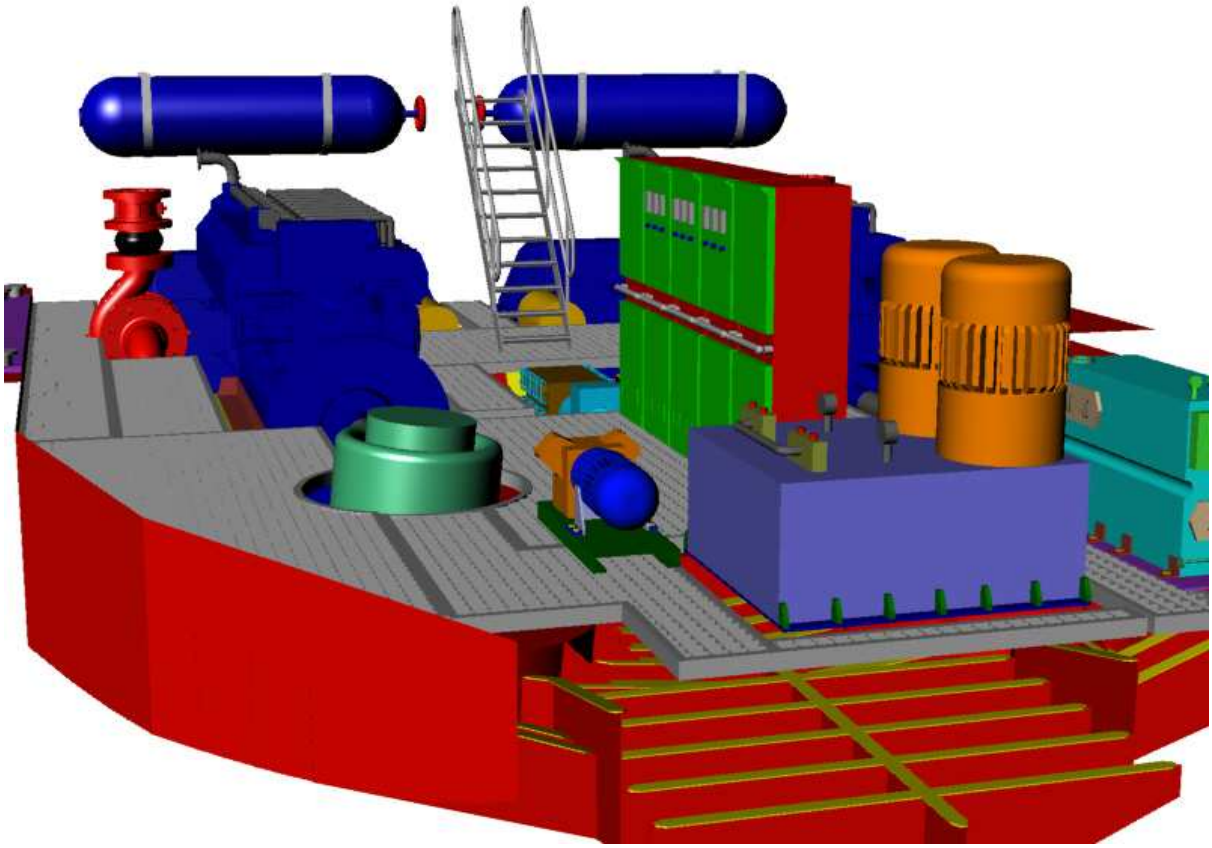


FIGURE 60 ENIGINE ROOM ARRENGEMENT RENDER

Engine room machinery is located forward, under main deck, in one compartment, and designed as a gas safe space according to Rules.

The propulsion plant configuration consists of two gas engines directly coupled to two azimuth thrusters, located forward.

Each main gas engines is fitted with an aft gearbox in order to provide energy to the shaft generators and to the FiFi pumps.

Additionally, one diesel harbor generator is installed in the engine room. This generator will supply power during harbor operations.

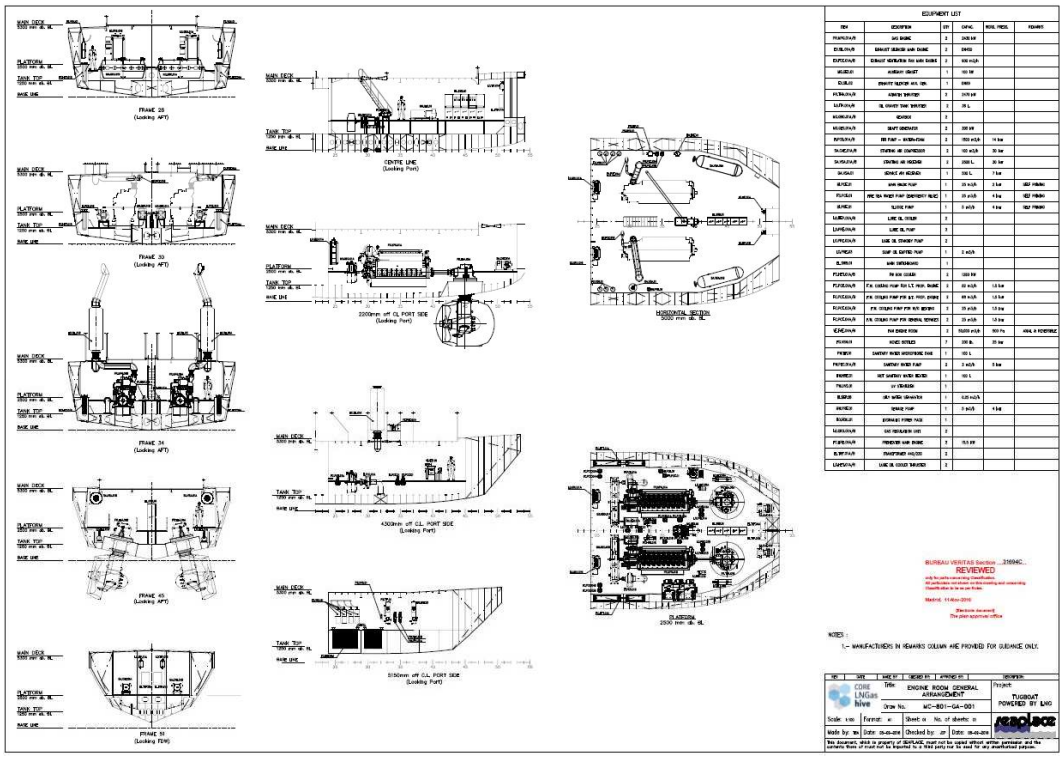


FIGURE 61 ENGINE ROOM GENERAL ARRANGEMENT

The drawing of the engine room machinery arrangement can be found in *"MC-801-GA-001 ENGINE ROOM MACHINERY ARRANGEMENT"*

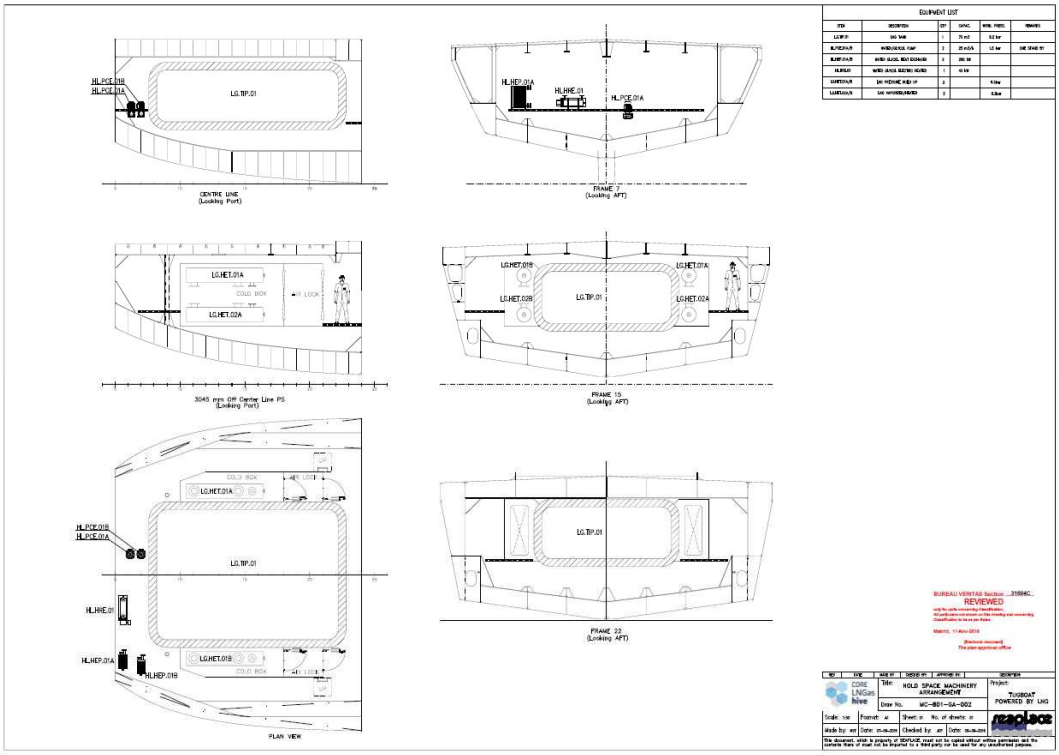


FIGURE 62 HOLD SPACE MACHINERY ARRANGEMENT

The hold space machinery arrangement is designed as shown in drawing *"MC-801-GA-002 HOLD SPACE MACHINERY ARRANGEMENT"*

3.4.2 EQUIPMENT LIST

A detailed list stating all equipment needed for tugboat to fulfil its purpose is developed. Location, service, capacity and power are specified.

Equipment list is detailed in document: "*MC-801-EQ-001_00 EQUIPMENT LIST*".

CODE	SERVICE	DESCRIPTION	QTY
PR.THA.01A/B	Propulsion	AZIMUTH THRUSTER	2
PR.MPG.01A/B	Propulsion	GAS ENGINE	2
MG.GED.01	Electric Generation	AUXILIARY GENSET	1
MG.GBO.01A/B	Electric Generation	GEARBOX	2
MG.GES.01A/B	Electric Generation	SHAFT GENERATOR	2
EG.UPS.01	Electric Generation	UPS	1
EG.EBT.01	Electric Generation	EMERGENCY BATTERIES	1
EX.SIL.01A/B	Exhaust System	EXHAUST SILENCER MAIN ENGINE	2
EX.SIL.02	Exhaust System	EXHAUST SILENCER AUX. GEN.	1
EX.FCE.01A/B	Exhaust System	EXHAUST VENTILATION FAN MAIN ENGINE	2
BI.PCE.01	Bllge System	MAIN BILGE PUMP	1
BI.PRE.01	Bilge System	SLUDGE PUMP	1
BI.PRM.01	Bilge System	CHAIN LOCKER MANUAL PUMP	1
BI.SEP.01	Bilge System	OILY WATER SEPARATOR	1
FS.PCE.01	Fire Fighting	FIRE SW PUMP (EMERGENCY BILGE)	1
FS.PCE.02	Fire Fighting	PORTABLE FIRE SW PUMP	1
FC.PCE.01A/B	Fresh Water Cooling	FW COOLING PUMP FOR L.T. PROP.ENGINE	2
FC.PCE.02A/B	Fresh Water Cooling	FW COOLING PUMP FOR H.T. PROP. ENGINE	2
FC.PCE.03A/B	Fresh Water Cooling	FW COOLING PUMP FOR W/G HEATING	2
FC.PCE.04A/B	Fresh Water Cooling	FW COOLING PUMP FOR GENERAL SERVICES	2
FC.HET.01A/B	Fresh Water Cooling	BOX COOLER	2
FC.TIA.01A/B	Fresh Water Cooling	FW COOLING EXPANSION TANK	2
FC.HRE.01A/B	Fresh Water Cooling	FW PREHEATER MAIN ENGINE	2
HL.PCE.01A/B	LNG Heating System	WATER GLYCOL PUMP	2
HL.HEP.01A/B	LNG Heating System	WATER GLYCOL HEAT EXCHANGER	2
HL.HRE.01	LNG Heating System	WATER GLYCOL ELECTRIC HEATER	1
HL.TIA.01	LNG Heating System	WATER GLYCOL EXPANSION TANK	1
LG.GRU.01A/B	Gas Supply System	GAS REGULATION UNIT	2
LG.TIP.01	Gas Supply System	LNG TANK	1
LG.HET.01A/B	Gas Supply System	LNG PRESSURE BUILD UP	2
LG.HET.02A/B	Gas Supply System	LNG VAPORIZER/ HEATER	2
IG.VSN.01	Inert Gas System	INERT GAS CYLINDER RACK	1
LO.HEP.01A/B	Lube Oil System	LUBE OIL COOLER MAIN ENGINE	2
LO.HRE.01A/B	Lube Oil System	LUBE OIL HEATER MAIN ENGINE	2
LO.PRE.01A/B	Lube Oil System	LUBE OIL PRIMING PUMP	2
LO.PRE.02A/B	Lube Oil System	LUBE OIL STAND-BY PUMP	2
LO.PRE.03	Lube Oil System	SUMP OIL EMPTIED PUMP	1
LO.TIP.01A/B	Lube Oil System	OIL GRAVITY TANK THRUSTER	2
LO.HET.01A/B	Lube Oil System	LUBE OIL COOLER THRUSTER	2
VE.FAE.01A/B/C/D	Ventilation System	COLD BOX FAN	4
VE.FAE.02A/B	Ventilation System	AIR LOCK FAN	2
VE.FAE.03A/B/C/D	Ventilation System	DOUBLE WALL/ GRU FAN	4
VE.FAE.04	Ventilation System	ENGINE ROOM FAN	1
VE.FAE.05	Ventilation System	ENGINE ROOM FAN	1
VE.FCE.06	Ventilation System	HOLD SPACE FAN	1

CODE	SERVICE	DESCRIPTION	QTY
HO.HDU.01	Hydraulic Oil	**HYDRAULIC POWER PACK**	1
FI.PCE.01A/B	FiFi-1 System	**FIFI PUMP WATER/FOAM**	2
FI.MON.01A/B	FiFi-1 System	**FIFI MONITOR WATER**	2
FI.UMX.01A/B	FiFi-1 System	**FIFI FOAM MIXER**	2
SA.CAE.01A/B	Starting Air System	**STARTING AIR COMPRESSOR**	2
SA.VSA.01A/B	Starting Air System	**STARTING AIR RECEIVER**	2
GA.VSA.01	Service Air System	**SERVICE AIR RECEIVER**	1
IA.DRY.01	Instrument Air System	**CONTROL AIR DRYER MAIN ENGINES**	1
IA.RED.01	Instrument Air System	**CONTROL AIR REDUCER UNIT MAIN ENGINES**	1
EL.SWB.01	Electric System	**MAIN SWITCHBOARD**	1
EL.SWB.02	Electric System	**EMERGENCY SWITCHBOARD**	1
EL.TRF.01A/B	Electric System	**TRANSFORMER 400/230 V**	2
PW.TIF.01	Sanitary Water System	**SANITARY WATER HYDROPHORE TANK**	1
PW.PCE.01A/B	Sanitary Water System	**SANITARY WATER PUMP**	2
HW.HRE.01	Sanitary Water System	**HOT SANITARY WATER HEATER**	1
PW.UVS.01	Sanitary Water System	**SANITARY WATER UV STERILIZER**	1
BW.PRE.01	anitary Discharge Syste	**SEWAGE PUMP**	2
FG.VSN.01	Fire Gas System	**NOVEC BOTTLES**	7
FP.DPU.01	Fire Foam System	**DRY POWDER UNIT**	1
	Anchoring system	**ANCHOR**	2
	Anchoring system	**ANCHOR WINDLASS WINCH**	1
	Towing System	**TOWING WINCH**	1
	Mooring system	**ELECTRIC CAPSTAN**	1
	Mooring system	**DOULE BITT**	6
	Mooring system	**PANAMA CHOCK**	7
	Mooring system	**ROLLER**	3
	Life Saving	**INFLATABLE LIFERAFT**	2
	Life Saving	**EMBARKATION LADDER**	2
	Life Saving	**LIFEBUOY**	2
	Life Saving	**LIFEBUOY WITH LINE**	2
	Life Saving	**LIFEBUOY WITH LIGHT**	2
	Life Saving	**LIFEBUOY WITH LIGHT & SMOKE**	2
	Life Saving	**LIFEJACKET**	12
	Life Saving	**INMERSION SUIT**	8
	Life Saving	**SURVIVAL CRAFT PORTABLE RADIO**	2
	Life Saving	**SEARCH AND RESCUE LOCATING DEVICE**	1
	Life Saving	**ROCKET PARACHUTE FLARES**	12
	Life Saving	**LINE THROWING RECHARGEABLE APPLIANCE**	1
	Life Saving	**MUSTER STATION**	1
	Life Saving	**FAT KIT PLUS STRETCHER**	1
	Life Saving	**MEDICAL LOCKER**	1
	Life Saving	**MUSTER LIST CONTAINERS**	3
	Life Saving	**RLS SATELLITARY RADIOBEACON (EPIRB)**	1

CODE	SERVICE	DESCRIPTION	QTY
	Fire Fighting Equipment	FIRE BLANKET	1
	Fire Fighting Equipment	FIREMAN OUTFIT	4
	Fire Fighting Equipment	EMERGENCY ESCAPE BREATHING DEVICE (EE	5
	Fire Fighting Equipment	PORTABLE FIRE EXTINGISHER	
	Laundry Equipment	WASHING MACHINE	1
	Laundry Equipment	DRYER MACHINE	1
	Laundry Equipment	IRONING BOARD	1
	Laundry Equipment	WASHING BASIN	1
	Radio & Communication	Satellite Communication Plant INMARSAT F	1
	Radio & Communication	Satellite Communication Plant INMARSAT C	2
	Radio & Communication	Iridium Satellite Telephone	1
	Radio & Communication	MF/HF Single-Side-Band (SSB) Radiotelepho	1
	Radio & Communication	VHF Radiotelephone with DSC	2
	Radio & Communication	VHF Radiotelephone	1
	Radio & Communication	Weatherfax	1
	Radio & Communication	NAVTEX	1
	Radio & Communication	UHF Portable Communication Set	6
	Radio & Communication	VHF Portable Communication Set	3
	Radio & Communication	UHF Head Communication Set	2
	Navigation	Magnetic Compass	1
	Navigation	Gyrocompass	2
	Navigation	Autopilot	1
	Navigation	Dual Axis Speed Log Doppler type	1
	Navigation	Navigation Echosounder	1
	Navigation	DGPS System	2
	Navigation	X-Band Radar	2
	Navigation	Dual Electronic Chart Display Unit (ECDIS)	1
	Navigation	Voyage Data Recorder (VDR)	1
	Navigation	AIS System	1
	Navigation	Master Clock & Clocks	
	Navigation	Chronometer	
	Navigation	Clinometer	
	Navigation	Anemometer	
	Navigation	Anemascope	
	Navigation	Rate of Turn Indicator	
	Navigation	Azimuth Thruster Direction Indicator	
	Navigation	Search Lights	2
	Navigation	Flood Lights	6

TABLE 14 TABLE OF EQUIPMENTS

3.4.3 ENGINE ROOM FLOODING CALCULATION

Calculation has been carried out to show that the time taken from alarm activation plus time to reach and fully close manually operated valves is less than time taken for the influx of water to reach the control without submergence of the platform on which the person is operating the valves.

Nominal diameter	DN	65	mm
External diameter	Do	76,1	mm
Thickness	th	5,6	mm
Internal diameter	Di	64,9	mm
Pipe Internal area	S	0.003	m2
Distance between valve control and bridge	d	31.2	m
Time required to close the valve	t	30	s
Draught at fully load condition	D	3.5	m
Pipe height from base line	h	1,8	m
Pressure height from pipe fracture to load line	H	1.7	m
Flooding alarm height	ha	0,1	m
Total engine room area	A	187,2	m^2
Valve Control height	hf	1,7	m
Total volume in level alarm and valve control	Vt1	205,9	m^3
Total volume of bottom tanks and sea chest	Vt2	40,19	m^3
Total Volume (Vt1-Vt2)	Vt	163,1	m^3
Floodable volume	V	130,5	m^3
Time to be required to operated valve closing	Ta	352	s
Total filling time	Te	8319	s

TABLE 15 FLOODING CALCULATIONS

Time to close the valve is shorter than time for flooding so the hand actuator of sea chest valve must be provided above 1.7m above base line.

These calculations are included in the document: "*MC-801-DC-001_ENGINE ROOM FLOODING CALCULATION*"

3.4.4 PROPELLER

3.4.4.1 AZIMUTH THRUSTER

After estimating the necessary power for the navigation and the bollard pull, the vessel is arranged with two azimuth thruster US 255 CP delivered by Rolls Royce in the fwd., with the following main characteristics:

Number of thrusters	2
Type	Rolls Royce US 255 CP type (controllable pitch)
Max input power	2470Kw each
Diameter	2800mm
Motor speed	1000rpm
Number of blades	4

TABLE 16 THRUSTER CHARACTERISTICS

FIGURE 63 ROLLS ROYCE AZIMUTH THRUSTERS

3.4.5 POWER GENERATION

3.4.5.1 MAIN GAS ENGINE

Speed power curves in order to predict the free sailing smooth water speed of the designed LNG Tugboat are calculated. Reading in those curves it can be seen that two Gas engines Rolls-Royce are needed in machinery room with the following main characteristics:

- C26:33L9PG.
- Number of cylinders: 9
- Cylinder bore: 260 mm
- Piston stroke: 330 mm
- Rated power (MCR): 2430 kW
- Engine speed: 1000 rpm
- Fuel type : Natural Gas

Automatic and remote control systems for the propulsion plant as per class rules.

Monitoring and alarm system are located in wheelhouse and engine control room.

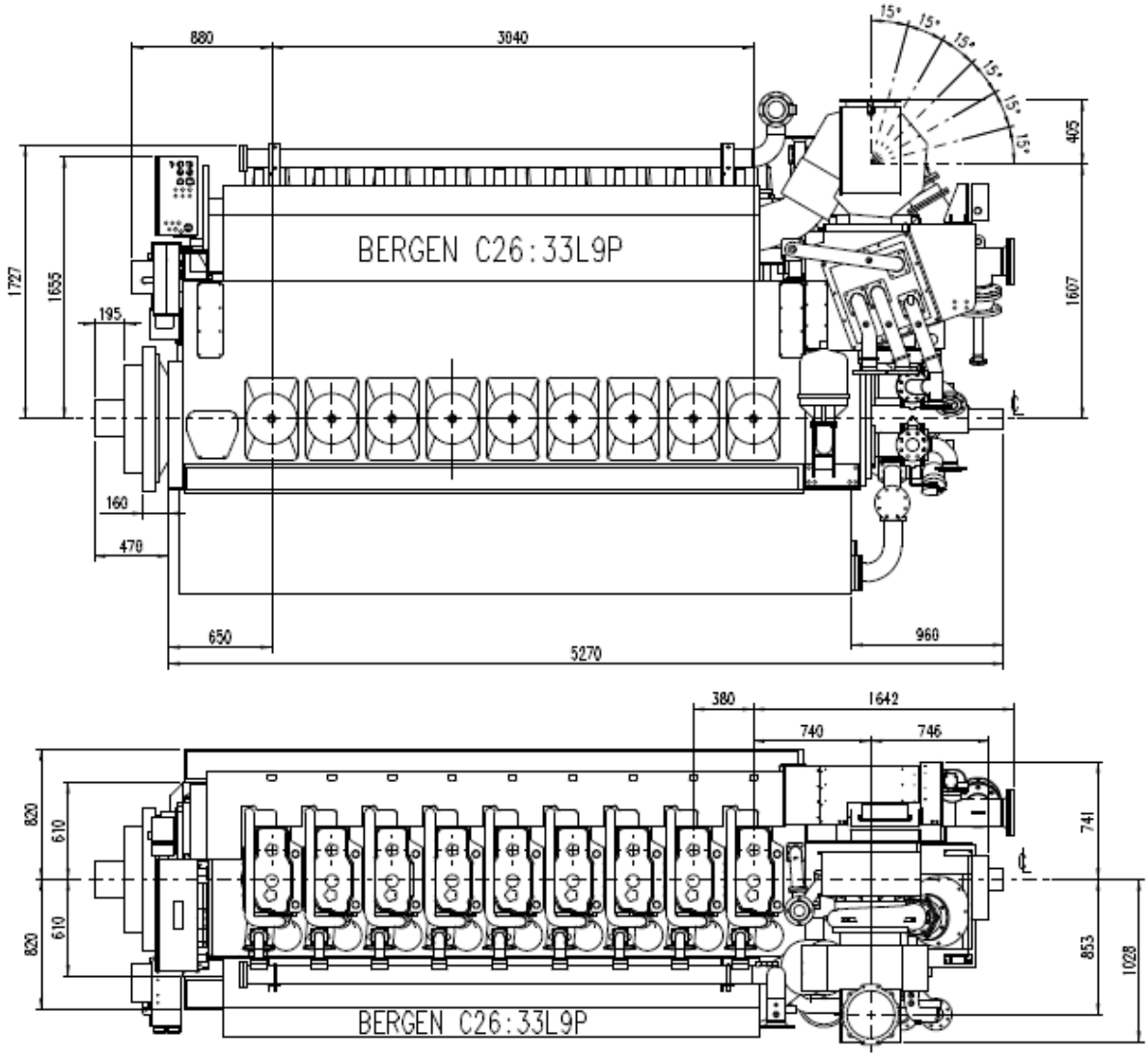


FIGURE 64 ROLLS ROYCE BERGEN GAS ENGINE

3.4.5.2 AUXILIARY DIESEL GEN-SET

As per electrical load calculations, and in order to fulfil all the operational requirements, the tugboat has one auxiliary generator. The auxiliary generator power is selected with sufficient capacity for the supply of essential auxiliaries (25 kW estimated), with automatic starting and connection to the main switchboard.

A harbor Diesel generator of 100 kW, arranged in machinery room, provides 125 kVA at 50 Hz.

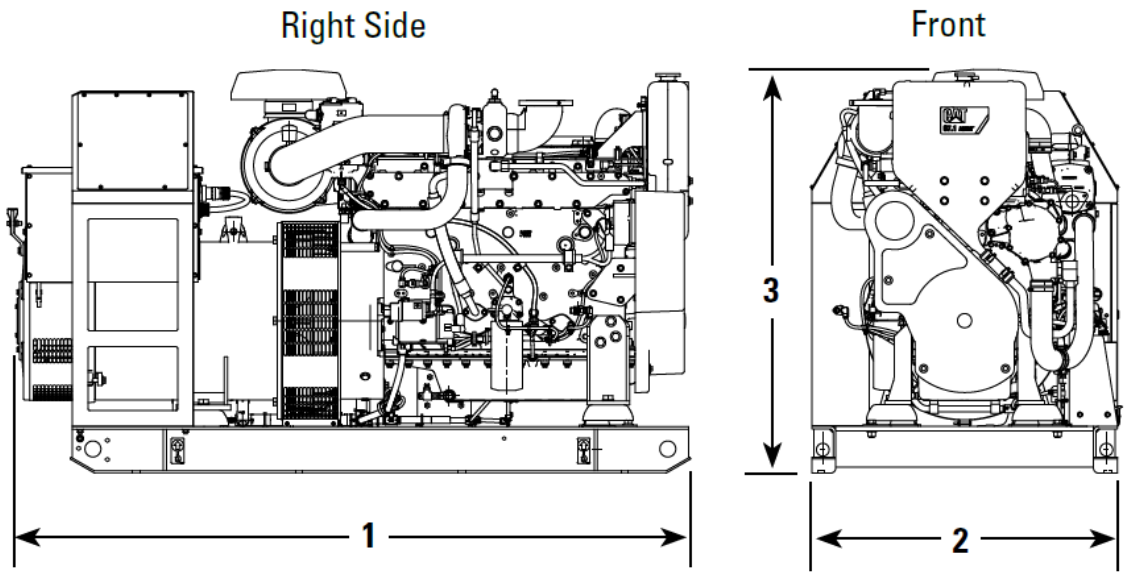


FIGURE 65 CAT C7.1 MARINE GENERATOR SET

3.4.5.3 GEARBOX

After the necessary calculations two Kumera 4FGC gearboxes are chosen for the machinery room.

The gearbox is a combined power transmission group of FiFi pumps and shaft generators, and is fed by the main gas engines. The tugboat will require one gearbox per engine.

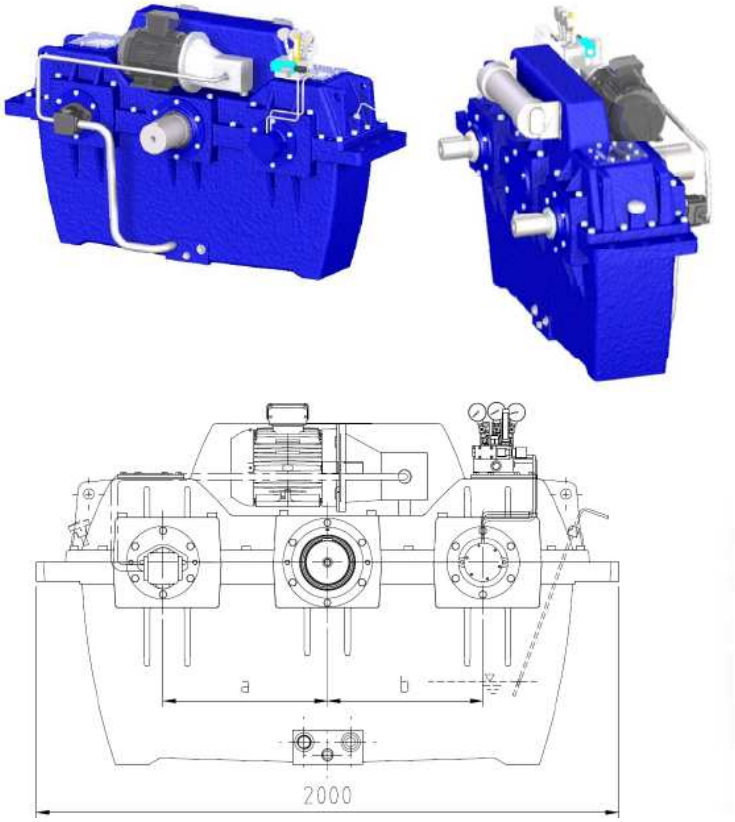


FIGURE 66 KUMERA NORGEAR 4FGC-1100

3.4.5.4 SHAFT GENERATOR

Two shaft generators are installed in machinery room, one per engine.

The shaft generators are coupled to the gearbox, and supply power during both operational conditions, service and machinery load. Each generator provides 300 kW (375 kVA) at 50 Hz

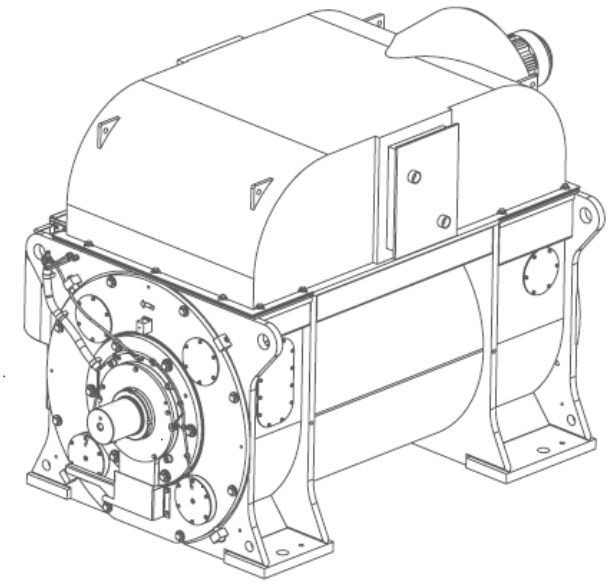


FIGURE 67 PERMANENT MAGNET MACHINE

3.4.6 AUXILIARY MACHINERY AND SYSTEMS

3.4.6.1 COOLING SYSTEM

A closed cooling system with box coolers is designed for fresh water in order to eliminate the need to treat sea water in the engine room. Fresh water is forced through a U-tube-bundle, located in the box coolers. The cooling effect is reached by natural circulation of the outboard water in the sea-chest or by a circulation due to the speed of the vessel.

FW cooling systems are arranged using box-coolers with high and low temperature circuits for fresh water. Both independent circuits are fitted with temperature indicators and thermostatic valves.

The cooling system is designed as shown in diagram *"MC-801-PI-005_01_FRESH WATER COOLING SYSTEM".*

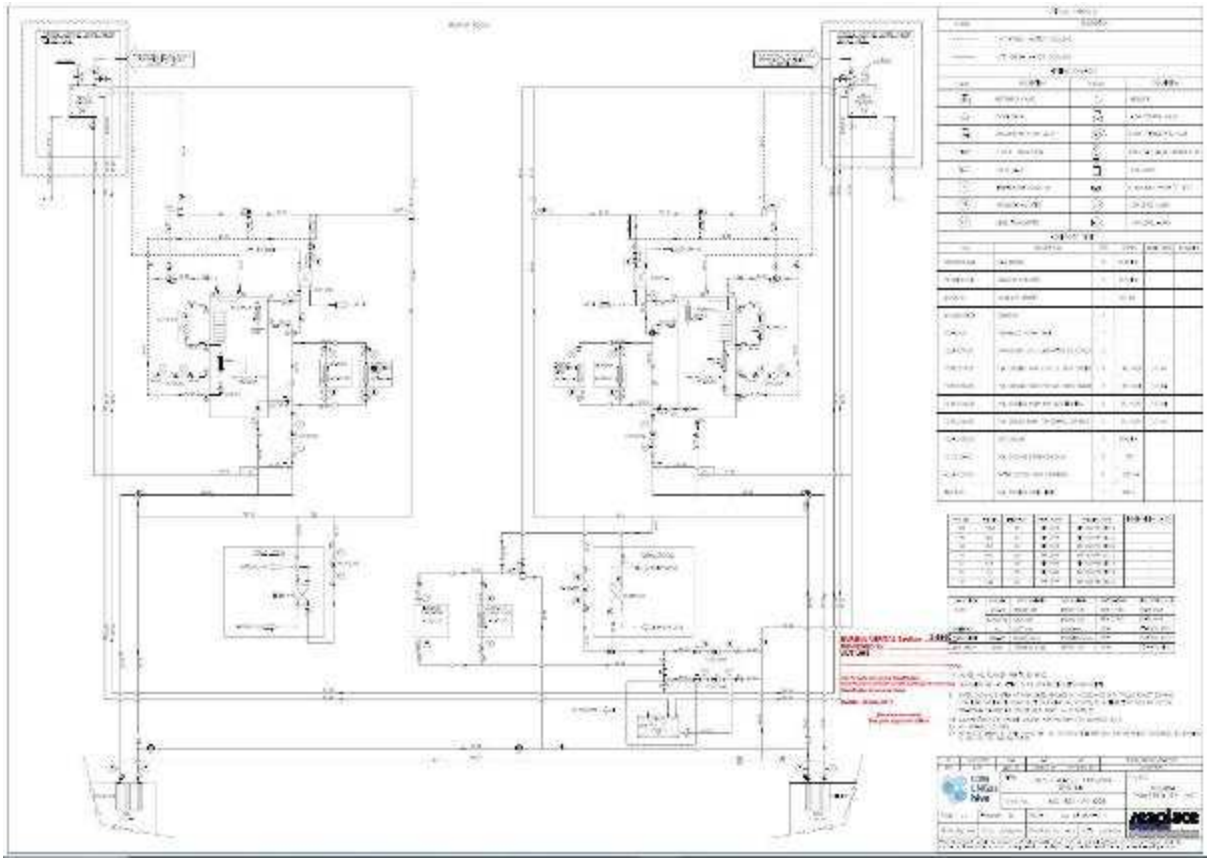


FIGURE 68 FRESH WATER COOLING SYSTEM

Main Gas Engines Cooling System

The engines are cooled by fresh water in a closed circuit, according to supplier standard.

The cooling system is provided with box cooler designed to remove heat from engine.

Box Cooler

Two box coolers is fitted in engine room, on both sides of the vessel; sea chest has both high and low grids and arranged for minimum air suction.

The box coolers provides cooling for the following equipment:

- The main gas engines,
- The hydraulic system of the azimuth thrusters,
- Hydraulic power station,

FIGURE 69 BOX COOLER

3.4.6.2 MARINE GASOIL SYSTEM

The ship's harbour diesel generator runs on Marine Gas Oil. The MGO storage tank is located on the double hull (starboard) of the engine room, with a capacity of 4.3 m^3 as shown in: "*NA-801-CP-001-01_Capacity Plan*".

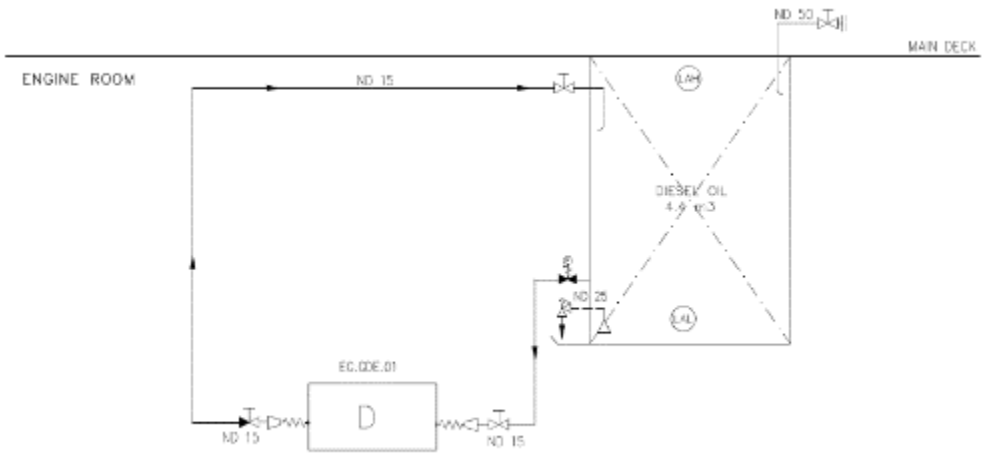


FIGURE 70 DIESEL OIL SYSTEM

3.4.6.3 HYDRAULIC OIL SYSTEM

The vessel is provided with the following hydraulic oil systems:

- Hydraulic oil azimuth propulsion.
- Hydraulic oil for deck equipment (including hydraulic mooring winches).
- Hydraulic power for remote valves.

3.4.6.4 LUBE OIL SYSTEM

The lube oil system is arranged in the engine room for main engines and auxiliary engine.

Each main engine and auxiliary engine have separate wet sump lubrication oil system, according to the engine manufacturer

The main engines are equipped with electrically driven priming pumps mounted on the engines, and duplex type oil filters.

Sump oil emptied pump is fitted between the lube oil sumps and the waste oil tank.

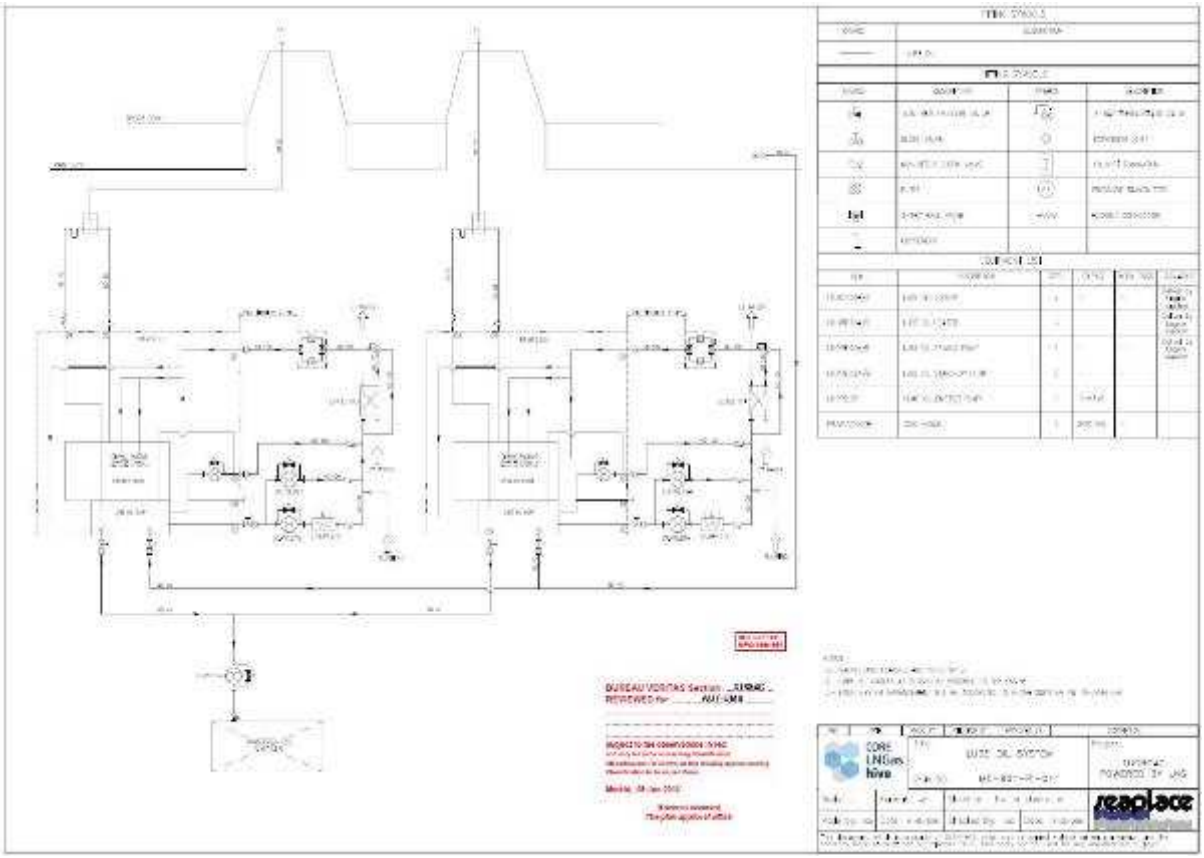


FIGURE 71 LUBE OIL SYSTEM DIAGRAM

The lube oil system diagram is designed as shown in drawing "*MC-801-PI-011_LUBE OIL SYSTEM".*

3.4.6.5 EXHAUST SYSTEM

The exhaust gas pipes from main engines and harbour generator are carried out through exhaust casing trunk. Separate exhaust pipes are arranged for all combustion machinery.

Exhaust pipes are made of mild steel and insulated with mineral wool material to ensure a maximum surface temperature of 50º C. Insulation is covered with galvanized steel plate.

All exhaust pipes are flexibly suspended, necessary number of expansion joints are fitted and the pipes must be locally reinforced with double plate or similar at the point of connection to vessel structure.

Rupture disc is installed at the exhaust of the gas engines.

Mechanical ventilation is installed at the exhaust pipe to vent possible methane pockets at the exhaust gases.

Silencers are mounted with flexible bellows in exhaust pipes from the engines. Spark arresters are installed on top of funnels or at silencers.

Necessary drainage from exhaust pipes and silencers are arranged draining to bilge.

The exhaust system must be designed and outfitted for acceptable low pressure losses, and to prevent damages due to vibrations. The silencers on all exhaust lines have normally a damping of 35 DB A.

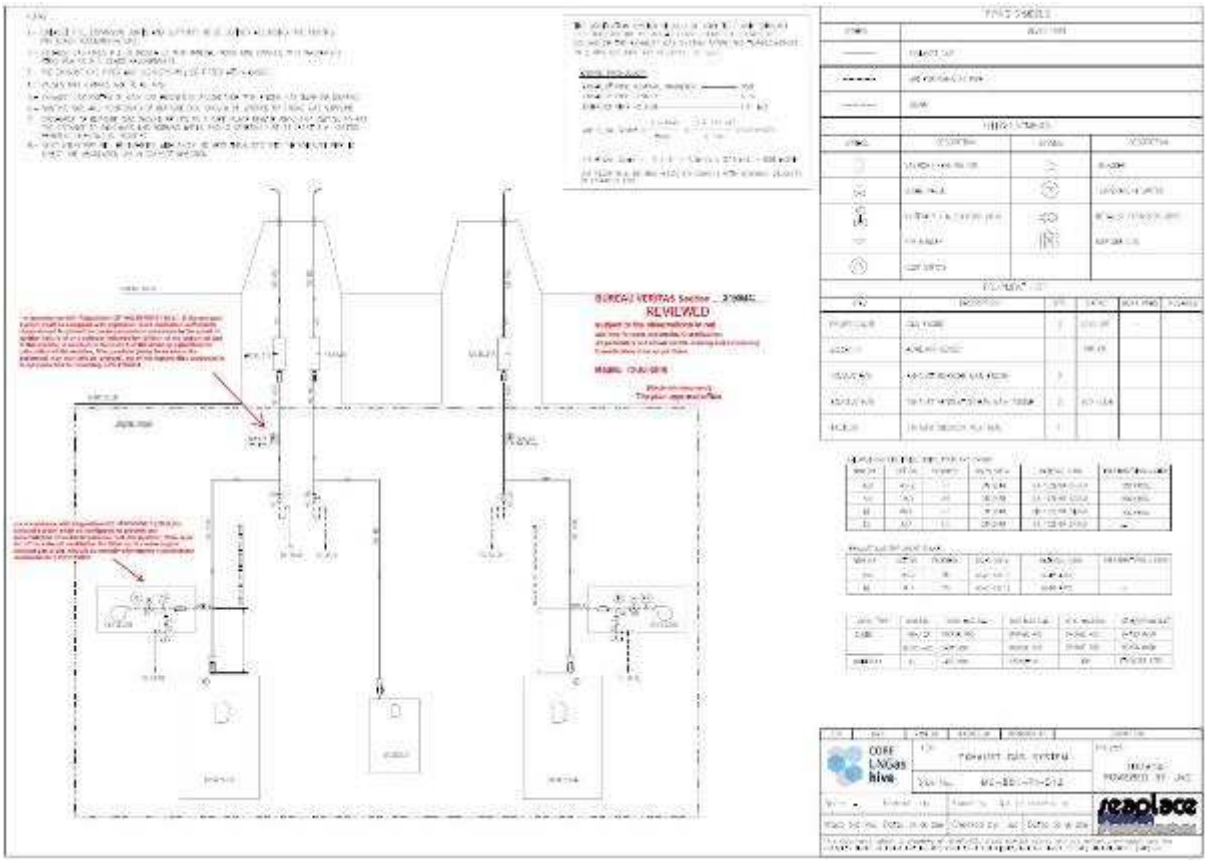


FIGURE 72 EXHAUST SYSTEM

The exhaust system diagram is designed as shown in drawing "*MC-801-PI-013_EXHAUST SYSTEM".*

3.4.6.6 COMPRESSED AIR SYSTEM

Starting Air System

The main engines are arranged for compressed air starting.

-Two starting air compressors, 100 m3/h at 30 bar,

-Two starting air bottles 2500 l.

Both compressors are connected in such a way that can work as stand by one of the other and discharge to any of the starting bottle through a water/oil separator with drain to bilge.

Air bottles are connected in parallel to a main air pipe that supplies high pressure air for starting main engines.

Working and Instrument Air System

Working air system is provided with adequate number of air outlets for quick connection, arranged according to best practice in engine room and external deck.

Air line for the following equipment is provided:

-Sanitary Water hydrophore tank

-Sea chest cleaning

Working air system is provided with following equipment:

-One working air bottle 500 l

Cross connection from starting air system is provided with a reducing pressure valve, from 30 to 7 bar and by pass pipe.

Instrument air circuit take air from working air collector, through an air dryer and supply air to equipment:

-Main engines

- Diesel engine

-Fire dampers

-Quick closing valves.

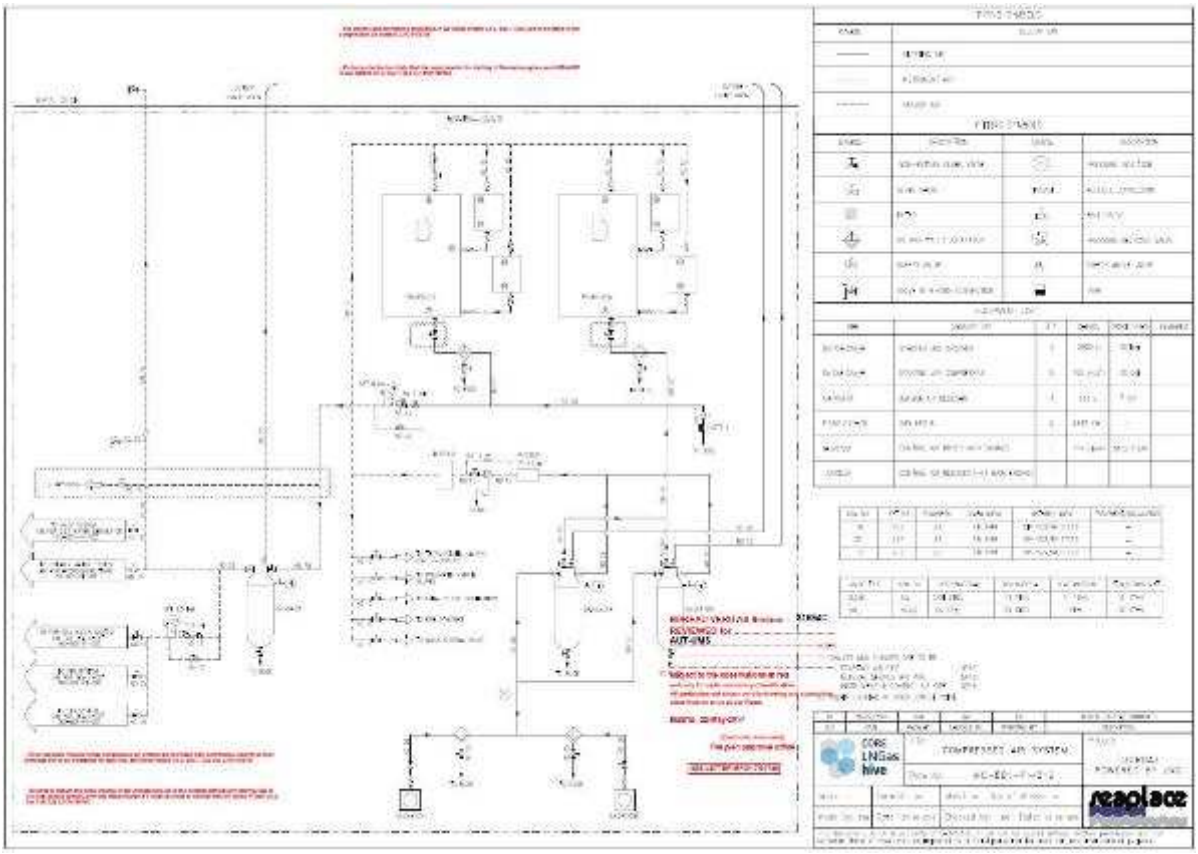


FIGURE 73 COMPRESSED AIR SYSTEM

The compressed air system is designed as shown in diagram *"MC-801-PI-012_01_COMPRESSED AIR SYSTEM".*

3.4.6.7 SEA CHEST

Three sea intake chests is fitted in engine room, two for FIFI 1 pumps and another one for fire SW system.

3.5 VESSEL PIPPING SYSTEM

All vessel piping systems have been calculated following applying the rules and regulations.

3.5.1 LNG SYSTEM

3.5.1.1 FUEL GAS SUPPLY

This system is designed to supply natural gas to the gas engines at the pressure and temperature range defined by the engine's manufacturer.

The gas fuel is supplied from the LNG Tank.

PBU (Pressure Build-up Unit)

The pressure build up unit pressurises the LNG storage tank to the design pressure, in order to maintain the LNG flow to the vaporizer and hence to the gas engines without cryogenic pumps.

Vaporizer

The function of the HP vaporizer is to vaporize LNG to natural gas to the design temperature and pressure defined by the Gas Regulation Unit. Heat is supplied from the engine cooling system via the water Glycol system.

Gas regulating units

Two gas valve units are fitted, one for each engine. They are located in separate gas tight enclosures. The gas regulating units ensure supply of fuel gas with correct pressure and purity to the engine, and also cater for the required safety shut-off functions. The natural gas supply pressure to the main engines is 4-6 bar according to the engine manufacturer.

Master Gas Valve

Two master gas valves, one per cold box, providing emergency shut-down of gas supply to the engine room is provided.

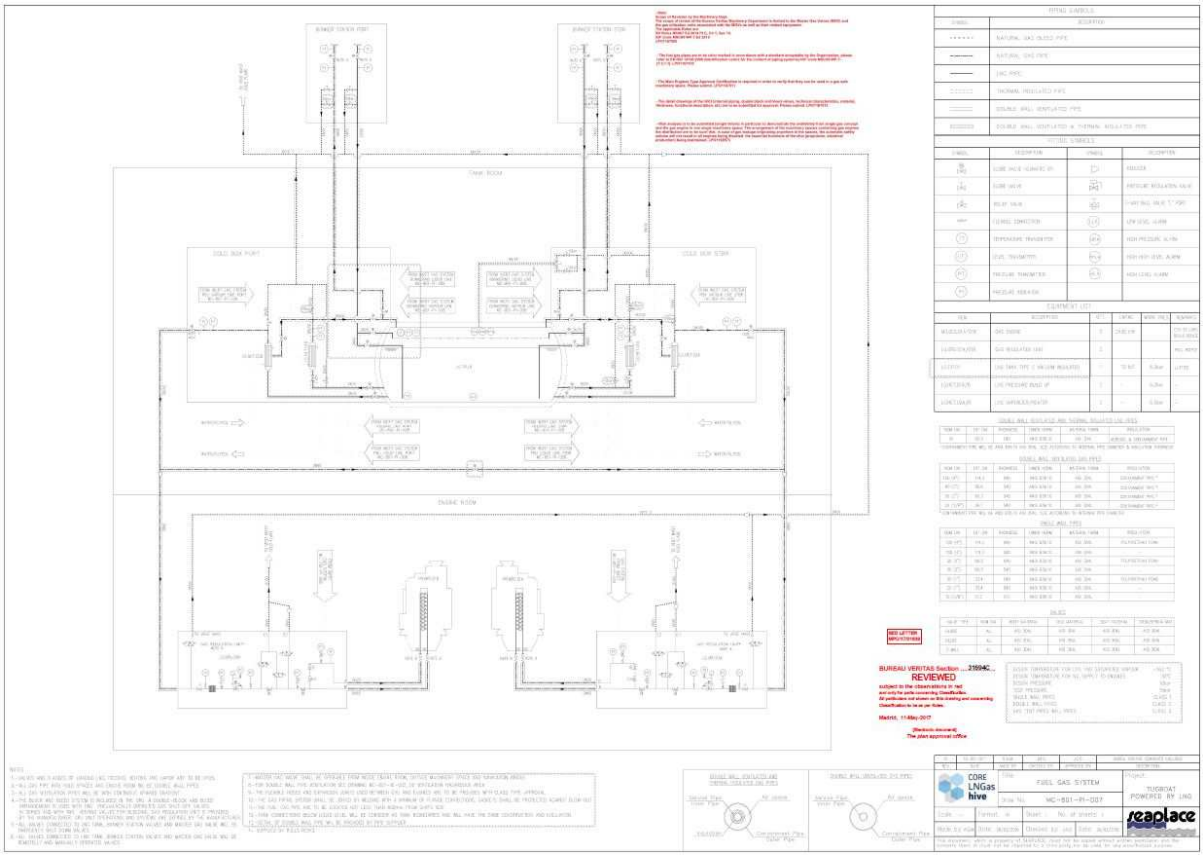


FIGURE 74 FUEL GAS SUPPLY

The fuel gas supply system is designed as shown in diagram "*MC-801-PI-007_01_FUEL GAS SUPPLY".*

3.5.1.2 INERT GAS SYSTEM

The inert gas is responsible of purging the Natural Gas inside LNG/NG pipes. The inert gas selected for this vessel is Nitrogen.

Nitrogen purity of 98%, dew point -50ºC and supply pressure of 10 bar.

The inert bottles are located at the deck store on main deck.

The inert gas system has been designed to comply with the requirements. The document describing the design of the system is:" *MC-801-PI-008_01_INERT GAS SYSTEM*".

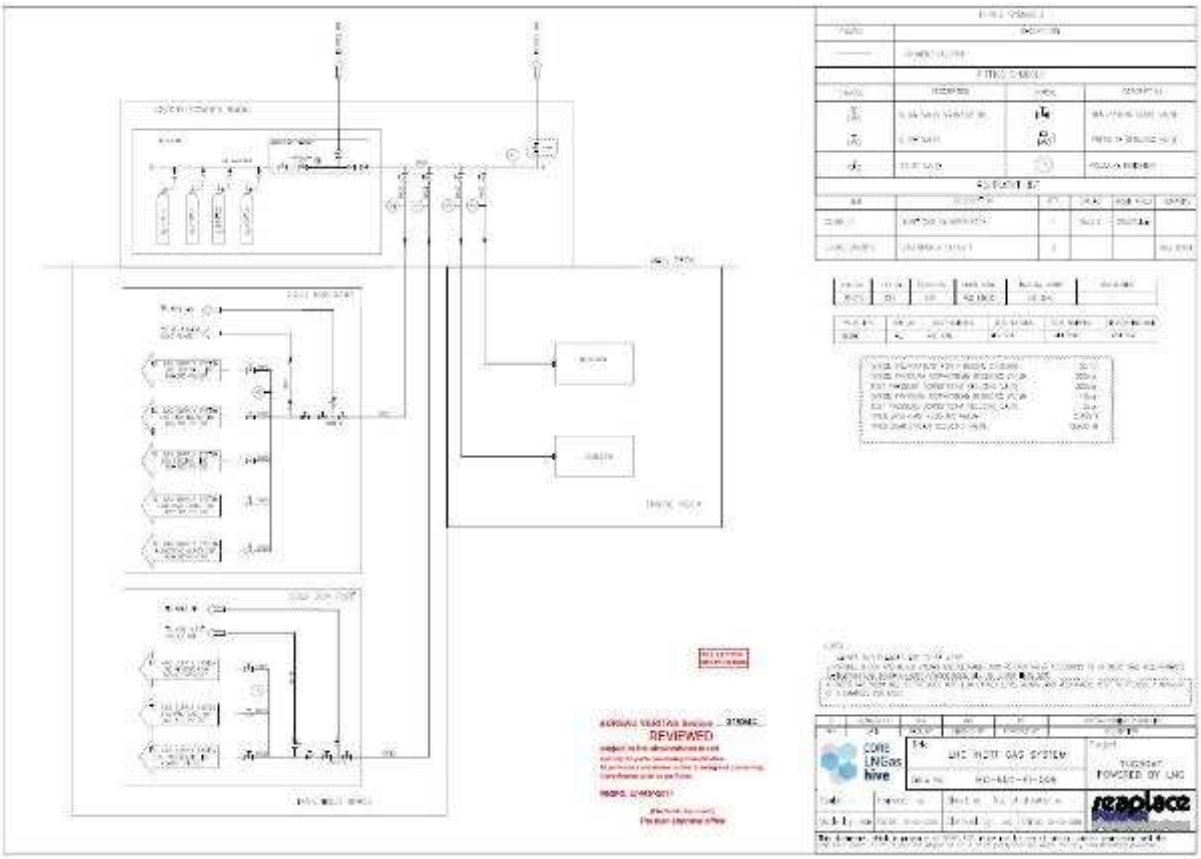


FIGURE 75 INERT GAS SYSTEM

3.5.1.3 LNG HEATING SYSTEM

The LNG heating system has been calculated and designed. The drawing depicting the system is:*"MC-801-PI-006_01_LNG HEATING SYSTEM*".

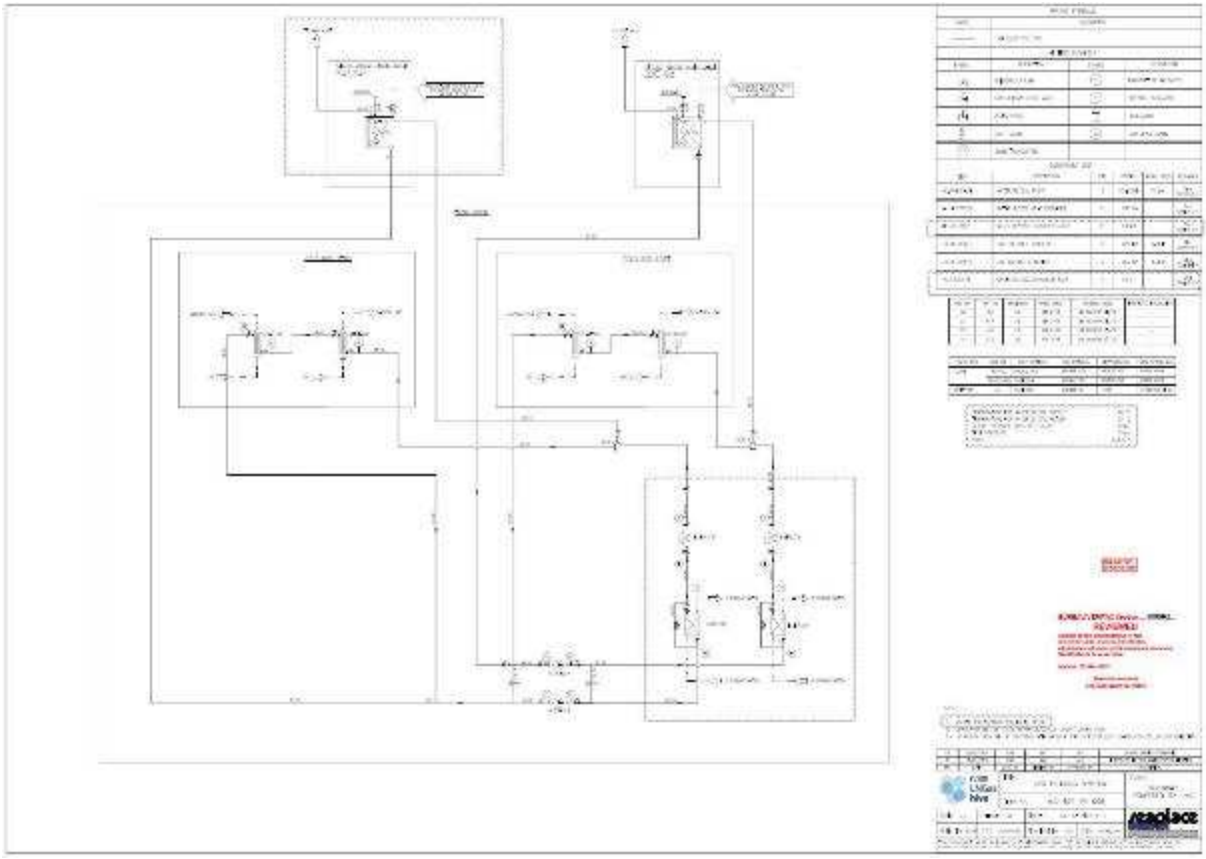


FIGURE 76 LNG HEATING SYSTEM

The water glycol LNG heating system provides energy from the LT cooling water to the PBU and Vaporizer/Heater through two heat exchangers and two circulating pumps. Each heat exchanger has enough capacity to fulfil the requirements of each cold box.

An additional water glycol electric heater is provided to ensure the heating capacity in all the operational modes.

Water Glycol expansion tank is fitted above main deck level to ensure circuit filling, and absorb the expanding fluid and limit the pressure within the system.

FIGURE 77 ALPHA LAVAL GLYCOL HEATHER

3.5.2 BILGE SYSTEM

An efficient bilge system capable of pumping out from any watertight compartment under all practical conditions is designed. Its purpose is to process oil contaminated discharges.

The system has branches connecting to the spaces:

- Hold Space
- Engine Room
- Aft Peak
- Forward Peak

The oily water separator suctions from bilge water tank, process oily bilge water and discharges treatment water over board and oil to sludge tank. The oily water separator is able to produce an effluent with oil content of less than 5 ppm.

Two 30 m^3/h pumps working at 5 bar to be needed.

The bilge system diagram can be found in document: "*MC-801-PI-002_01_BILGE SYSTEM*".

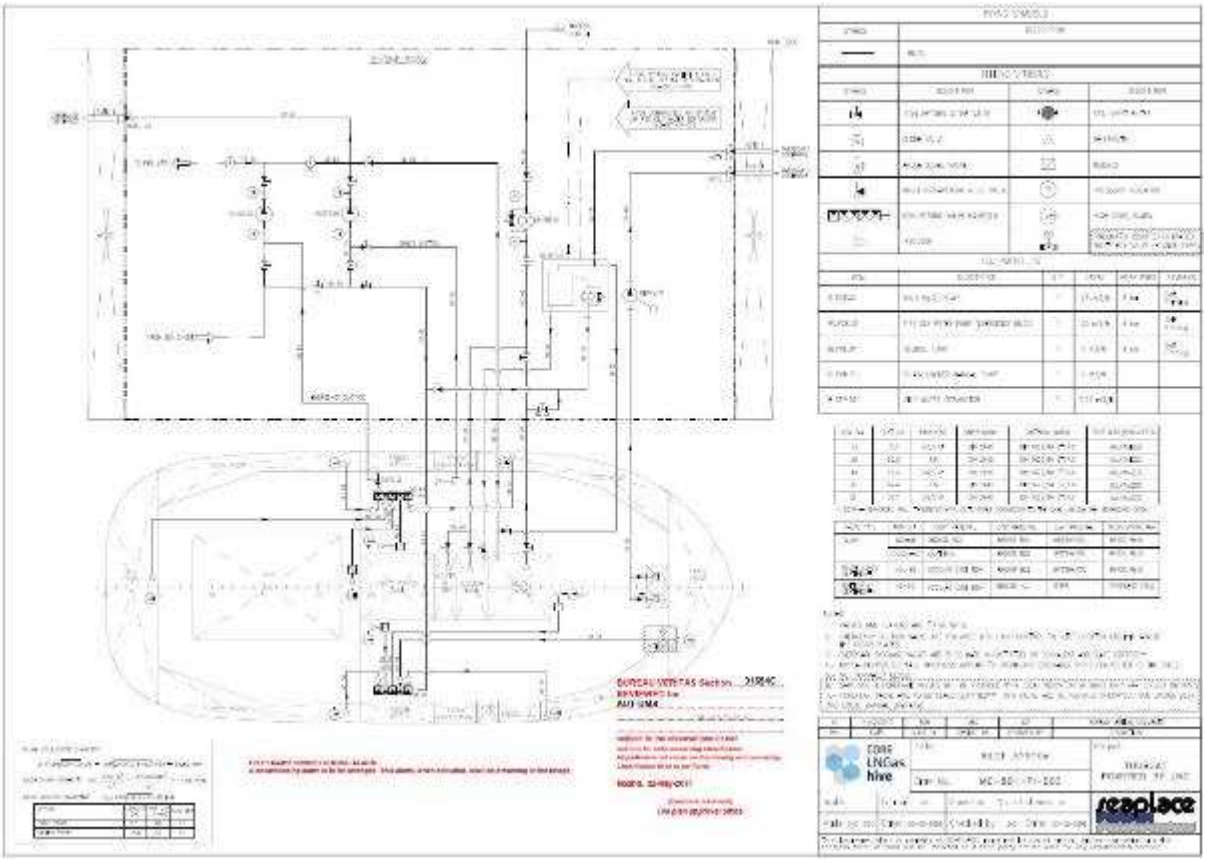


FIGURE 78 BILGE SYSTEM

3.5.3 FIRE FIGHTING AND WASH DOWN SYSTEMS

The Firefighting system is designed according to regulation and the vessel necessities.

The Fire Fighting System of the vessel is made up of the following systems:

- Fire SW System to general vessel protection.
- Novec System in machinery spaces.

3.5.3.1 SW FIREFIGHTING SYSTEM

Fire SW system provides fire protection for all spaces and open decks, sufficient hydrants in accordance with SOLAS requirements are arranged in following spaces:

- Accommodation Space.
- Engine Room.
- Hold Space.

In order to comply with the Fire Sea Water System requirements two firefighting pumps are installed on engine room. One fixed and one portable.

Two pumps, 25 m3/h at 4 bar, centrifugal self-priming type located in engine room

Pumps located in engine room take suction from sea chest. The pumps are provided with:

- Shut-off valve on suction and discharge side for maintenance procedure
- Non return valve on discharge side.
- Pressure indicator is provided on suction and discharge.

Hydrants are provided with valve (ND 40) with hose connection of quick type. One fire hose box is mounted adjacent to each hydrant in machinery space and open decks.

3.5.3.2 FIXED NOVEC FIRE-EXTINGUISHING SYSTEM

A fixed Novec 1230 fire system with be fitted for the engine room fire protection according to Regulations.

Novec 1230 Fluid is a clean Agent, colourless, low odour and is electrically non-conductive. Novec Fluid suppresses the fire by removing the heat energy and interrupting the combustion process. Novec 1230 is stored as fluid and discharged as gas. The fluid is stored in steel cylinders, pressurised with nitrogen to 34.5 bar at 21ºC.

The following equipment is located:

-Nozzles

-Manual release stations

-Fluid cylinders

The agent containers are located on the engine room. A manually initiated power release is located outside the engine room. Each pressure container should be fitted with an automatic overpressure release device.

Novec bottles discharge by a non-return valve and flexible connection to manifold, each bottle is provided with isolated valve to dismount and filling operations.

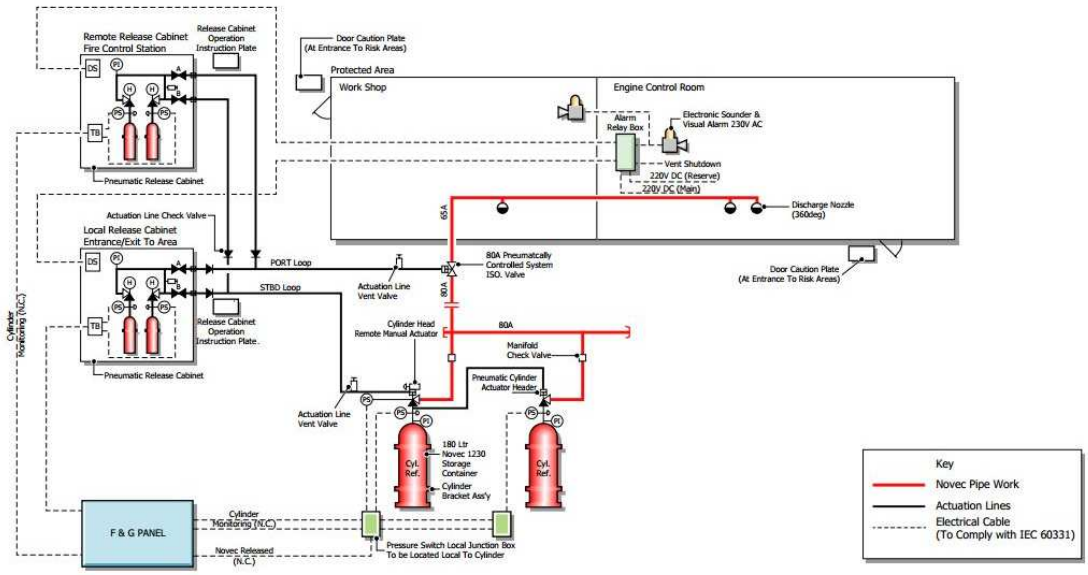


FIGURE 79 NOVEC SYSTEM FOR ENGINE ROOM CONTROL

The drawing containing the NOVEC system diagram is: "*MC-801-PI-014_NOVEC SYSTEM*".

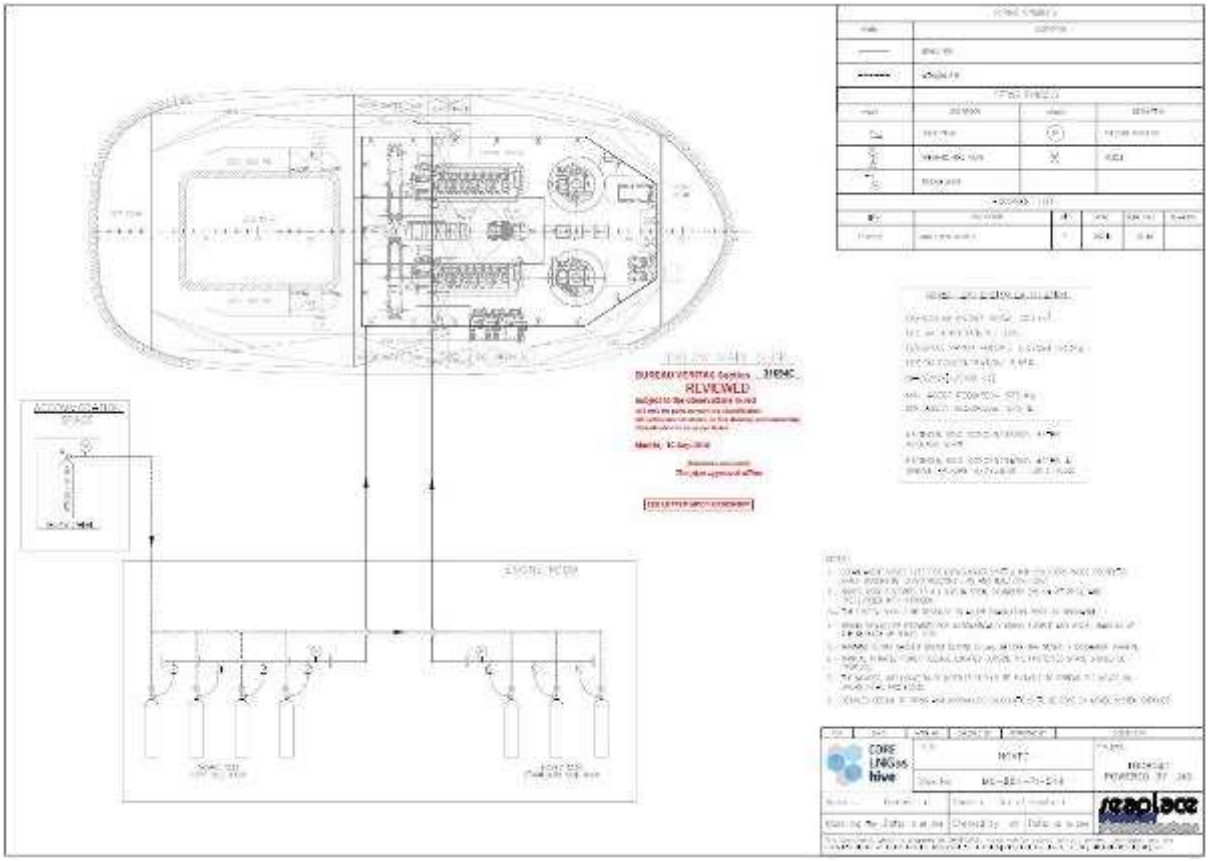


FIGURE 80 NOVEC SYSTEM DIAGRAM

3.5.3.3 FIRE FIGHTING AND FIREMEN EQUIPMENT

The vessel is equipped with fire extinguishers, etc., according to the rules. This includes:

- Water extinguishers
- Spare CO_2 cartridge
- Fire extinguishers
- Powder extinguishers
- Hydrants valves with flanges
- Hoses
- Nozzles
- Fiberglass cabinets for firehoses

3.5.3.4 FIRE DETECTION AND EXTINCTION

A fixed fire detection and fire alarm system are provided with the following requirements:

- 8 smoke detectors
- 2 flame detectors
- 8 heat detectors
- 1 push bottom for fire alarm
- 8 manually operated call points are places in number and position to ensure readily accessible means of notification.

3.5.3.5 FIXED DRY CHEMICAL POWDER EXTINGUISHING SYSTEM

Respecting the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels a fixed dry chemical powder fire extinguishing system is calculated.

The system will protect the bunkering area against fire. It is fitted in the main deck to cover all possible leak points and is arranged as follows:

- One independent self-contained dry chemical powder unit is fitted in Dry Power Room intended for this purpose.
- Associated controls, pressurizing medium fixed piping and hand hose lines installed on the system.
- One dry chemical powder main header is provided for supply to hand hose line. This collector is controlled by one master valve remote operation.
- One Hand hose lines are fitted clos bunkering stations

Additionally, portable dry powder extinguishers of at least 5 Kg is fitted on board.

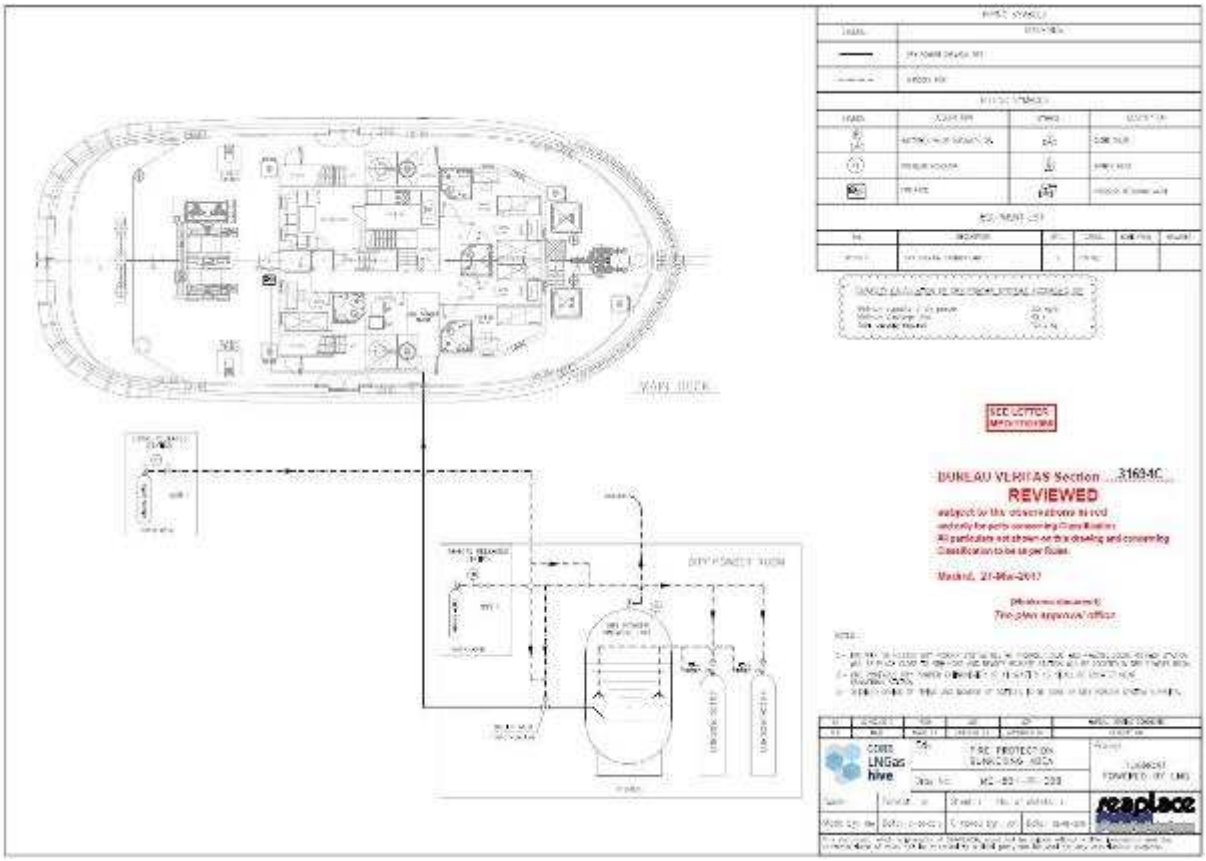


FIGURE 81 FIRE PROTECTION BUNKERING AREA

The fire protected bunkering area is designed as shown in drawing *"MC-801-PI-009_01_FIRE PROTECTION BUNKERING AREA".*

3.5.3.6 SAFETY RELIEF SYSTEM

LNG tank is equipped with two safety relief valves at the top of the tank. The setting pressure of the valves are up to 5% above MARVS (maximum allowable relief valve system). This valve is installed with other valve normally open that in case of maintenance of the safety relief valve allows isolating the tank.

These safety valves are connected to the vent header that discharges through the vent mast.

All LNG piping lines where LNG can get trapped between valves are arranged with a safety relief valve connected to the vent header. The setting of these valves is lower than the nominal pressure of the pipes.

3.5.3.7 GAS DETECTORS

A gas detection system is installed as required by rules to avoid gas leakage propagation and continue in gas mode operation. Gas detectors are located at those areas sensitive to gas leakage.

A permanently installed system of gas detection and audible and visual alarms should be provided for:

1. Engine Room,
2. Bunkering stations,
3. Cold boxes,
4. Airlocks.

The gas detection equipment is capable of sampling and analysing from each sampling head location sequentially at intervals not exceeding 30minutes, except that in the case of gas detection for the ventilation hoods and gas ducts sampling should be continuous. Common sampling lines to the detection equipment should not be fitted.

In the case of toxic gases, hold space should be provided with a permanently installed piping system for obtaining gas samples from the spaces. Gas from these spaces should be sampled and analysed from each sampling head location by means of fixed or portable equipment at intervals not exceeding 4 h and in any event before personnel enter the space and at 30 minute intervals while they remain therein.

The vessel should be provided with at least two sets of portable gas detection equipment acceptable to the Administration and suitable for the products carried.

3.5.4 FiFi 1 SYSTEM

The ship is equipped with a firefighting system to comply with service notation FiFi-1 and is made up of the following system:

- Water Fire-Fighting System.
- Fixed Foam fire-Fighting System.
- Portable Fire-Fighting Equipment.
- Firemen's Outfits.
- Self-protection water-spraying system

FiFi 1 System calculations can be found on: "*MC-801-PI-018_01_FIFI1 SYSTEM*".

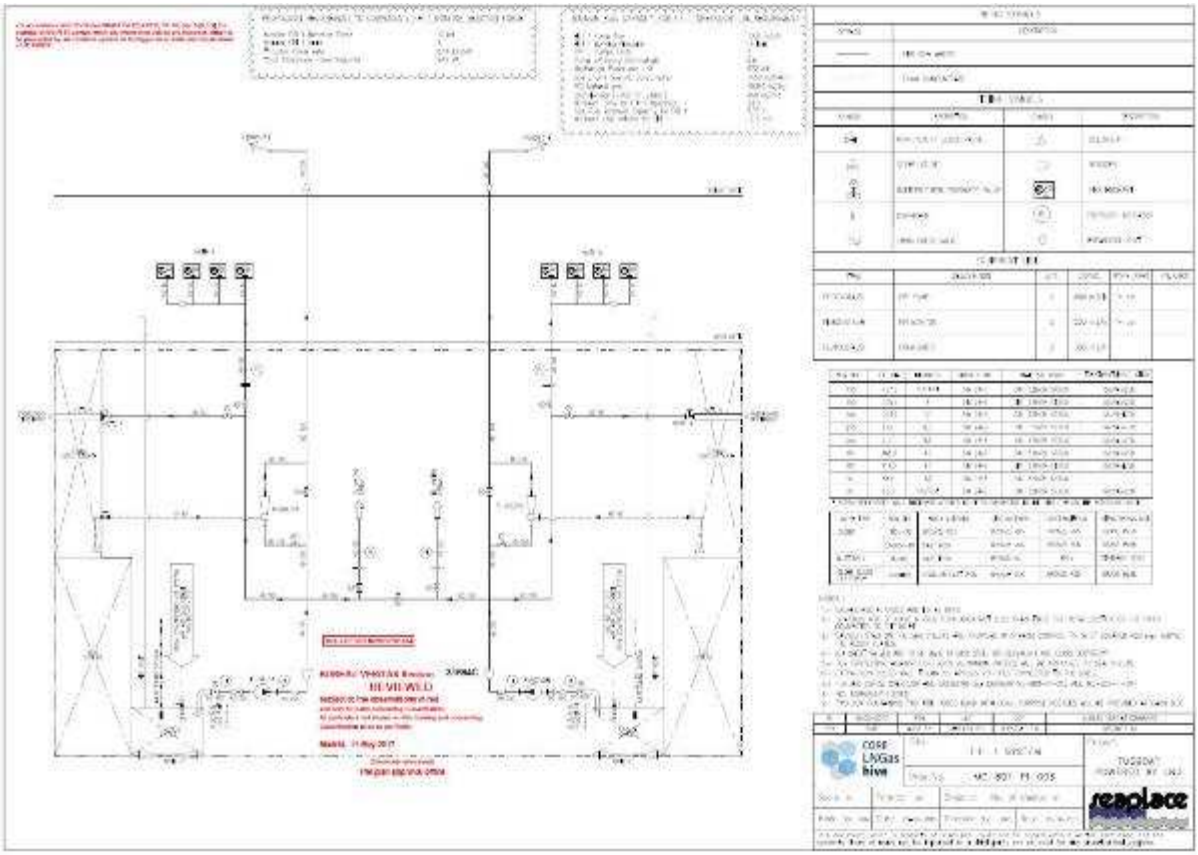


FIGURE 82 FIFI1 SYSTEM

3.5.4.1 WATER FIRE-FIGHTING SYSTEM

A water fire-fighting system is fitted with the following components:

- Two independent FiFi Sea chests, located in the engine room.
- Two FiFi-1 pumps located in the engine room. These pumps are connected to the main engines through the gearboxes.
- Two monitors located at each side of the bridge deck.

FIGURE 83 FFS 1200LB SINGLE / DUAL FLOW MONITOR

3.5.4.2 FIFI PUMP

The necessary foam concentrate to be provided by the monitors is estimated.

Two FiFi pumps are installed in machinery room, one per engine. They are coupled to the gearbox, and have a capacity of 1500 m3/h at 14 bar each.

3.5.4.3 FIXED FOAM FIRE-FIGHTING SYSTEM

A foam generating system, with a foam tank installed in the engine room, and an ejector for mixing the foam is installed on board.

3.5.4.4 PORTABLE FIRE-FIGHTING EQUIPMENT

At least four hydrants are fitted at each side to comply with the notation FiFi-1. These hydrants are connected to the main fire-fighting pumps. Fire hose and fire hose boxes are fitted and located to comply with the Society.

3.5.4.5 FIREMEN'S OUTFITS

Air breathing apparatuses, protective clothing and others constituting parts of firemen's outfits are of a type approved by the Society and located in a safe position readily accessible from the open deck.

3.5.4.6 SELF-PROTECTION WATER-SPRAYING SYSTEM

Vessel is provided with a SW drencher system to protect the ship external area with a water spray shield.

The system has sufficient capacity to maintain an average application rate of 10 l/min/m2 over the external vertical areas of the ship.

To comply with these requirements the FiFi 1 pumps are connected to the drencher system.

3.5.5 VENTILATION

To comply with the IGF recommendations, ventilation and air renovation calculations are done and the different system are design and fitted to these calculations

3.5.5.1 ENGINE ROOM VENTILATION

The ventilation of the engine room supplies fresh air for consumption on MCR of main engines and harbour generator. Furthermore ventilation flow is enough to remove the heat emissions of equipment located in engine room. Fans are capable of maintain a securing overpressure in the engine room. Exhaust air is led outside through the casing. An exhaust louver is located in upper part of funnel.

Calculations for the engine room ventilation are made.

Two axial flow fans are installed in the engine room where one of them is reversible

Engine room supply and exhaust louvers are provided with remote closing devices

Two exhaust gas fan (one per gas engine) are installed at the exhaust pipe of each of the gas engines after the turbocharger to avoid methane pockets that could be dangerous.

The engine room ventilation drawing is depicted in drawing *"SK-801-VE-001_ENGINE ROOM VENTILATION".*

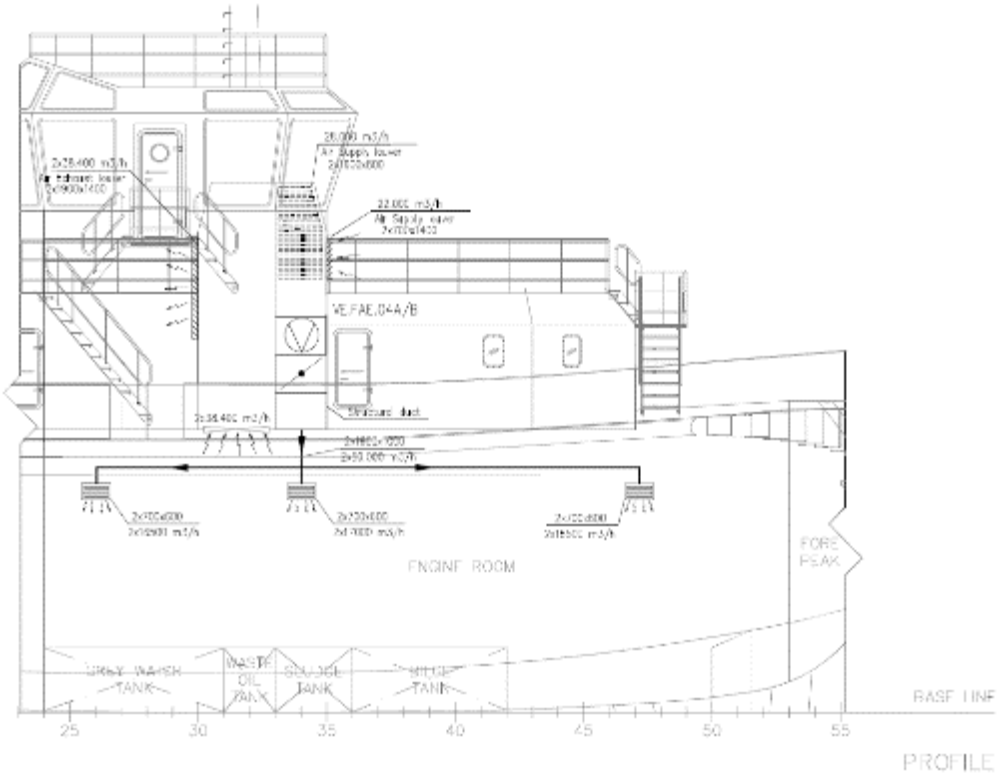


FIGURE 84 ENGINE ROOM VENTILATION PROFILE

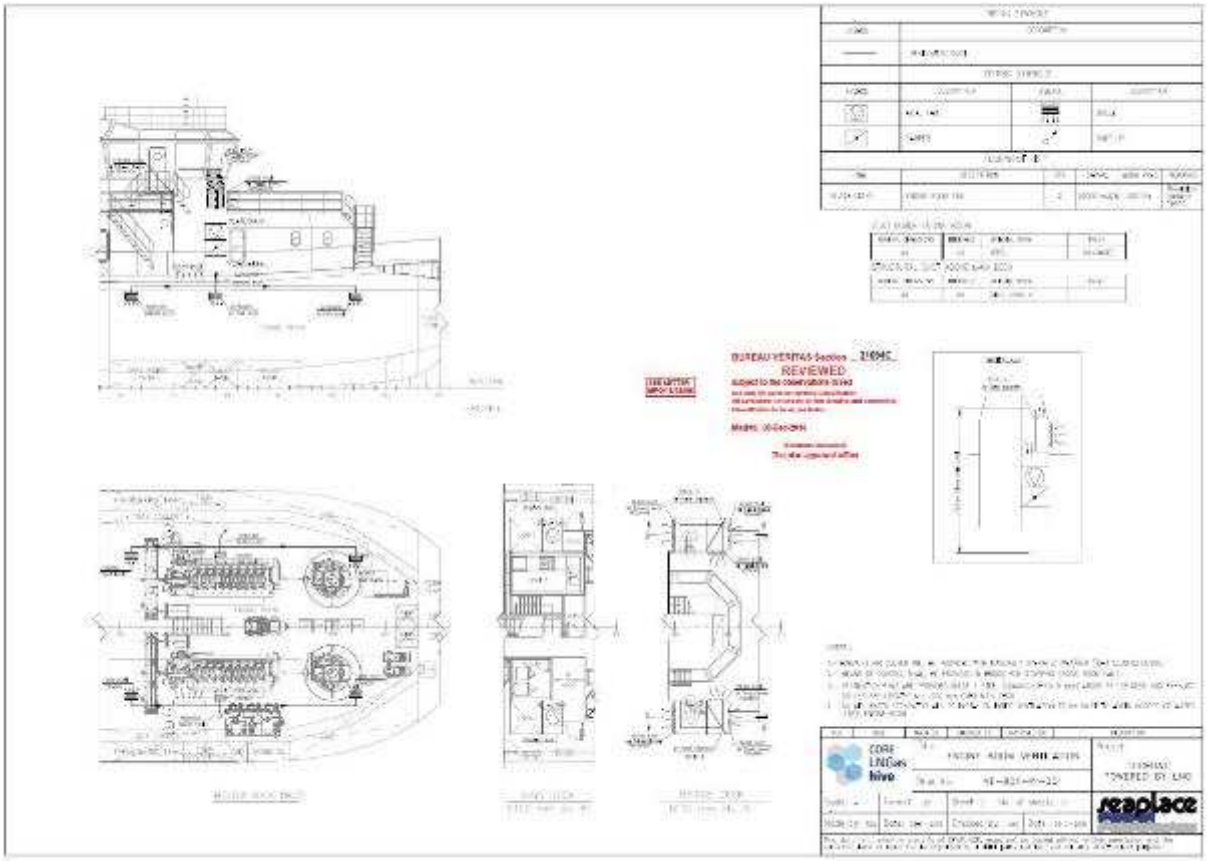


FIGURE 85 ENGINE ROOM VENTILATION

3.5.5.2 COLD BOX VENTILATION

Two Cold Boxes Rooms are fitted in the hold space, at each side of the tank, with all LNG associated equipment.

These rooms are considered as gas hazardous area zone 1.

The size of the ventilation system is determined by the negative pressure to be reached. In this case, it has been estimated than a renewal rate of 30 changes per hour will be required.

The cold box ventilation drawing is contained in document *"MC-801-VE-003_HOLD SPACE VENTILATION".*

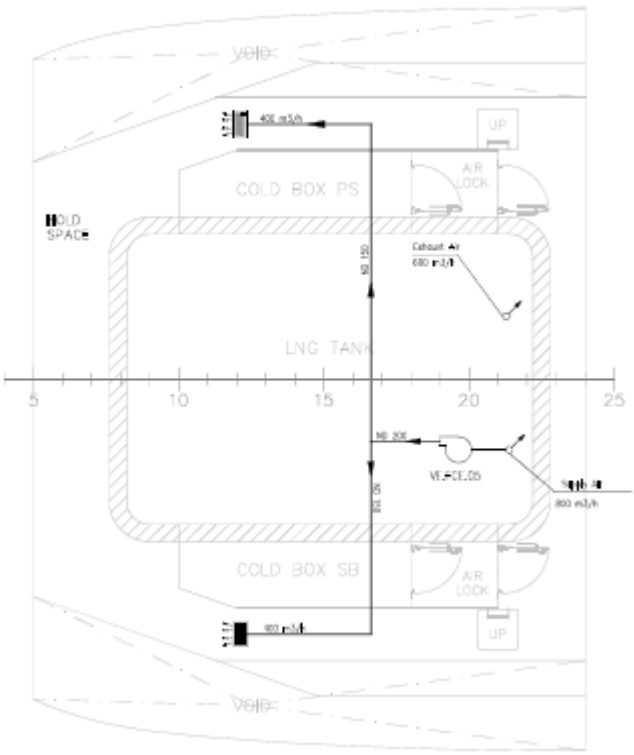


FIGURE 86 HOLD SPACE VENTILATION BELOW MAIN DECK

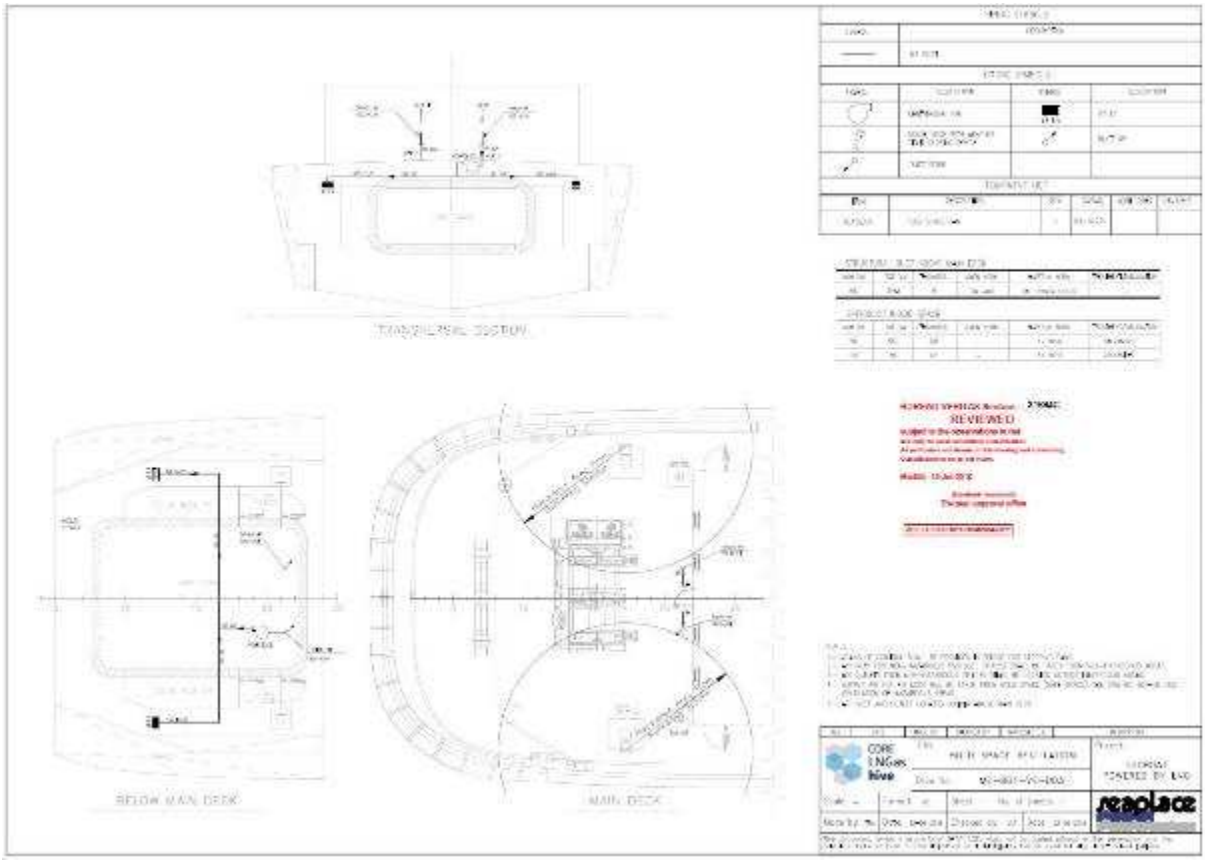


FIGURE 87 HOLD SPACE VENTILATION

3.5.5.3 GAS REGULATION UNIT VENTILATION

The engine room wall, where the Gas Regulation Unit (GRU) is located, requires its own ventilation system, which is calculated and design.

3.5.5.4 AIRLOCK VENTILATION

The Cold Boxes Rooms are designed with a double door system forming an air-lock between this room and the tank room. The air locks are considered as gas hazardous area zone 2.

The ventilation for the air lock is designed as an overpressure type, and takes air from a gas safe room (hold space).

The exhaust is common for the ventilation of the air-locks. Exhaust air mushroom and fan inlet is provided with automatic closing devices.

A ventilation diagram including hazardous areas 1 and 2 and the GRU (gas regulation unit) can be consulted in document: "*MC-801-VE-002_00 VENTILATION HAZARDOUS AREA*"

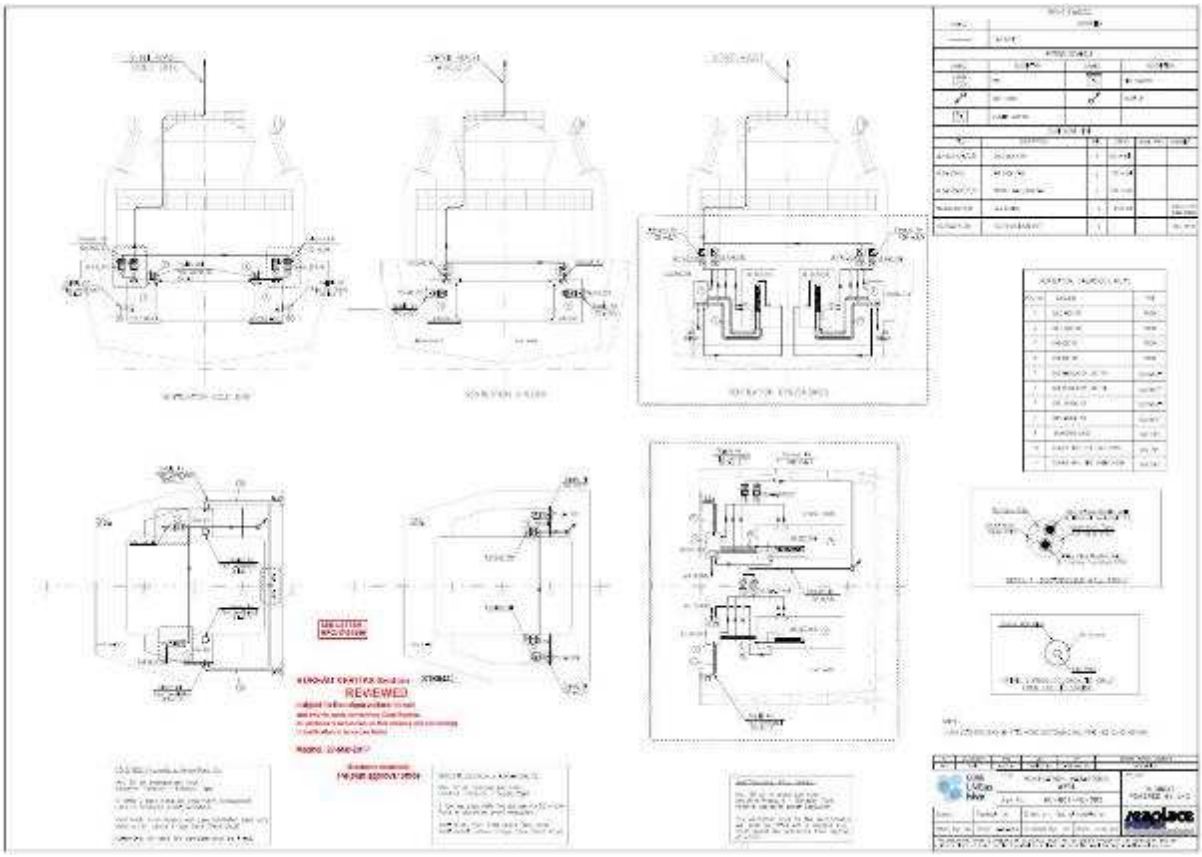


FIGURE 88 VENTILATION HAZAROUS AREAS

3.5.6 AIR AND OVERFLOW SYSTEM

The air vent system includes tanks fitted with air pipes and sounding devices in compliance with class requirements. Air pipes connect the top of the tank to the outside through an air pipe outlet with:

- Air pipe valve with float check.
- FO tanks equipped with spark arrestor.
- Sea chest arranged as goosenecks.

A drawing of the air vent system is contained in document: "*MC-801-PI-015_AIR VENT SYSTEM*".

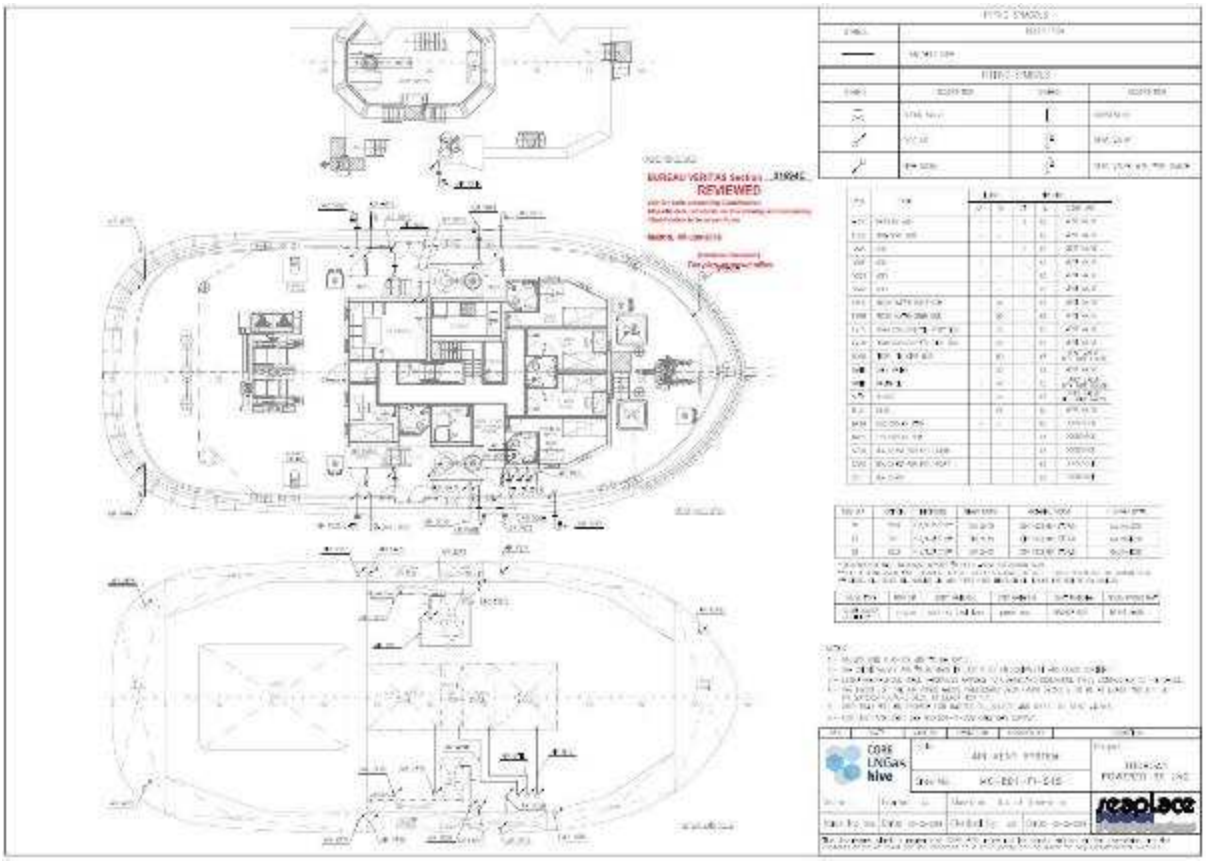


FIGURE 89 AIR VENT SYSTEM

3.5.7 SOUNDING SYSTEM

All tanks included in the vessel are fitted with sounding pipes or other approved means for measuring the level of liquid in the tanks.

Normally sounding pipe led to open deck with plug. Sounding pipes inside spaces to have a self-closing device.

The sounding system calculations and design are reflected on document; "*MC-801-PI-017_SOUNDING SYSTEM*"

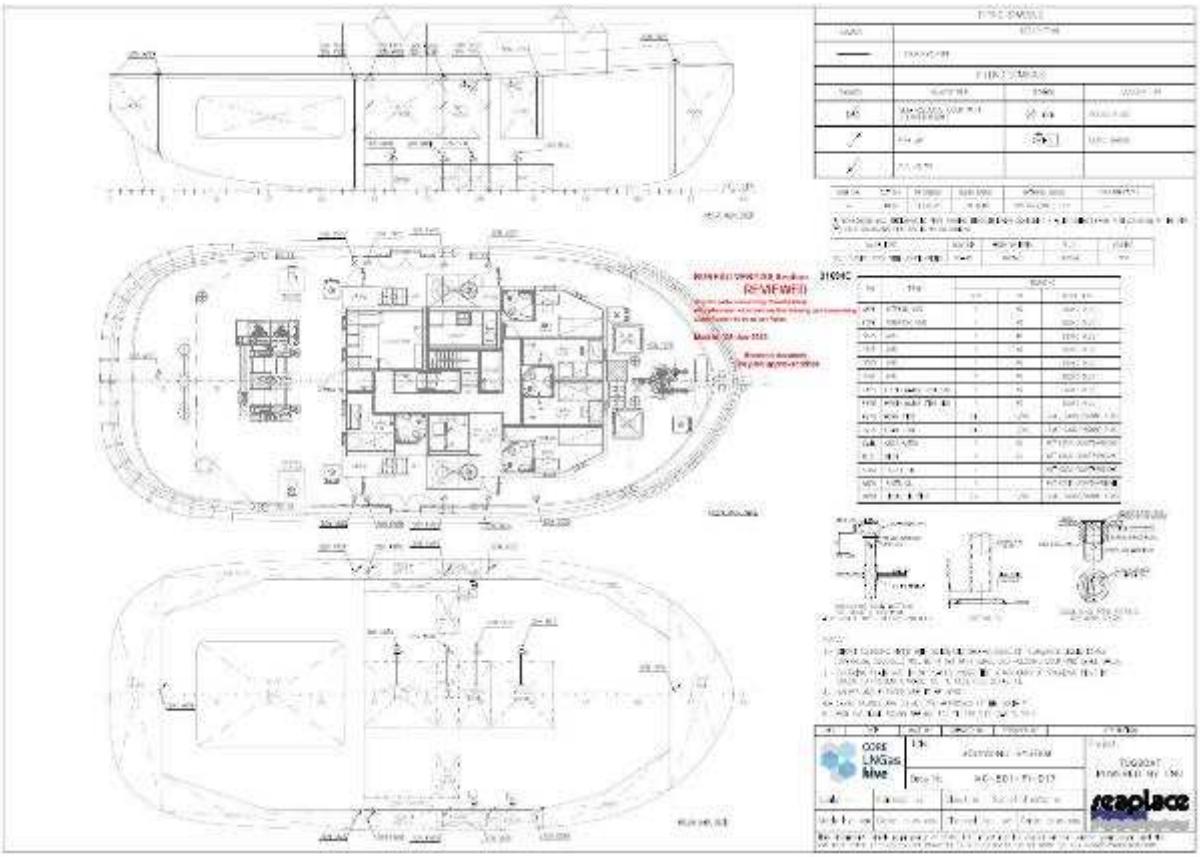


FIGURE 90 SOUNDING SYSTEM

3.5.8 DRAINING SYSTEM

Sufficient number of draining pipes are arranged from each decks considering that the vessel may have positive and negative trimming.

Draining is accessible for cleaning and scuppers will be provided with grating to prevent flow blocking.

The draining system design can be found in document: "*MC-801-PI-016_DRAIN SYSTEM*"

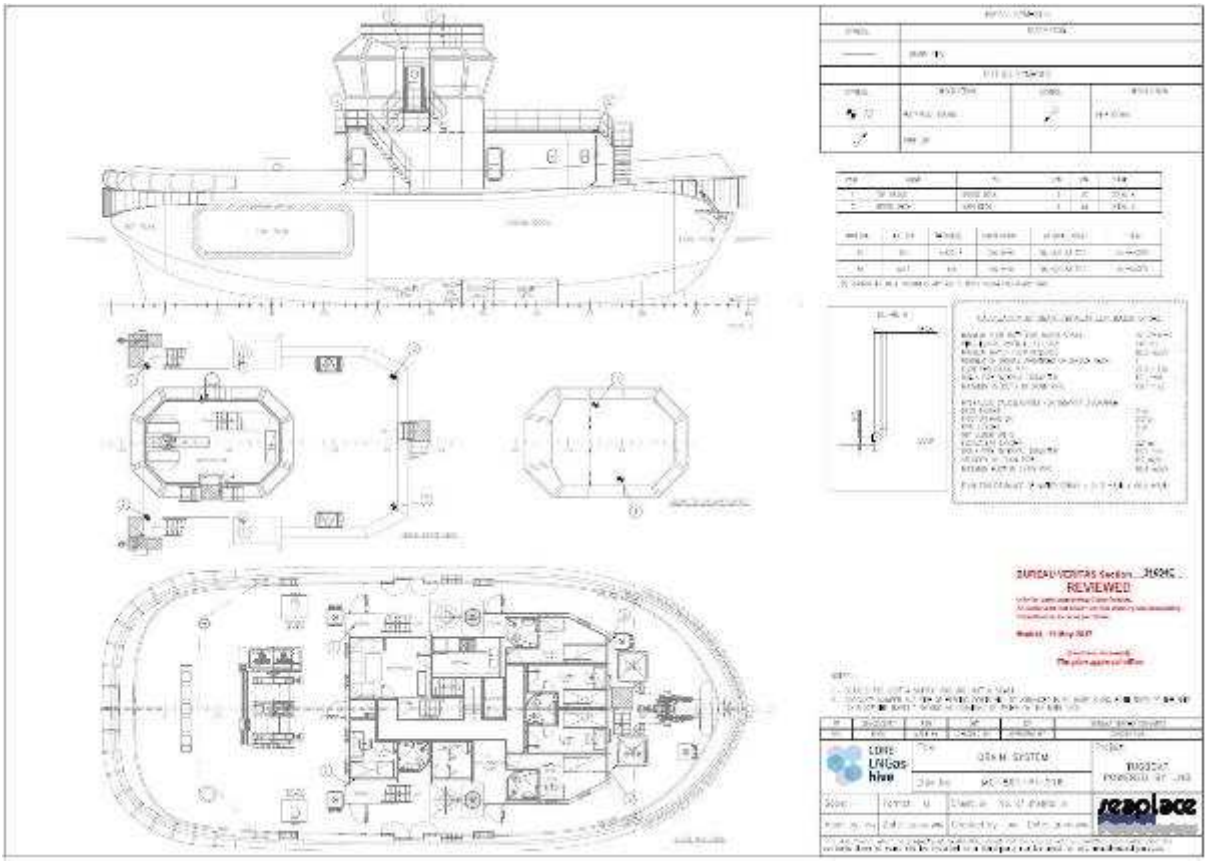


FIGURE 91 DRAIN SYSTEM

3.5.9 SANITARY AND FRESH WATER SYSTEM

3.5.9.1 F.W. FILLING SYSTEM

A common filing & transfer system is provided for fresh water.

The bunker station of fresh water filling is arranged on main deck connected to a main filling pipe and discharge to FW tanks.

Fresh water for the accommodation has been calculated and the document containing the diagram is:" *AC-801-PI-001_Potable and F.W. Hot & Cold P.D. in Accommodation*".

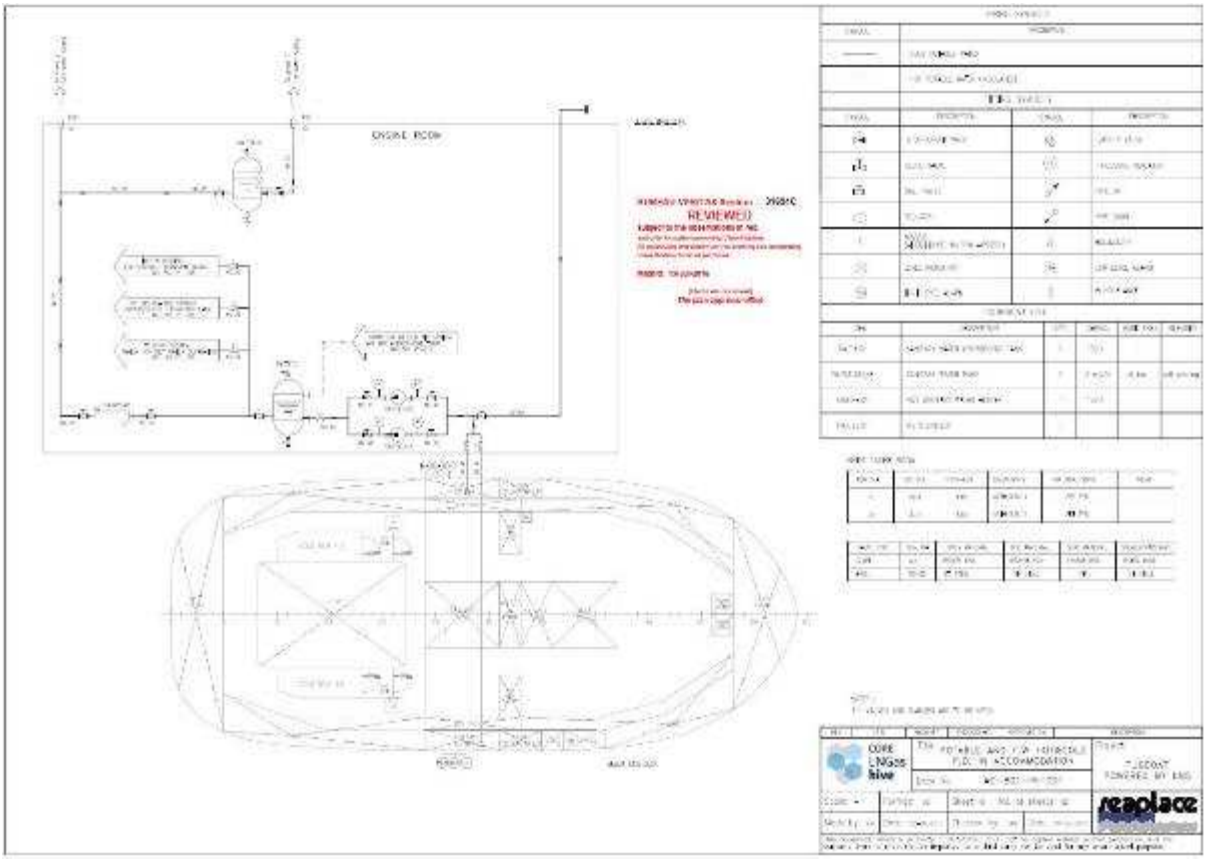


FIGURE 92 POTABLE AND F.W. HOT & COLD P.D. IN ACCOMMODATION

3.5.9.2 SANITARY WATER SYSTEM

To provide potable water to accommodation consumers, a sanitary system will be install with the following equipment:

- Two sanitary water pumps of 3m3/h at 5.0 bar
- One hydrophore tank of 100 l
- One electric heater of 100 l
- One sanitary water UV filter sterilizer.

The document referring to the design of the sanitary water system is *"AC-801-PI-003_Sanitary discharge Black&Grey Water system in Accom. P.D"*.

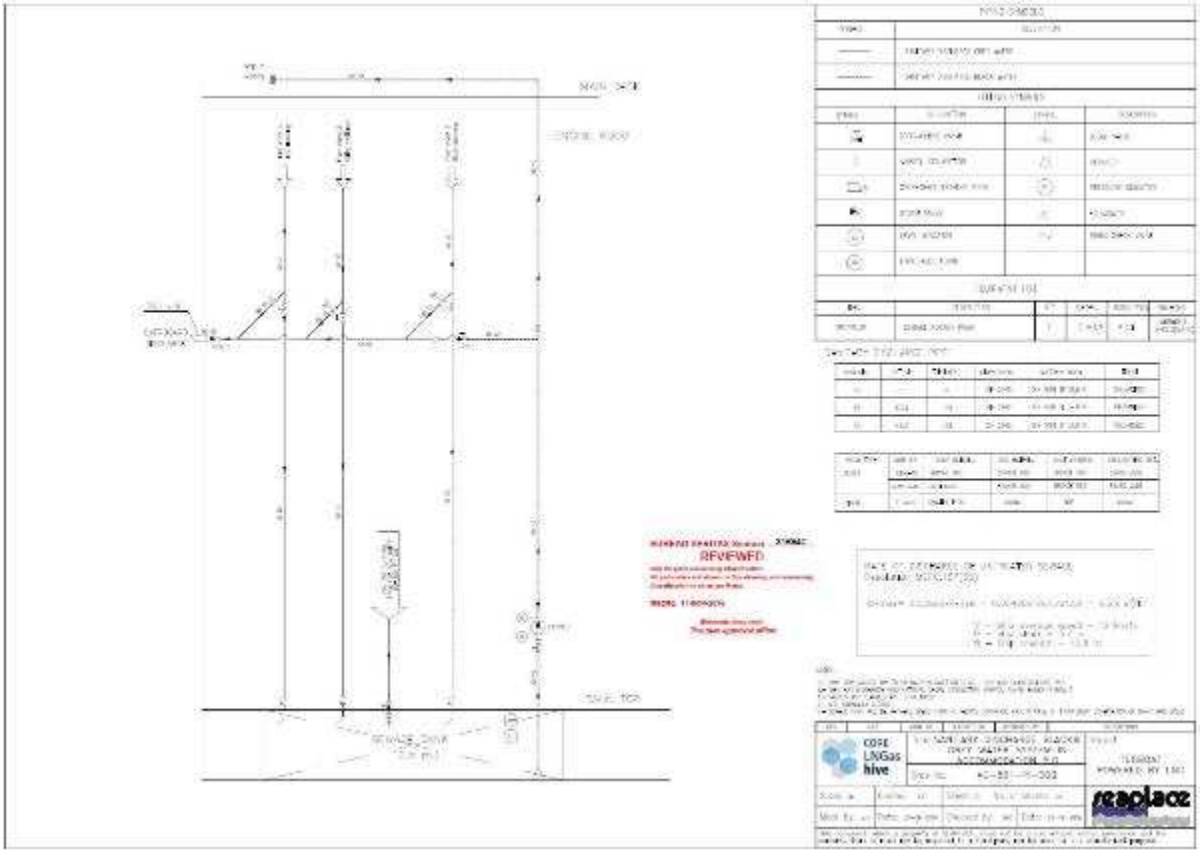


FIGURE 93 SANITARY WATER SYSTEM

3.6 ELECTRICAL

The design of the electrical configuration and load distribution to support the main engines and the equipment (consumers) has been calculated. The load balance has been estimated for five operation modes defined as:

- Navigation
- Towing
- FiFi
- Harbour
- Emergency

The electrical load for each mode of operation has been calculated for the vessel intact condition.

The distribution of power consumers is made according preliminary one line diagram: "*EL-801-UD-001_01 ONE LINE DIAGRAM*".

3.6.1 ELECTRICAL ONE-LINE DIAGRAM

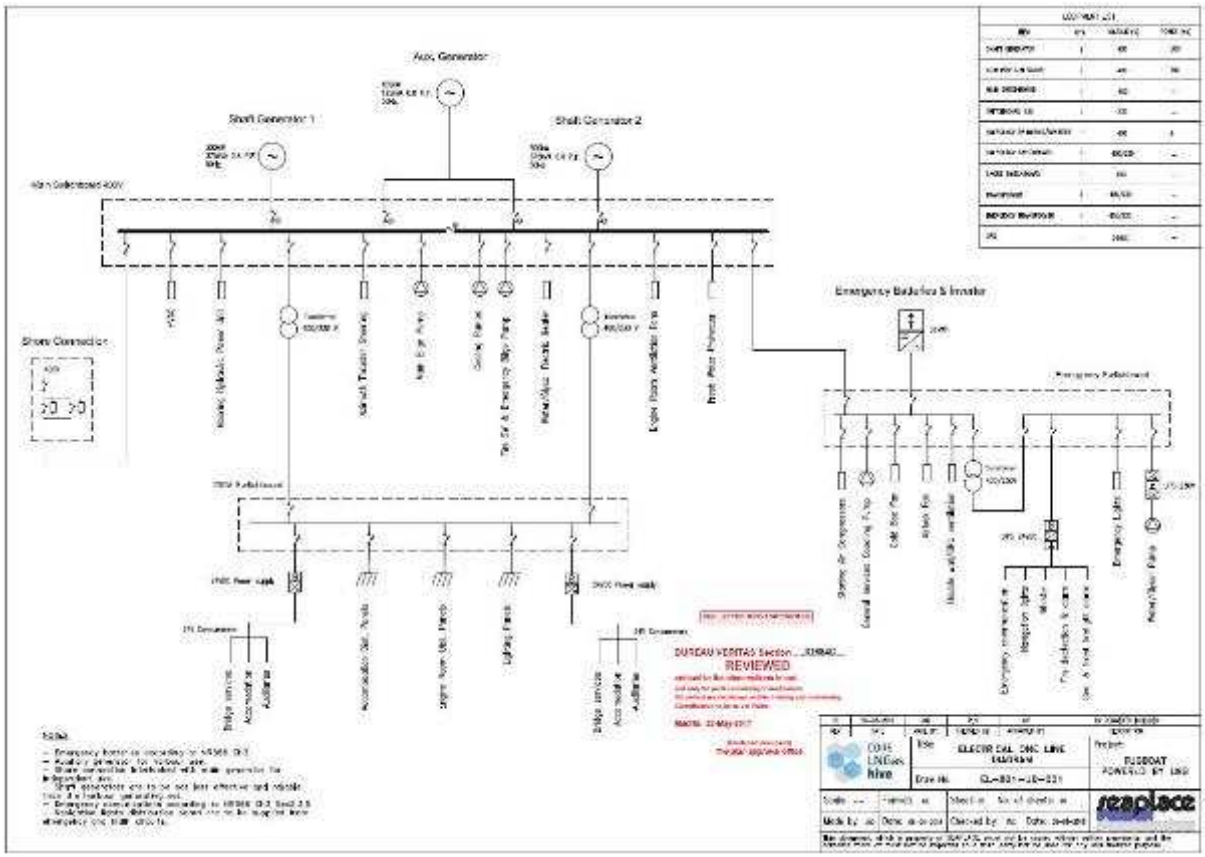


FIGURE 94 ONE LINE DIAGRAM

3.6.2 ELECTRICAL LOAD CALCULATION

As per electrical load calculations, and in order to fulfil all the operational requirements, the tugboat has two shaft generators each of 300 kW, and one auxiliary generator providing 100 kW. The auxiliary generator power is selected with sufficient capacity for the supply of essential auxiliaries (25 kW estimated), with automatic starting and connection to the main switchboard. Starting and connection is to be preferably within 30 seconds but in any case not more than 45 seconds after loss of power.

The emergency batteries preliminary power are 20 kW in order to fulfil with the emergency loads calculated.

The electrical load in each operational condition calculation is detailed in the table below:

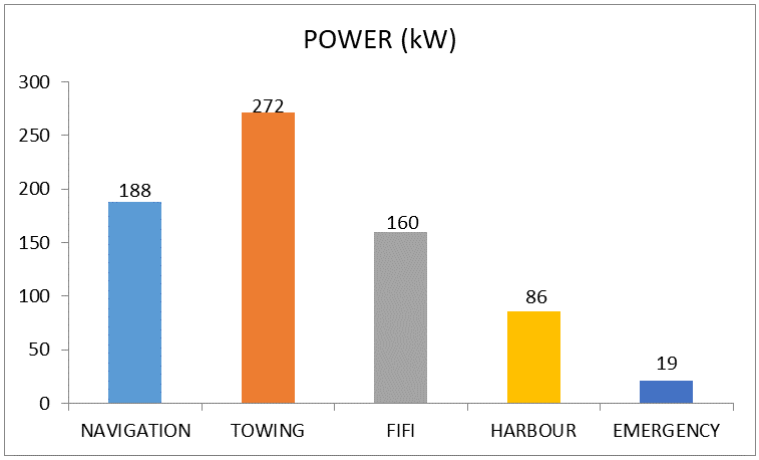


FIGURE 95 OPERATIONAL ELECTRIC LOADS

The detailed calculations are contained in the document: "*EL-801-LA-001_00 ELECTRIC LOAD CALCULATION*".

3.7 SAFETY

The vessel must comply with rules and regulations of Classification Society, and the requirements of SOLAS and the class notation.

3.7.1 LIFESAVING EQUIPMENT PLAN

Lifesaving appliances are in compliance with rules and regulations of Classification Society, and according to the requirements and respective amendments of Solas.

- One rescue boat, with an electric crane.
- Two life rafts for 8 persons each are placed on Bridge Deck in both sides.
- Two embarkation ladders on Main Deck.
- Hydrostatic release equipment, fittings and connections are installed
- Eight life buoys are distributed on both sides of the ship and as far as practicable. Two with lifeline, two with light and two with light and smoke signal.
- Twelve life jackets with light is provided
- One immersion suit is provided for every person on board.
- Two survival craft portable radio.
- One search and rescue location device.
- Twelve rocket parachute flares.
- One muster station.
- One fat kit plus stretcher.
- One Medical locker.
- Five emergency scape breathing device.
- Three muster list containers.
- One RLS satellitary Radiobeacon (EPIRB)

The plan with the situation of the different lifesaving equipment can be found in document"*SL-801-LS-001_01 LIFE SAVIN*G EQUIPMENT".

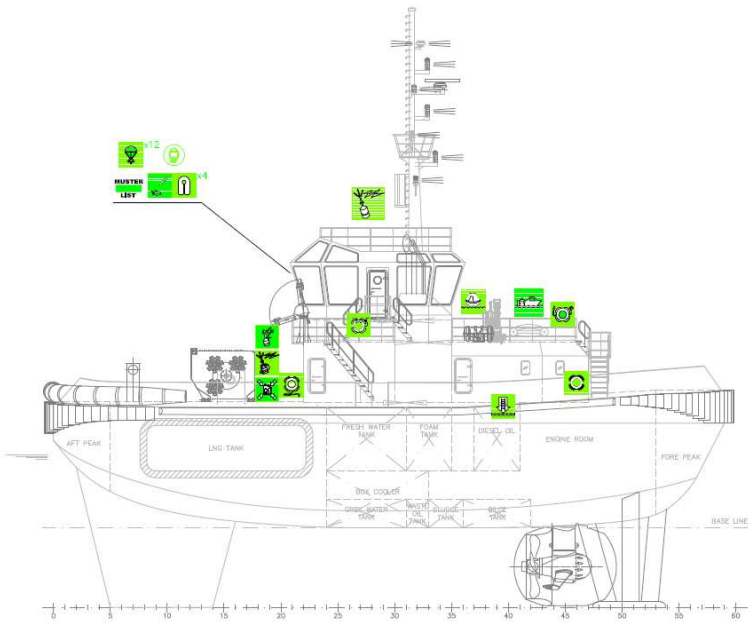


FIGURE 96 LIFESAVING EQUIPMENT PLAN PROFILE

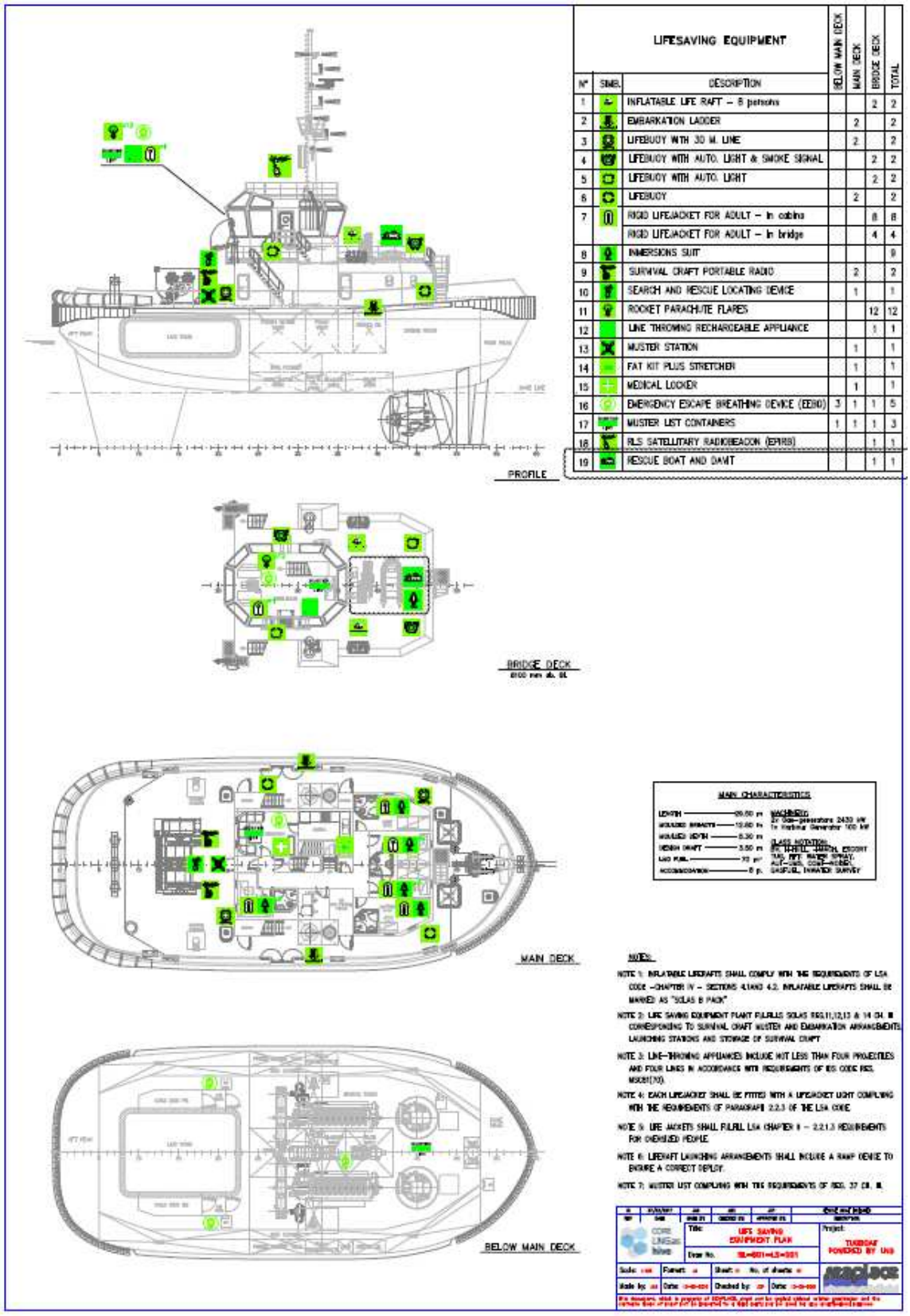


FIGURE 97 LIFESAVING EQUIPMENT PLAN

3.7.2 FIRE FIGHTING EQUIPMENT PLAN

The Fire Fighting System of the vessel is made up of the following system:

- Fire SW System to general vessel protection.
- Novec System in machinery spaces.

The plan with the situation of the different lifesaving equipment is defined in document"*SL-801-SA-001_01 FIRE FIGHTING EQUIPMENT*".

DESCRIPTION	TOTAL
Smoke detector	8
Flame detector	2
Heat detector	8
Push bottom for fire alarm	1
Manually operated call point	8
Fire control panel	1
Fire hydrant	3
FiFi 1 hydrant	12
Sea water fire hose & box	3
Fixed power fire extinguishing installation	1
Power section valve	1
Power fire hose & box	1
Water/Foam monitor (FiFi 1)	2
Fire SW pump (25m3/h-4bar)	1
Main bilge pump (25m3/h-2bar)	1
FiFi 1 pump	2
Portable fire SW pump (25m3/h-4bar)	1
Space with NOVEC extinguisher system	1
NOVEC audible and visible alarm	1
NOVEC battery	1
Fixed fire extinguishing installation foam	2
Foam section valve	2
Fire control plan	5
Emergency scape breathing device (EEBD)	5
Fireman outfit	4
Spare charges for breathing apparatus	2
Air compressor for breathing apparatus	1
Portable fire extinguisher powder - 5 Kg	12
Portable fire extinguisher wet chemical - 6 Kg	1
Portable fire extinguisher foam - 9 Kg	2
Spare charges for fire extinguishers	12
Fire damper in vent duct (galley)	1
Closing appliance for exterior ventilation (stores)	4
Closing appliance for exterior ventilation (machinery)	4
Fire damper gravity (airlock)	2
Fire damper (cold box)	4
Fire damper (double wall gas pipe)	4
Quick closing valve	1
Fire blanket	1
Deep fat fryer firefighting equipment	1
Water spray system	5
Emergency battery pack	1

Emergency switchboard	1
Remote control fire pump	1
Shut off engine room fans	1
Remote control for fire damper	1
Remote control F/CLOS.APPLVENTILATION	1
NOVEC release station	1
Powder release station	1
Foam release station	1

TABLE 17 FIRE FIGHTING EQUIPMENT PLAN

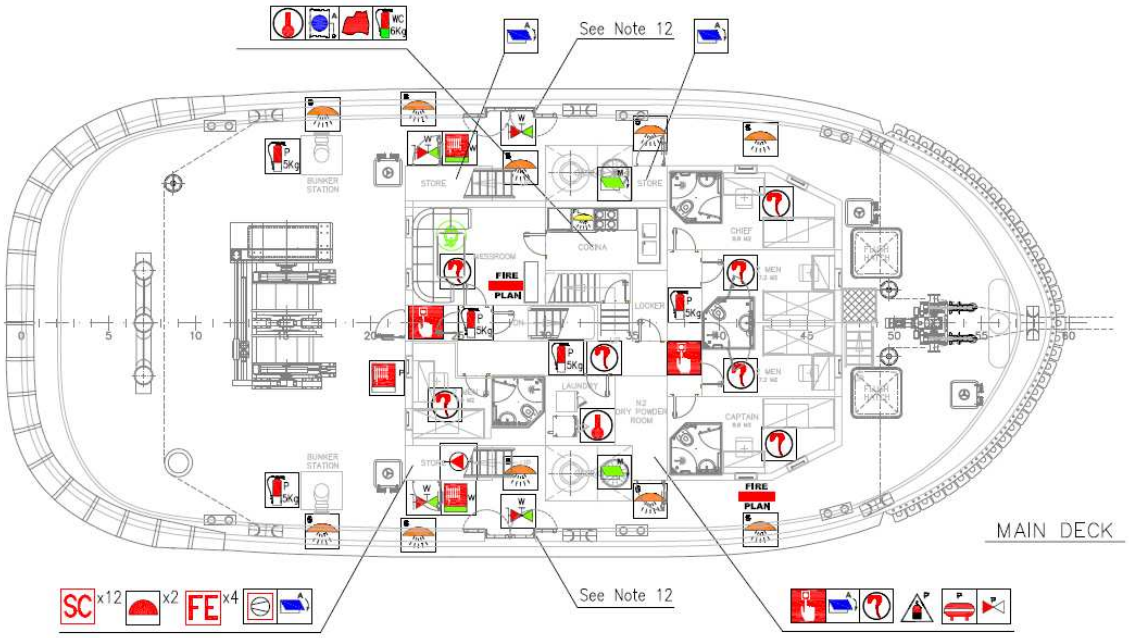


FIGURE 98 FIREFIGHTING EQUIPMENT PLAN MAIN DECK

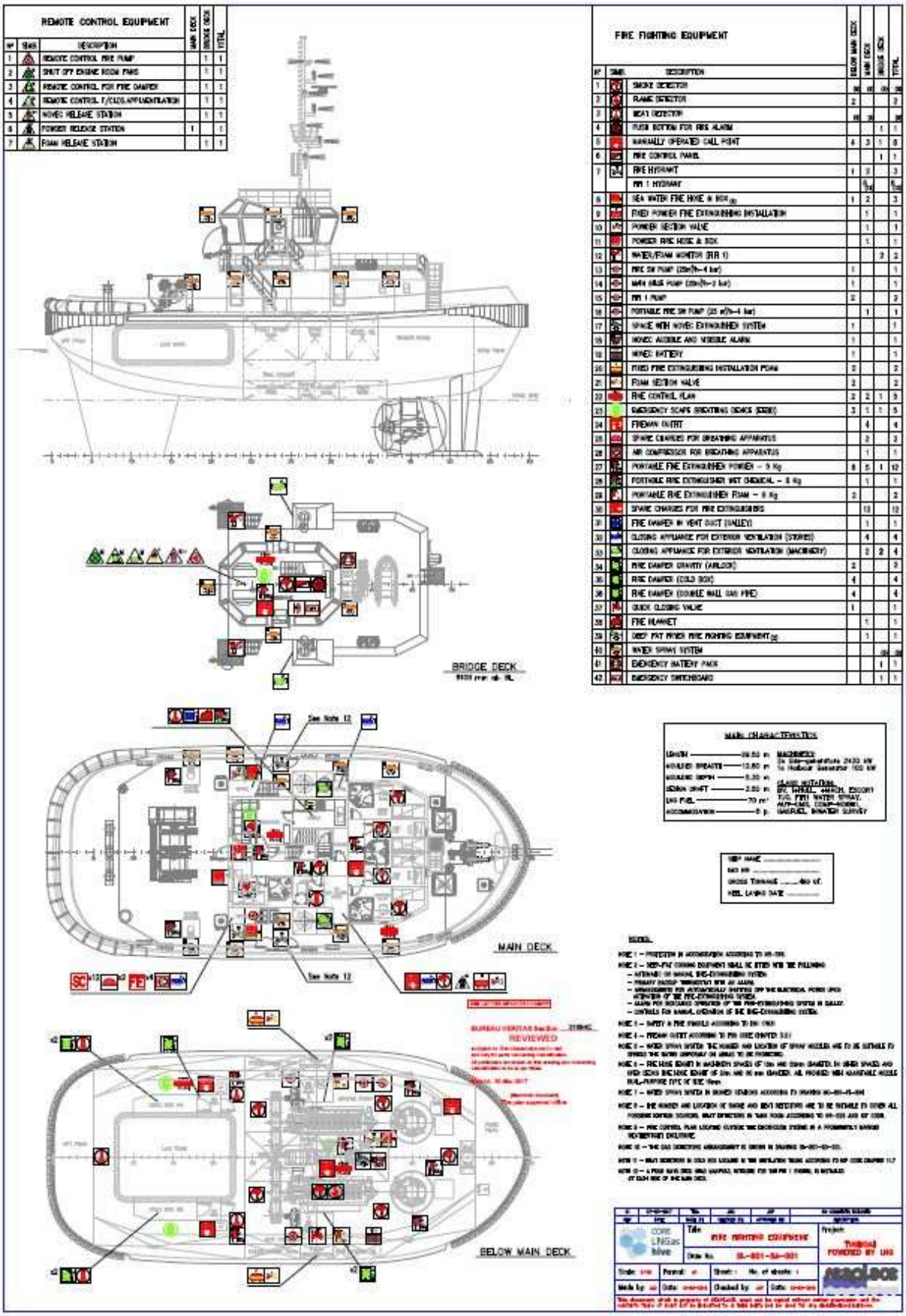


FIGURE 99 FIREFIGHTING EQUIPMENT PLAN

3.7.3 ESCAPE ROUTE PLAN

The document showing the escape route is" *SL-801-SA-002_01 ESCAPE ROUTE PLAN*".

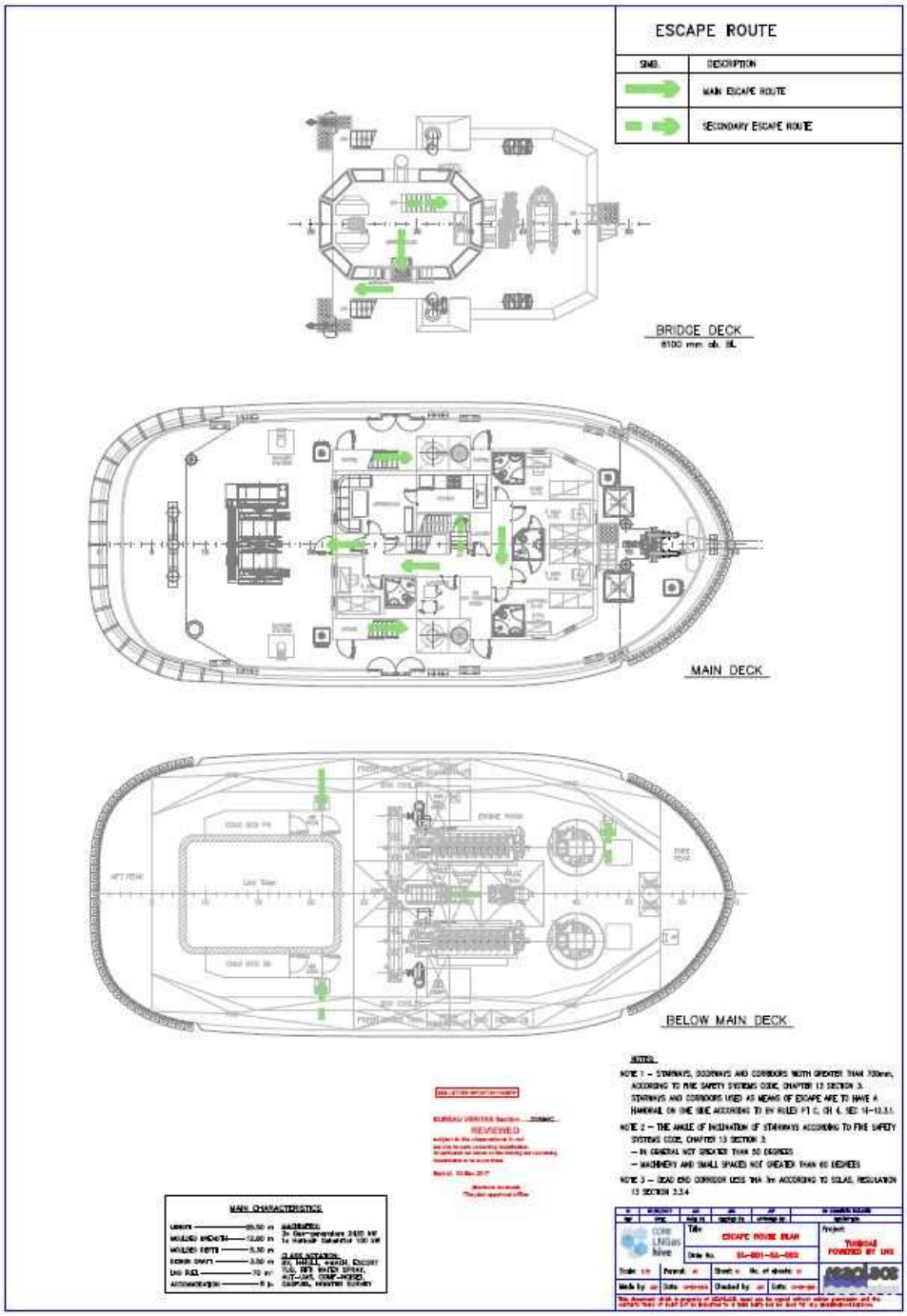


FIGURE 100 ESCAPE ROUTE PLAN

3.7.4 DANGEROUS AREA PLAN

According with the BV rules the dangerous areas are classified into three zones as follows:

- Zone 0 (red): an area in which an explosive gas atmosphere or a flammable gas with a flashpoint below 60ºC is present continuously or is present for long periods.
- Zone 1 (yellow): an area is which an explosive gas atmosphere or a flammable gas with a flashpoint below 60ºC, is likely to occur in normal operation.
- Zone 2 (green): an area in which an explosive gas atmosphere or a flammable gas with a flashpoint below 60ºC is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and exists for a short period only.

The Dangerous area plan is contained in document: "*SL-801-DA-001_01 DANGEROUS AREA PLAN*".

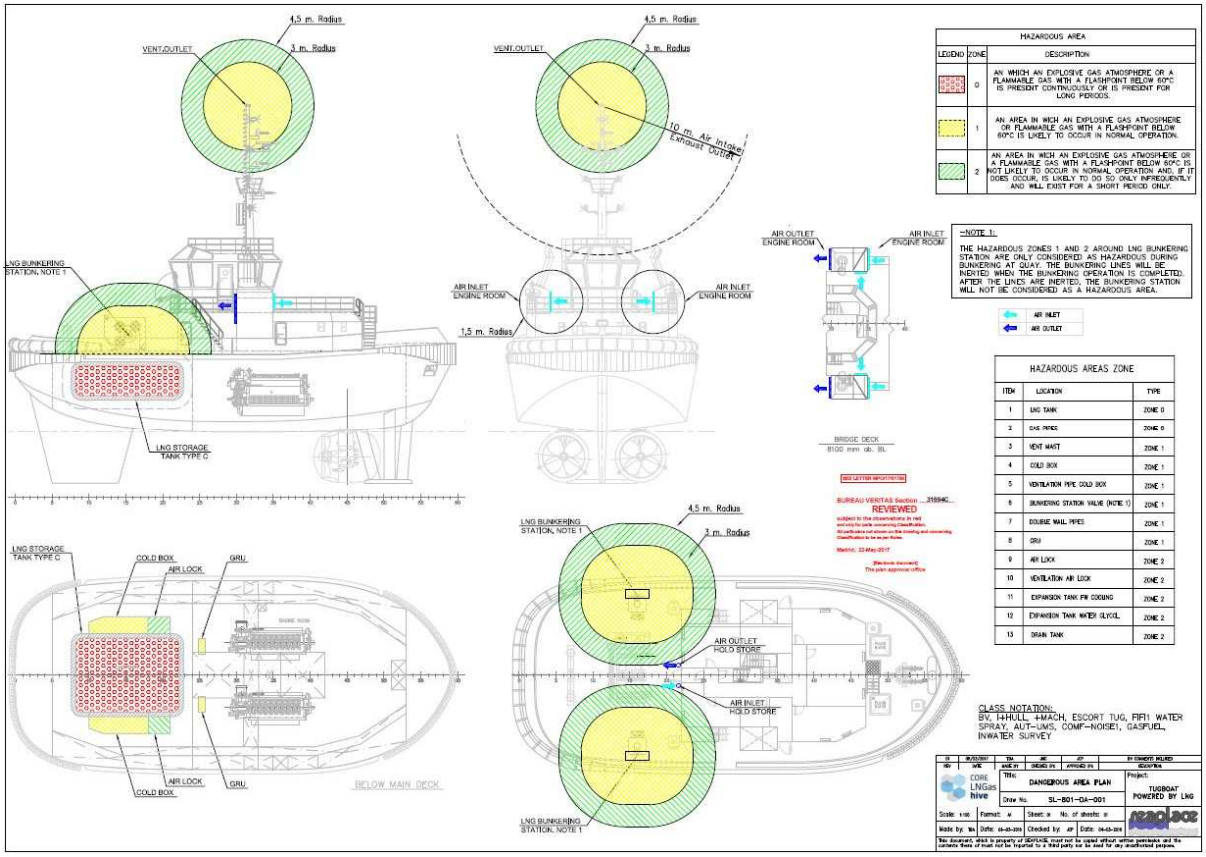


FIGURE 101 DANGEROUS AREA PLAN

3.7.5 GAS DETECTION

The number of detectors must be arranged according with the size, layout and ventilation of the space. Furthermore, two sets of portable gas detection equipment are provided on board.

The audible and visual alarms from the gas detection equipment must be located in each compartment equipped with gas detectors.

The detectors must be continuous detections type with immediate response. The audible and visible alarms from the gas detection equipment initiates on the navigation bridge.

The gas detection system design can be found on: "*SL-801-GD-001_01 GAS DETECTION*".

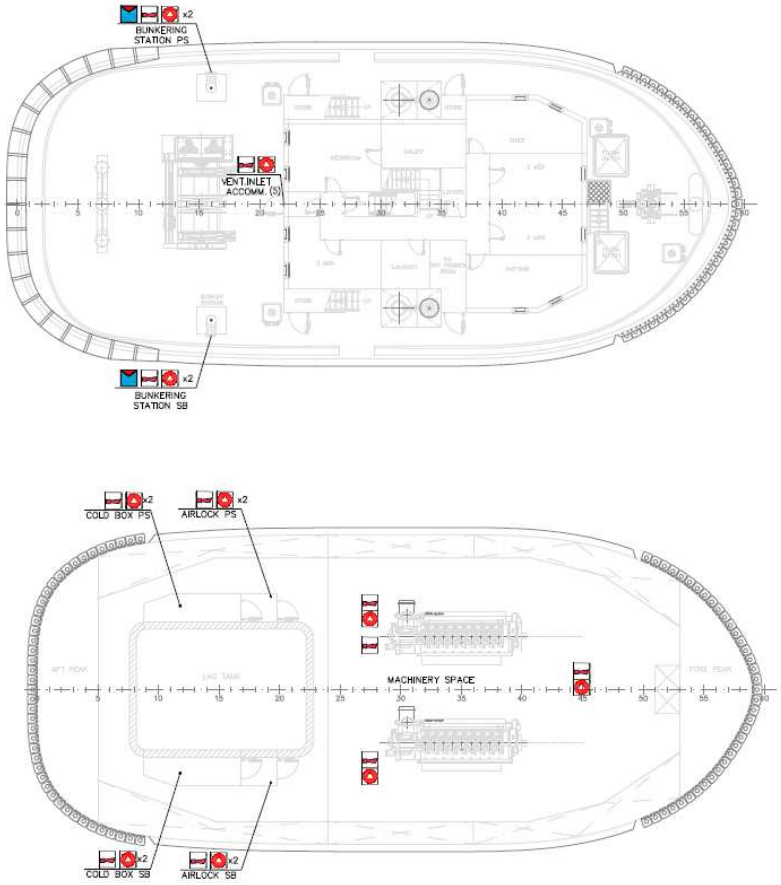


FIGURE 102 GAS DETECTION OVER AND UNDER MAIN DECK

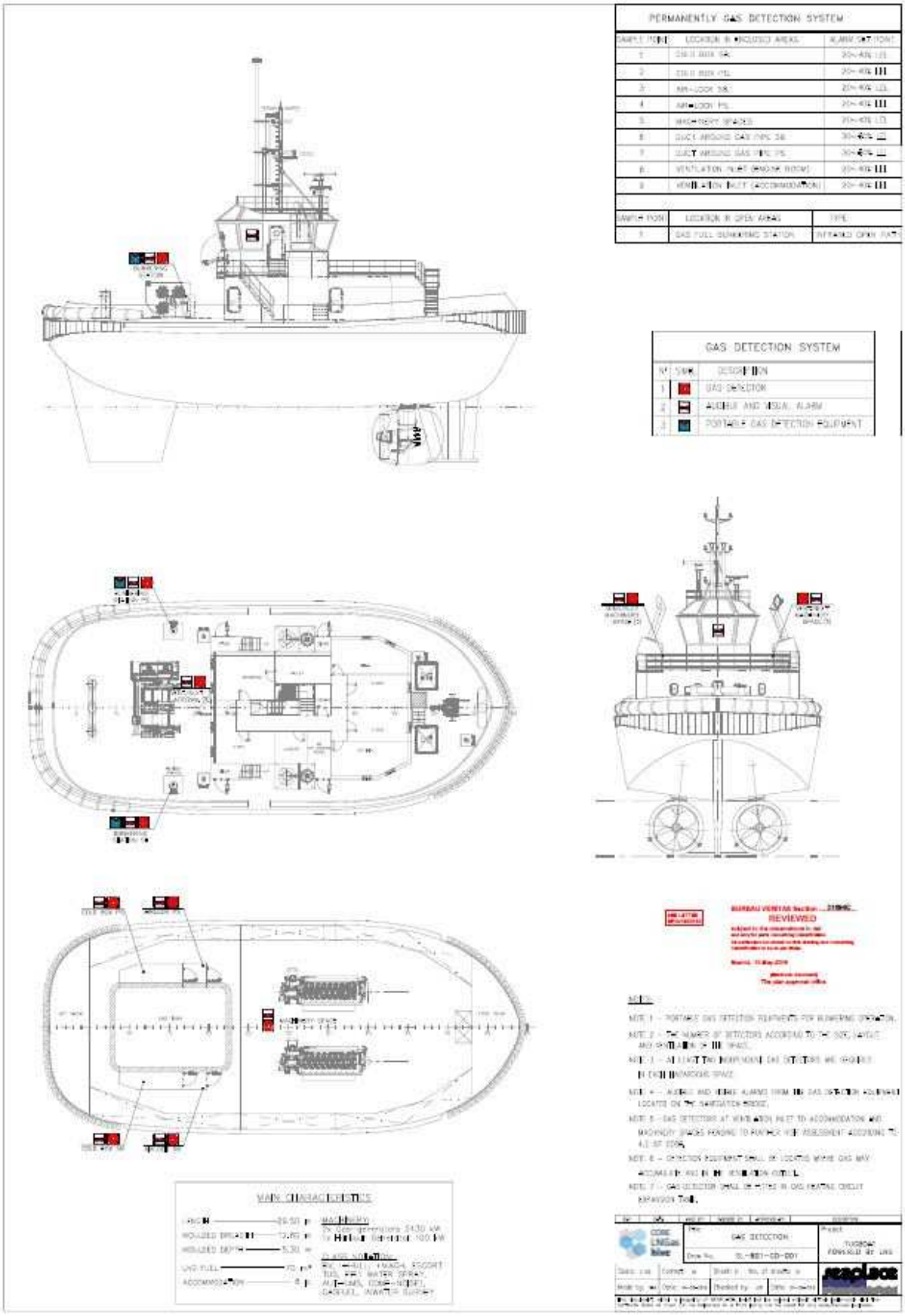


FIGURE 103 GAS DETECTION

3.7.6 BULKHEAD FIRE DIVISION

The document *"AC-801-FI-001_01 ACCOMODATION BULKHEAD FIRE DIVISION"* shows the fire integrity of bulkheads according with the IGC Code and SOLAS.

The doors, windows and hatches arranged in each bulkhead must be equivalent to the division in which they are fitted.

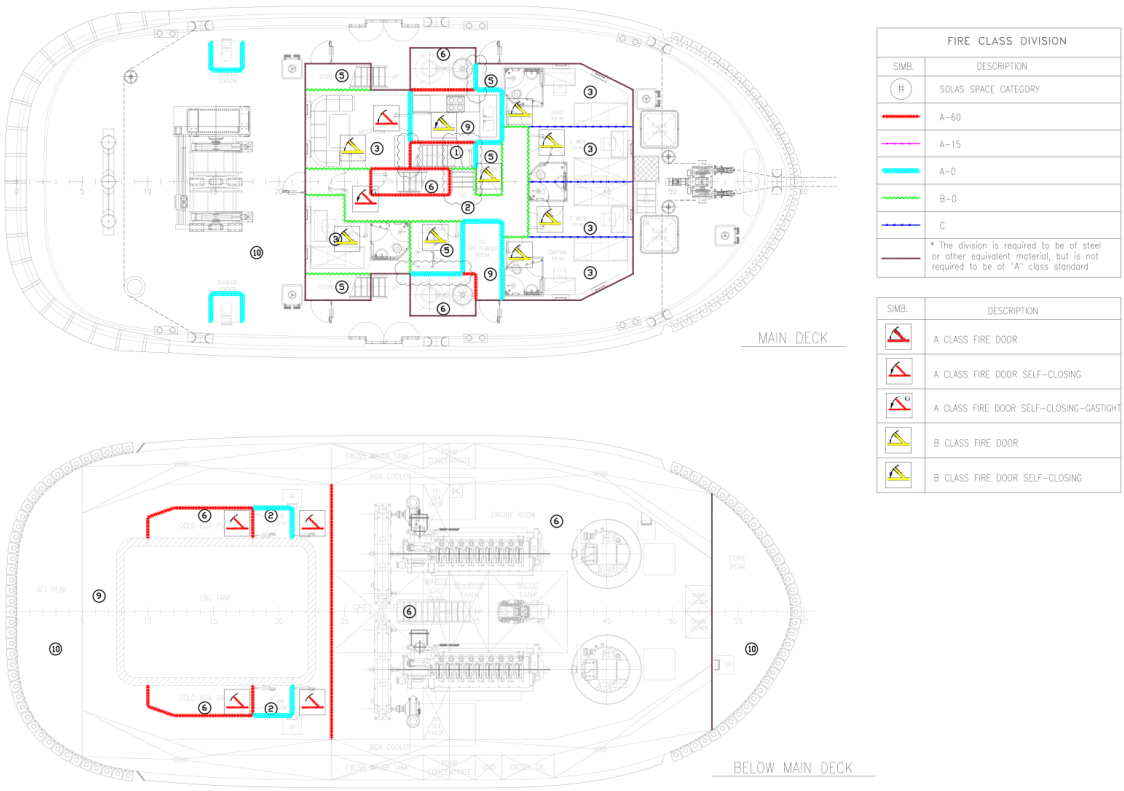


FIGURE 104 ACCOMMODATION BULKHEAD FIRE DIVISION

3.7.7 DECK FIRE DIVISION

The document "*AC-801-FI-002_01 ACCOMODATION DECK FIRE DIVISION*" shows the fire integrity of decks according with the IGC Code and SOLAS.

The doors, windows and hatches arranged in each deck must be equivalent to the division in which they are fitted.

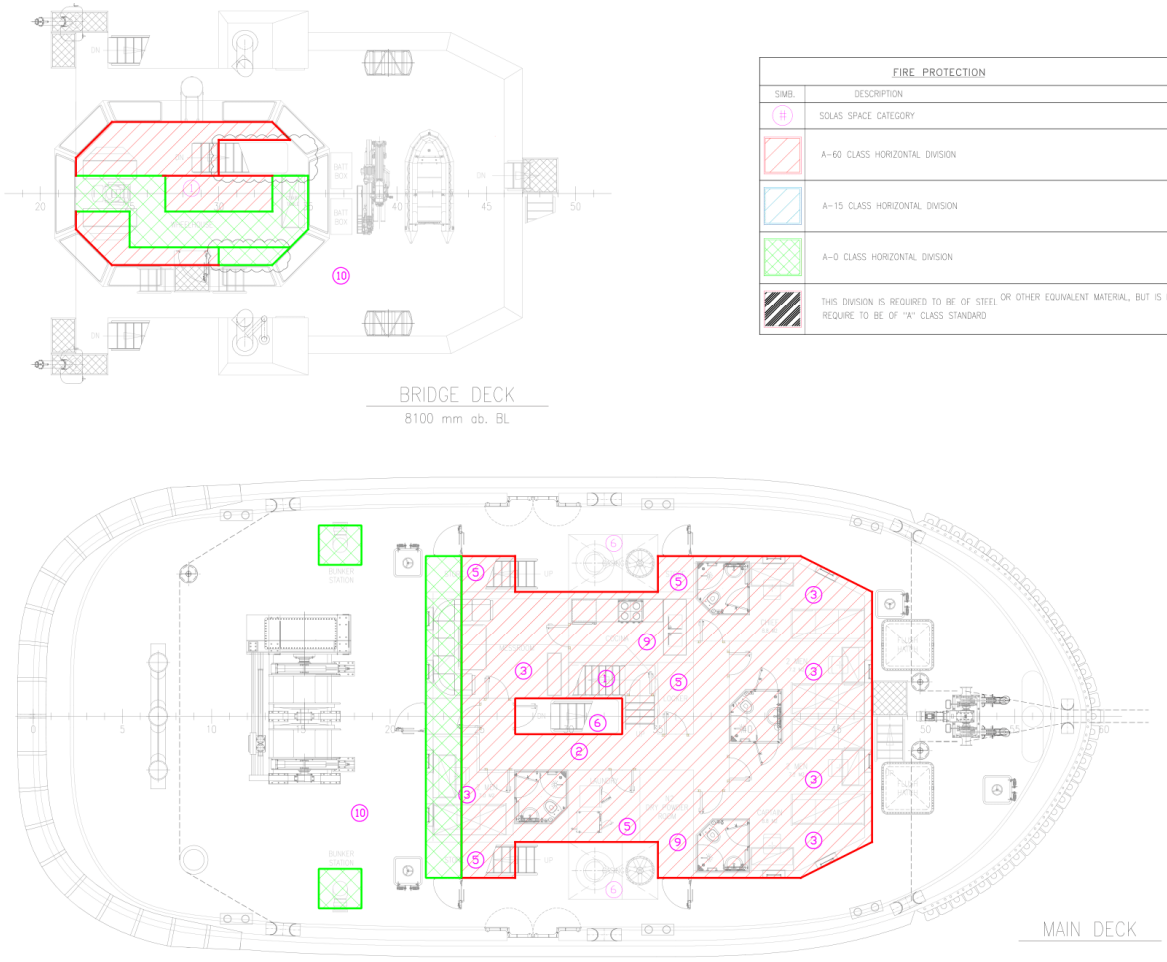


FIGURE 105 ACCOMMODATION DECK FIRE DIVISION

3.7.8 NAVIGATION LIGHTS

Following the requirement of the International Regulations for Preventing Collisions at Sea (COLREG) the navigations lights have been chose and place.

NAVIGATION AND SIGNAL LIGHTS				
N°	DESCRIPTION	TYPE	COLOUR	LOCATION
1	MAST HEAD LIGHT	UNBROKEN OVER 225° FROM AHEAD TO 22.5° ABAFT THE BEAM ON EITHER SIDE VISIBILITY 5 MILES WITH DUPLICATE LAMPS	WHITE	MAST
2	STERN LIGHT	UNBROKEN OVER 135° FROM ASTERN TO 67.5° ABAFT THE BEAM ON EITHER SIDE VISIBILITY 2 MILES WITH DUPLICATE LAMPS	WHITE	BRIDGE DECK
3	PORT LIGHT	UNBROKEN OVER 112.5° FROM AHEAD TO 22.5° ABAFT THE BEAM ON PORT SIDE 3 MILES VISIBILITY 2 MILES WITH DUPLICATE LAMPS	RED	CASING
4	STBD LIGHT	UNBROKEN OVER 112.5° FROM AHEAD TO 22.5° ABAFT THE BEAM ON STBD VISIBILITY 2 MILES WITH DUPLICATE LAMPS	GREEN	CASING
5	ANCHOR LIGHT	UNBROKEN 360° VISIBILITY 2 MILES	WHITE	MAST
6	ALL ROUND LIGHT	UNBROKEN 360° VISIBILITY 2 MILES	RED	MAST
7	ALL ROUND LIGHT	UNBROKEN 360° VISIBILITY 2 MILES	WHITE	MAST
8	ALL ROUND LIGHT	UNBROKEN 360° VISIBILITY 2 MILES	RED	MAST
9	TOWING LIGHT	UNBROKEN OVER 135° FROM ASTERN TO 67.5° ABAFT THE BEAM ON EITHER SIDE VISIBILITY 2 MILES. WITH DUPLICATE LAMPS	YELLOW	MAST
10	TOWING MAST HEAD LIGHT	UNBROKEN OVER 225° FROM AHEAD TO 22.5° ABAFT THE BEAM ON EITHER SIDE VISIBILITY 5 MILES. WITH DUPLICATE LAMPS	WHITE	MAST
11	BALL	DAY SIGNAL		MAST
			BLACK	MAST
				MAST
12	BICONIC	DAY SIGNAL	BLACK	MAST
13	TOWING MAST HEAD LIGHT	UNBROKEN OVER 225° FROM AHEAD TO 22.5° ABAFT THE BEAM ON EITHER SIDE VISIBILITY 5 MILES	WHITE	MAST

FIGURE 106 NAVIGATION LIGHTS LIST

The drawing showing the emplacement and the list is: "*SL-801-NL-001_NAVIGATION LIGHTS*".

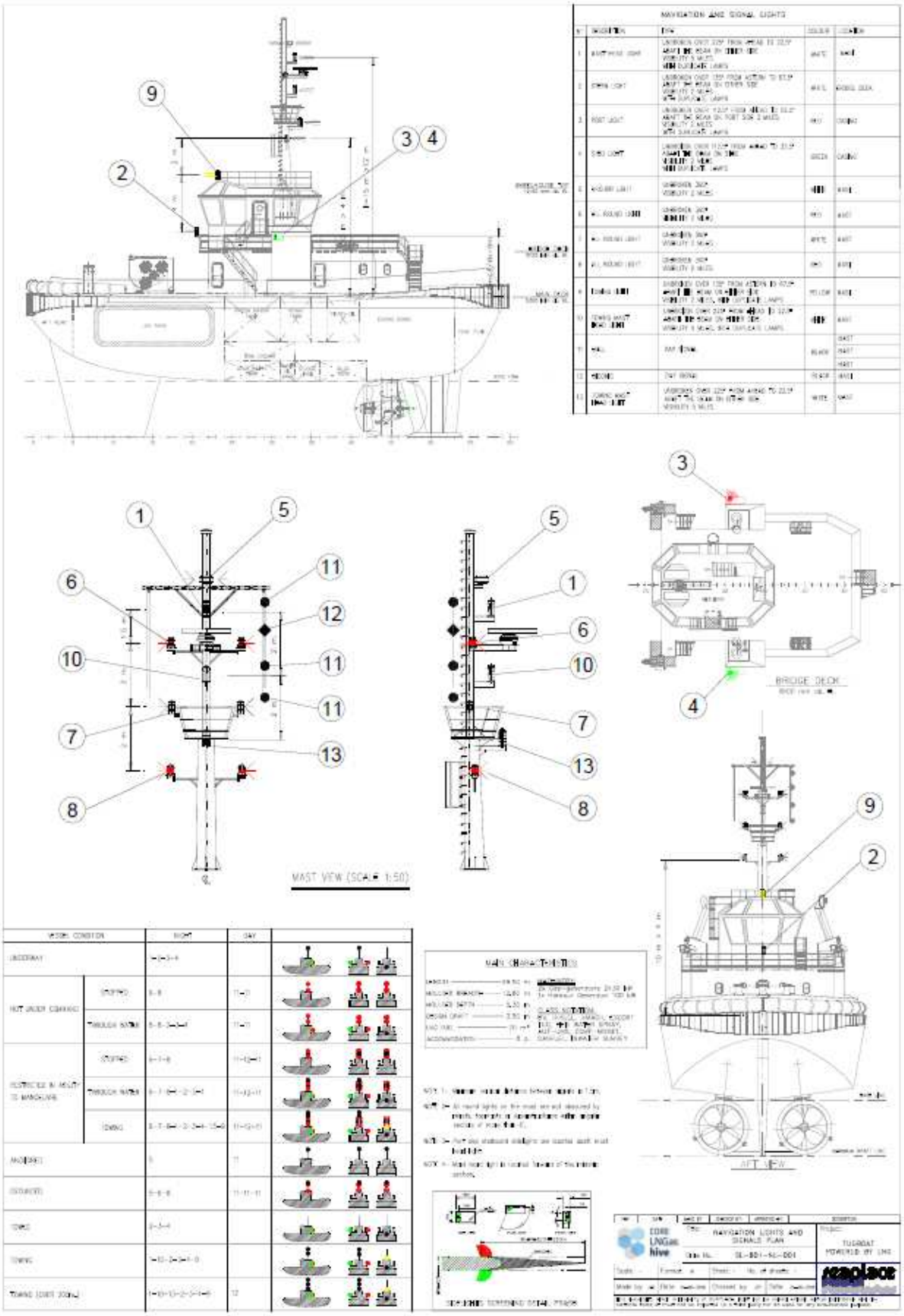


FIGURE 107 NAVIGATION LIGHTS AND SIGNAL PLAN

3.8 MOORING

3.8.1 EQUIPMENT NUMBER

The EN has been calculated according with the BV rules as indicated in Section 4, 2.1.2 Equipment Number for ships with perpendicular superstructure front bulkhead.

$$EN = K(L \cdot B \cdot D)^{2/3}$$

K - K = 1.30 for tugs with the navigation notation unrestricted navigation

- K = 1.20 for tugs with the navigation notation coastal area or sheltered area

L The distance, in m, measured on the summer load waterline, from the fore-side of the stem to the after side of the rudder post, or to the centre of the rudder stock where there is no rudder post. L is to be not less than 96% and need not exceed 97% of the extreme length on the summer load waterline

B Moulded breadth, in m

D Depth, in m

These calculations are depicted on document: "*MO-801-CS-001_00-Equipment number*".

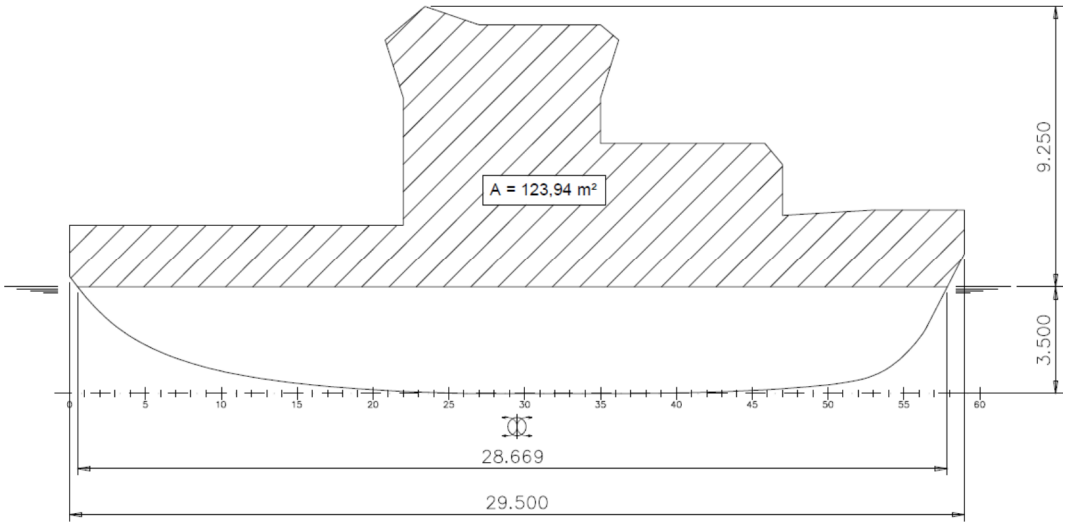


FIGURE 108 EQUIPMENT NUMBER VALUES

BOWER ANCHORS	EQUIPMENT NUMBER EN			STOCKLESS BOWER ANCHORS		STUD LINK CHAIN CABLES FOR BOWER ANCHORS		
	A<EN<B			N	MASS PER ANCHOR (kg)	TOTAL LENGTH (m)	DIAMETER (mm)	
	A	EN	B				Mild Steel	High Strength Steel
	192	198	208	2	600	275	26	22

MOORING LINES & TOWLINE	EQUIPMENT NUMBER			TOWLINE		MOORING LINES		
	A<EN<B			MINIMUM LENGTH (m)	MINIMUM BREAKING STRENGTH (kN)	N	LENGTH OF EACH LINE (m)	MINIMUM BREAKING STRENGTH (kN)
	A	EN	B					
	192	198	208	180	183	2	110	78

TABLE 18 EQUIPMENT NUMBER CALCULATIONS

3.8.2 MOORING ARRANGEMENT

The mooring has to be calculated taking into consideration all different forces that may appear during the tooling of another vessel.

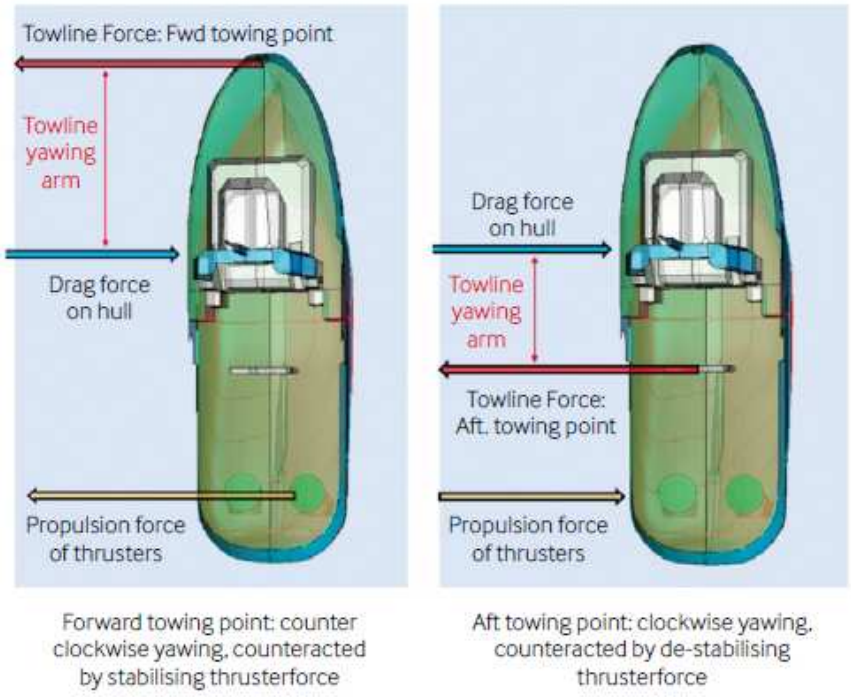


FIGURE 109 FORCES DURING TOWING ON A HORIZONTAL PLANE

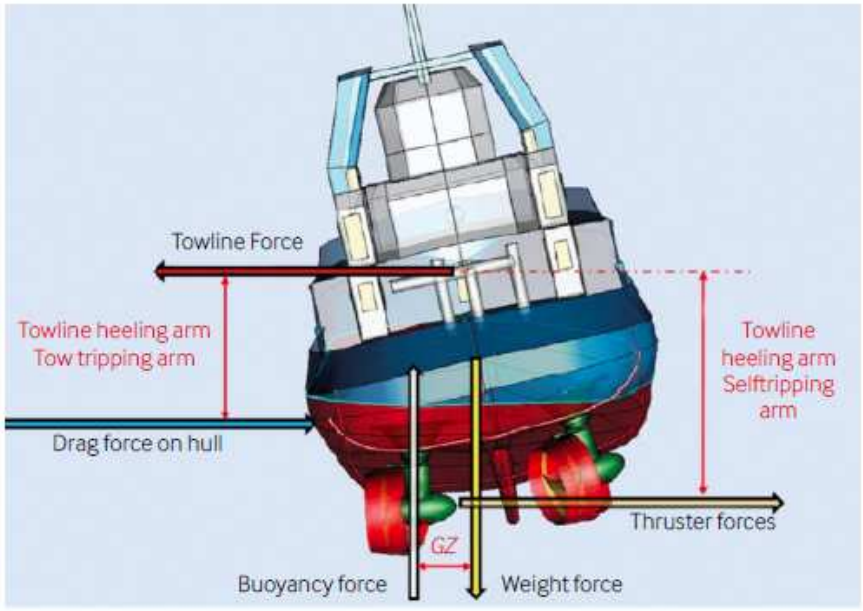


FIGURE 110FORCES DURING TOWING ON A VERTICAL PLANE

The mooring calculations are done following Bureau Veritas Regulation.

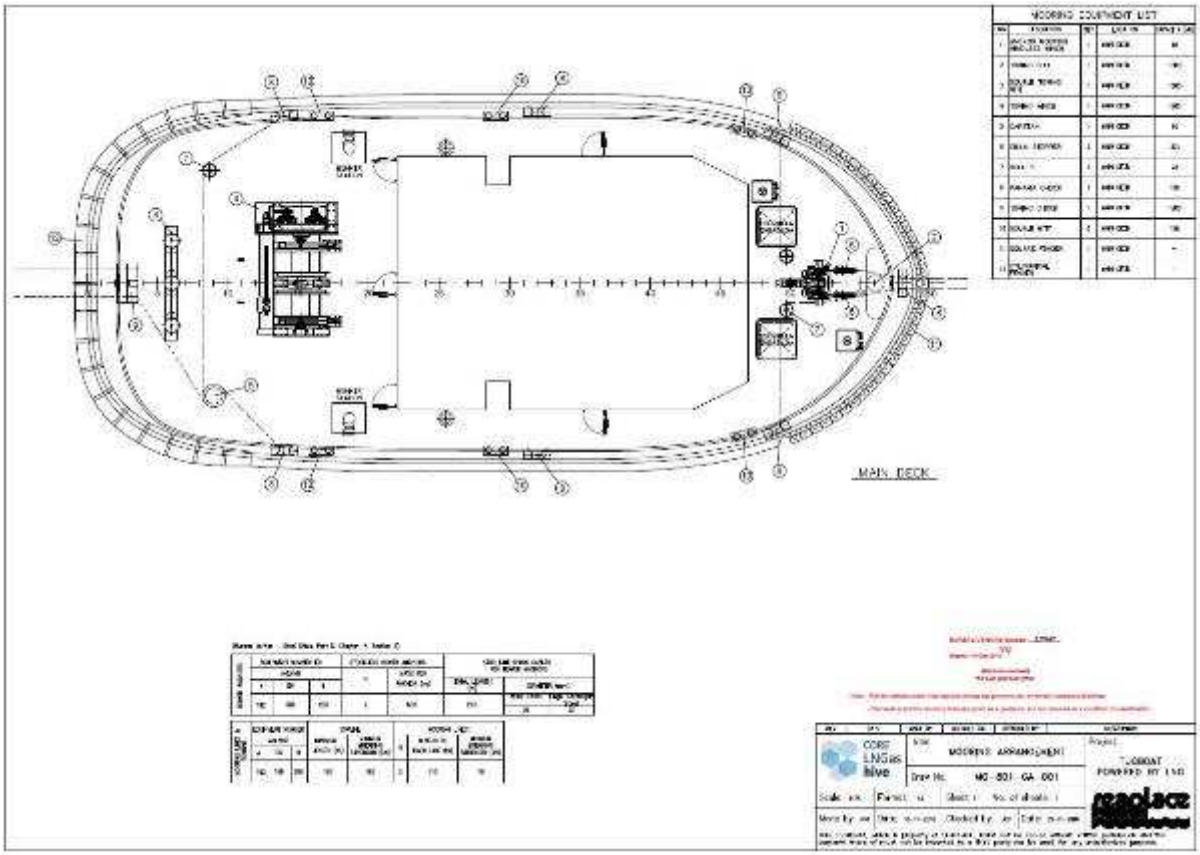


FIGURE 111 MOORING ARRANGEMENT

4 CERTIFICATION

BUREAU VERITAS has reviewed, approved and stamped the Basic Design documents submitted by SEAPLACE. BUREAU VERITAS has issued an Approval in Principle Certificate of the LNG Powered Tugboat.

MARINE DIVISION

DIRECTION MARINE

MPO/17/02233

APPROVAL IN PRINCIPLE – LNG Powered Tugboat -

Issued within scope of Bureau Veritas Marine Branch General Conditions.
Délivrée dans le cadre des Conditions Générales de la Branche Marine du Bureau Veritas.

Bv Register Number	:	**31694C**
Type of Vessel	:	**Tug Boat / Escort Tug** **Fire Fighting** **GasFuel** **Water spraying 1** **Unrestricted Navigation.** **AUT – UMS** **COMF – NOISE 1** **INWATER SURVEY**

Vessel's Characteristics:

L = 29,5 m.
B = 12,8 m.
D = 3,5 m.
C = 5,3 m.
GT < 500
Propulsion Power = 2 x 2430 kW.
Bolard Pull 80 Tn.

This is to certify,

That listed documents included in this attestation, have been reviewed within the general conditions of the Marine Division of Bureau Veritas in order to check the compliance with the applicable requirements of:

- NR566, February 201, "Hull Arrangement, Stability and Systems for Ships less than 500 GT.
- NR600, "Hull Structure and Arrangement for the Classification of Cargo Ships less than 65 m and Non Cargo Ships less than 90 m".
- NR529, May 2017, "Safety Rules for Gas – Fuelled Engine Installations in Ships".
- IGF Code, 2016

The following letters and the stamped drawings, include the information regarding the reviewing of the documents:

- **MPO/16/02026/BPP**
- **MPO/16/02084/BPP**
- **MPO/16/03396**
- **MPO/17/01080**
- **MPO/17/01110**
- **MPO/17/01634**

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- **MPO/17/01639**
- **MPO/17/01738/MEG**
- **MPO/17/01697**
- **MPO/17/01736**
- **MPO/17/01747**
- **MPO/17/01750**
- **MPO/17/01751**
- **MPO/16/03061/SLR**
- **MPO/17/00951/SLR**
- **MPO/17/00952/SLR**
- **MPO/17/00953/SLR**
- **MPO/17/00954/SLR**
- **MPO/17/00955/SLR**
- **MPO/17/00956/SLR**
- **MPO/17/00957/SLR**

The stamped drawings and the letters are available in www.veristarpm.com

Madrid, 28th June, 2017

BUREAU VERITAS - REGISTRE INTERNATIONAL - BUREAU CENTRAL ESPAÑOL PARIS 1828 MPO

J. PANCORBO CRESPO

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List of Drawings Reviewed :

Title	Drawing nbr.	Rev.	Stamp	Global stamp	Approval date
ACCOMODATION BULKHEAD FIRE DIVISION	AC-801-FI-001	01	1b		29/03/2017
ACCOMODATION DECK FIRE DIVISION	AC-801-FI-002	01	1b		29/03/2017
AFT HOLD STRUCTURE	ST-801-BS-006	1	1b		16/03/2017
AFT PEAK	ST-801-BS-004	1	1b		16/03/2017
AIR VENT SYSTEM	MC-801-PI-015	0	1		08/06/2016
BHD FRAME 24	ST-801-BS-002	1	1		16/03/2017
BILGE SYSTEM	MC-801-PI-002	1	1	3b	11/05/2017
BILGE SYSTEM	MC-801-PI-002	1	3b	3b	22/05/2017
BODY PLAN	NA-801-BP-001	0	0		13/04/2016
BONJEAN CURVES	NA-801-CS-001	0	0		03/10/2016
CAPACITY PLAN	NA-801-CP-001	1	2	2	09/06/2016
CAPACITY PLAN	NA-801-CP-001	1	2	2	08/06/2016
COMPRESSED AIR SYSTEM	MC-801-PI-012	1	1b	3b	11/05/2017
COMPRESSED AIR SYSTEM	MC-801-PI-012	1	3b	3b	22/05/2017
DANGEROUS AREA PLAN	SL-801-DA-001	01	1b	1b	22/05/2017
DANGEROUS AREA PLAN	SL-801-DA-001	01	1b	1b	30/03/2017
DRAIN SYSTEM	MC-801-PI-016	1	1		11/05/2017
ELECTRICAL LOAD CALCULATION	EL-801-LA-001	1	2b		22/05/2017
ELECTRICAL ONE LINE DIAGRAM	EL-801-UD-001	1	1b		22/05/2017
ENGINE ROOM	ST-801-BS-005	1	1b		16/03/2017
ENGINE ROOM FLOODING CALCULATION	MC-801-DC-001	0	3		22/05/2017
ENGINE ROOM GENERAL ARRANGEMENT	MC-801-GA-001	0	1		11/11/2016
ENGINE ROOM VENTILATION	VE-801-PI-001	0	1	1b	05/12/2016
ENGINE ROOM VENTILATION	VE-801-PI-001	0	1b	1b	22/11/2016
EQUIPMENT LIST	MC-801-EQ-001	0	0	0	20/12/2016
EQUIPMENT LIST	MC-801-EQ-001	0	0	0	21/12/2016
EQUIPMENT NUMBER	MO-801-CS-001	0	1		05/07/2016
ESCAPE ROUTE PLAN	SL-801-SA-002	01	1b		30/03/2017
EXHAUST SYSTEM	MC-801-PI-013	0	1b		13/07/2016
FIFI 1 SYSTEM	MC-801-PI-018	1	1b	1b	11/05/2017
FIFI 1 SYSTEM	MC-801-PI-018	1	1b	1b	27/03/2017
FIRE FIGHTING EQUIPMENT	SL-801-SA-001	01	1b		30/03/2017
FIRE PROTECTION BUNKERING AREA	MC-801-PI-009	1	1b		27/03/2017
FIRE SEA WATER SYSTEM	MC-801-PI-003	0	1	3b	07/06/2016
FIRE SEA WATER SYSTEM	MC-801-PI-003	0	3b	3b	09/06/2016

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Title	Drawing nbr.	Rev.	Stamp	Global stamp	Approval date
FIRE SEA WATER SYSTEM	MC-801-PI-003	0	1b	3b	01/06/2016
FORCES MR-H/200/2X300-80/1	20360802	0	0		02/02/2017
FORE PEAK	ST-801-BS-003	0	1b		10/10/2016
FORWARD DOCKING SUPPORT	ST-801-SS-005	1	1		16/03/2017
FREEBOARD CALCULATION	NA-801-CS-008	0	0		03/10/2016
FREEING PORT AND BULWARK STRUCTURE	ST-801-GA-001	0	1b		25/11/2016
FRESH WATER COOLING SYSTEM	MC-801-PI-005	1	1	3	11/05/2017
FRESH WATER COOLING SYSTEM	MC-801-PI-005	1	3	3	22/05/2017
FUEL GAS SYSTEM	MC-801-PI-007	1	1b	1b	11/05/2017
FUEL GAS SYSTEM	MC-801-PI-007	1	1b	1b	27/03/2017
GAS DETECTION	SL-801-GD-001	01	1b	1b	22/05/2017
GAS DETECTION	SL-801-GD-001	01	1b	1b	30/03/2017
GENERAL ARRANGEMENT	GE-801-GA-001	2	2	2b	16/03/2017
GENERAL ARRANGEMENT	GE-801-GA-001	2	2	2b	11/05/2017
GENERAL ARRANGEMENT	GE-801-GA-001	2	2b	2b	22/05/2017
GENERAL ARRANGEMENT	GE-801-GA-001	2	2b	2b	30/03/2017
HOLD SPACE MACHINERY ARRANGEMENT	MC-801-GA-002	0	1		11/11/2016
HOLD SPACE VENTILATION	MC-801-VE-003	0	1b		13/07/2016
HULL AND DRAFT MARKS	NA-801-HM-001	0	0		03/10/2016
HYDROSTATIC CALCULATIONS	NA-801-CS-002	0	0		03/10/2016
LIFE SAVING EQUIPMENT PLAN	SL-801-LS-001	01	0		30/03/2017
LIGHTSHIP WEIGHT DISTRIBUTION	NA-801-CS-004	0	0		10/11/2016
LNG HEATING SYSTEM	MC-801-PI-006	2	1b		24/03/2017
LNG INERT GAS SYSTEM	MC-801-PI-008	1	1b		24/03/2017
LOADING CONDITIONS	NA-801-CS-005	0	0		10/11/2016
LUBE OIL SYSTEM	MC-801-PI-011	0	1	3b	08/06/2016
LUBE OIL SYSTEM	MC-801-PI-011	0	3b	3b	09/06/2016
MAIN DECK	ST-801-BS-020	1	1		16/03/2017
MAST STRUCTURE	ST-801-BS-071	0	1		25/10/2016
MIDSHIP SECTION	ST-801-BS-001	1	3		16/03/2017
MOORING ARRANGEMENT	MO-801-GA-001	0	2		14/12/2016
NAVIGATION LIGHTS AND SIGNALS PLAN	SL-801-NL-001	0	0		07/07/2016
NOVEC SYSTEM	MC-801-PI-014	0	1b		16/09/2016
POTABLE AND F.W. HOT&COLD P.D. IN ACCOMMODATION	AC-801-PI-001	0	1b		13/07/2016
SANITARY DISCHARGE BLACK & GREY WATER SYSTEM IN ACCOMMODATION P.D.	AC-801-PI-003	0	1		11/11/2016

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Title	Drawing nbr.	Rev.	Stamp	Global stamp	Approval date
SHELL EXPANSION	ST-801-BS-010	1	1b		16/03/2017
SKEG	ST-801-SS-002	0	1b		14/12/2016
SOUNDING SYSTEM	MC-801-PI-017	0	1		08/06/2016
SOUNDING TABLES	NA-801-CS-009	0	0		03/10/2016
SPEED POWER PREDICTION	HY-801-CS-001	0	0		11/11/2016
STABILITY CROSS CURVES	NA-801-CS-003	0	0		03/10/2016
SUPERSTRUCTURE	ST-801-BS-040	0	1b		28/10/2016
TONNAGE CALCULATION	NA-801-CS-007	0	0		21/04/2016
TOWING WINCH FOUNDATION	ST-801-FO-001	0.b	1b		17/02/2017
TOWING WINCH MR-H/200/2/300-8	20360755	E	0		02/02/2017
VENTILATION HAZARDOUS AREA	MC-801-VE-002	1	1b		27/03/2017
WELDING AND WELD CONNECTIONS	ST-801-WT-001	0	1b		06/05/2016
WHEELHOUSE STRUCTURE	ST-801-BS-070	0	1		28/10/2016

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Stamp Code :

(0) Informative Drawing (no reviewed).
(1) Drawing Revied without comments.
(1b) Drawing Reviewed with comment.
(2) Drawing View without comment
(2b) Drawing View with comment
(3) Drawing Reviewed including the applicable Additional Notations, without comments.
(3b) Drawing Reviewed including the applicable Additional Notations, with comments.

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