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Natural Gas Fueled Vessels for Coastal and Inland Waters

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PREAMBLE

The purpose of this Classification Note is to provide Classification requirements for ships using natural gas (LNG/ CNG) as fuel and operating in Indian Inland and Coastal waters.

This Classification Note provides requirements for the arrangement, installation, control and monitoring of machinery, equipment and systems using natural gas, as fuel, to minimize the risk to the ship, its crew and the environment.

This Classification Note has been developed based on the requirements of the ESTRIN (European Standard laying down Technical Requirements for Inland Navigation Vessels), Edition 2015/1, the IMO IGF Code and consultations with stakeholders.

This Classification Note is to be read in conjunction with the Rule requirements for Construction and Classification of Inland Waterways Ships and that for Coastal Ships. In addition, relevant statutory requirements are also to be complied with.

The requirements would be applicable for gas fueled vessels, intended to operate in Indian Inland and Coastal waters and contracted for construction, on or after 01 July 2017.

Section 1

General

1.1 Application

1.1.1 Unless expressly provided otherwise, this Classification Note is applicable to all Indian Coastal vessels, River Sea vessels and Inland Waterways vessels of length 24 m and over, using natural gas (LNG / CNG) as fuel for propulsion and/or for power generation.

1.1.2 Any relevant requirements of the Statutory Authority for gas fueled vessels are to be complied with in addition to this Classification Note.

1.1.3 The prescriptive requirements of the IGF Code may be referred for interpreting some of the requirements where they are not explicitly mentioned in this Classification Note.

1.1.4 In the case of vessels of length less than 24m, LNG/CNG may be used as fuel and the requirements would be specially considered based on individual designs and risk assessments.

1.2 Definitions

1.2.1 *Air Lock:* A space enclosed by gastight steel bulkheads with two gastight doors, intended to separate a non-hazardous area from a hazardous area.

1.2.2 *Bunkering* means the transfer of liquid or gaseous fuel from land based or floating facilities into a ships' permanent tanks or connection of portable tanks to the fuel supply system.

1.2.3 *Certified safe type* means electrical equipment that is certified safe by the relevant authorities recognized by the Administration for operation in a flammable atmosphere based on a recognized standard, such as IEC 60092-502:1999.

1.2.4 *CNG means Compressed Natural Gas*

1.2.5 *Design temperature* for selection of materials is the minimum temperature at which natural gas fuel may be loaded or transported in the fuel tanks.

1.2.6 *Design pressure*: the pressure on the basis of which the natural gas fuel tank or piping has been designed and built.

1.2.7 *Double block and bleed valve*: a set of two valves in series in a pipe and a third valve enabling the pressure release from the pipe between those two valves. The arrangement may also consist of a two-way valve and a closing valve instead of three separate valves.

1.2.8 *Double Wall Piping*: Piping with a double wall design for which the space between the walls is pressurized with inert gas and equipped to detect any leakage of one of the two walls.

1.2.9 *Dual fuel engines*: engines using natural gas and oil fuel with a flashpoint above 55 °C.

1.2.10 *Enclosed room*: any room within which, in the absence of forced ventilation, the ventilation will be limited and any explosive atmosphere will not be dispersed naturally.

1.2.11 *ESD*: emergency shutdown.

1.2.12 *Explosion pressure relief* means measures provided to prevent the explosion pressure in a container or an enclosed space exceeding the maximum overpressure the container or space is designed for, by releasing the overpressure through designated openings.

1.2.13 *Fuel containment system* is the arrangement for the storage of fuel including tank connections.

1.2.14 *Fuel Preparation room* means any space containing pumps, compressors and/or vaporizers for fuel preparation purposes.

1.2.15 *Hazardous area* means an area in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment.

1.2.16 *LEL* means the lower explosive limit.

1.2.17 *LNG* means liquefied natural gas.

1.2.18 *MARVS* means the maximum allowable relief valve setting in MPa.

1.2.19 *MAWP* means the maximum allowable working pressure of a system component or tank.

1.2.20 *Non-hazardous area* means an area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of equipment.

1.2.21 *Open deck* means a deck having no significant fire risk that at least is open on both ends/sides, or is open on one end and is provided with adequate natural ventilation that is effective over the entire length of the deck through permanent openings distributed in the side plating or deckhead.

1.2.22 *Risk* is an expression for the combination of the likelihood and the severity of the consequences.

1.2.23 *Semi-enclosed room*: a room limited by decks or bulkheads in such manner that the natural conditions of ventilation are notably different from those obtained on open deck.

1.2.24 *System components*: all components of the installation that may contain natural Gas (fuel tanks, pipelines, valves, hoses, pistons, pumps, filters, instrumentation, etc.)

1.2.25 *Tank Connection Space:* is a space surrounding all tank connections and tank valves that is required for tanks with such connections in enclosed spaces.

1.2.26 *Ventilated ducting*: a gas pipe installed in a pipe or duct equipped with mechanical exhaust ventilation.

1.3 General Requirements

1.3.1 The safety, reliability and dependability of the systems are to be equivalent to that achieved with new and comparable conventional oil-fueled main and auxiliary machinery.

1.3.2 The probability and consequences of fuel-related hazards are to be limited to a minimum through arrangement and system design, such as ventilation, detection and safety actions. In the event of gas leakage or failure of the risk reducing measures, necessary safety actions are to be initiated.

1.3.3 The design philosophy is to ensure that risk reducing measures and safety actions for the gas fuel installation do not lead to an unacceptable loss of power. Unacceptable loss of power means that it is not possible to sustain or restore normal operation of the propulsion machinery in the event of one of the essential auxiliaries becoming inoperative in accordance with SOLAS Ch II-1/26.3. However, IRS/ Administration, having regard to overall safety considerations, may accept a partial reduction in propulsion capability from normal operation.
As a guidance, this could be taken as power loss not exceeding 60% of the main propulsion and normal power supply.

1.3.4 Hazardous areas are to be restricted, as far as practicable, to minimize the potential risks that might affect the safety of the ship, persons on board, and equipment.

1.3.5 Equipment installed in hazardous areas are to be minimized to that required for operational purposes and are to be suitably and appropriately certified.

1.3.6 Unintended accumulation of explosive, flammable or toxic gas concentrations is to be prevented.

1.3.7 System components are to be protected against external damages.

1.3.8 Sources of ignition in hazardous areas are to be minimized to reduce the probability of explosions.

1.3.9 It shall be arranged for safe and suitable fuel supply, storage and bunkering arrangements capable of receiving and containing the fuel in the required state without leakage. Other than when necessary for safety reasons, the system is to be designed to prevent venting under all normal operating conditions including idle periods.

1.3.10 Piping systems, containment and over-pressure relief arrangements are to be provided that are of suitable design, construction and installation for their intended application.

1.3.11 Machinery, systems and components are to be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.

1.3.12 Fuel containment system and machinery spaces containing source that might release gas into the space are to be arranged and located such that a fire or explosion in either will not lead to an unacceptable loss of power or render equipment in other compartments inoperable.

1.3.13 Suitable control, alarm, monitoring and shutdown systems are to be provided to ensure safe and reliable operation.

1.3.14 Fixed gas detection suitable for all spaces and areas concerned are to be arranged.

1.3.15 Fire detection, protection and extinction measures appropriate to the hazards concerned are to be provided.

1.3.16 Commissioning, trials and maintenance of fuel systems and gas utilization machinery are to satisfy the goal in terms of safety, availability and reliability.

1.3.17 The technical documentation is to permit an assessment of the compliance of the system and its components with the applicable rules, guidelines, design standards used and the principles related to safety, availability, maintainability and reliability.

1.3.18 A single failure in a technical system or component is not to lead to an unsafe or unreliable situation.

1.3.19 A ship specific detailed operating manual of the natural gas system is to be provided on board the vessel using natural gas (LNG/ CNG) as fuel and which as minimum:

a) contains practical explanations about natural gas bunkering system, containment system, piping system, Gas supply system, engine room, ventilation system, leakage prevention and control, monitoring and safety system,

b) describes the bunkering operations, especially valves operation, purging, inerting and gas freeing,

c) describes the relevant method of electrical insulation during bunkering operations,

d) describes the details of risks identified in the risk assessment as referred to in 1.4 and the means by which they are mitigated.

1.4 Risk Assessment

1.4.1 A risk assessment is to be conducted on all concepts and configurations which are new or have been significantly modified. The risks arising from the use of natural gas affecting people on board including passengers, the environment, the structural strength and the integrity of the vessel are to be addressed. Reasonable consideration is to be given to the hazards associated with physical layout, operation, and maintenance, following a failure.

1.4.2 The risks are to be determined and assessed using a recognized risk analysis technique, such as International Standards ISO 31000 : 2009 and ISO 31010 : 2010. Loss of function, component damage, fire, explosion, tank room flooding, vessel sinking and electric overvoltage shall as a minimum be considered. The analysis must help to ensure that risks are eliminated wherever possible. Risks which cannot be eliminated entirely are to be mitigated to an acceptable level. The major scenarios and measures for eliminating or mitigating risks are to be described.

1.4.3 The Classification of hazardous areas (Section 9) on board is to be documented in the risk assessment report.

Section 2

Ship Design and Arrangement

2.1 General Requirements

2.1.1 The fuel tank(s) are to be located in such a way that the probability for the tank(s) to be damaged following a collision or grounding is reduced to a minimum taking into account the safe operation of the ship and other hazards that may be relevant to the ship.

2.1.2 Natural gas fuel tanks are to be located as close as possible to the longitudinal centerline of the vessel.

2.1.3 The distance between the ship's inner hull plating and the natural gas fuel tank is not to be less than 0.65 m. If fuel tanks are located:

a) below deck, the vessel is to have a double hull and a double bottom construction at the location of the fuel tanks. The distance between the ship's outer hull and inner hull is not to be less than 0.65 m. The depth of the double bottoms is not to be less than 0.65 m;

b) on open deck, the distance is to be, in general, at least B/5 from the vertical planes defined by the ship's sides. Alternatively, tanks may be located in line with the method outlined in clause 5.3.4, Part A-1 of the IGF Code.

2.1.4 Fuel storage tanks are to be protected against mechanical damage. Fuel storage tanks and/ or equipment located on open deck are to be located to ensure sufficient ventilation, so as to prevent accumulation of escaped gas.

2.1.5 The gas fuel tank is to be an independent tank designed in accordance with the IGF-Code (Type C tank).

2.1.6 When establishing functional loads for Inland Vessels, the loads corresponding to the most unfavourable static heel angle with the range 0° to 20° are to be considered.

2.2 Machinery Space Concepts

2.2.1 In order to minimize the probability of a gas explosion in a machinery space with gas-fuelled machinery, one of the two alternative concepts may be applied:

.1 Gas safe machinery spaces:

Arrangements in machinery spaces are such that the spaces are considered gas safe under all conditions, normal as well as abnormal conditions, i.e. inherently gas safe.

In a gas safe machinery space a single failure cannot lead to release of fuel gas into the machinery space.

All gas piping within the engine room boundaries are to be enclosed in a gastight enclosure, e.g. double wall piping or ventilated ducting

All fuel piping in gas safe machinery spaces is to be in accordance with Section 6/ 6.5.

.2 ESD protected machinery spaces:

Arrangements in machinery spaces are such that the spaces are considered non-hazardous under normal conditions, but under certain abnormal conditions may have the potential to become hazardous.

In the event of abnormal conditions involving gas hazards, emergency shutdown (ESD) is activated.

2.2.2 Requirements for ESD protected machinery spaces

.1 Engines using fuel gas mixed with air before the turbocharger are to be located in ESD protected machinery spaces.

.2 Measures are to be applied to protect against explosion, damage of areas outside of the machinery space and ensure redundancy of power supply. The following arrangement is to be provided but may not be limited to:

.1 Gas Detector
.2 Shut-off valve
.3 Redundancy; and
.4 Efficient Ventilation

.3 Gas supply piping within machinery spaces may be accepted without a gastight external enclosure based on the following:

.1 Engines for generating propulsion power are to be located in two or more machinery spaces not having any common boundaries unless it can be documented that a single casualty will not affect both spaces. Engines for generating electric power are also to be located in two or more machinery spaces in similar way;

.2 The gas machinery space is to contain only a minimum of such necessary equipment, components and systems as are required to ensure that the gas machinery maintains its function;

.3 A fixed gas detection system arranged to automatically shutdown the gas supply, and disconnect all electrical equipment or installations not of a certified safe type, is fitted.

.4 ESD protected engine rooms are to be designed to provide a geometrical shape that minimizes the accumulation of gases or formation of gas pockets. A good air circulation is to be ensured.

.5 The ventilation of ESD protected machinery spaces is to be designed in accordance with Section 10.

2.3 Location and Protection of Natural Gas Fuel Piping

2.3.1 Natural Gas fuel piping are not to be located less than 0.8 m from the vessel's side and from the bottom.

2.3.2 Fuel piping through other engine rooms or nonhazardous enclosed areas of the vessel are to be enclosed in double wall piping or ventilated ducting.

2.3.3 Fuel piping is not to be led directly through accommodation spaces, service spaces, electrical equipment rooms or control stations as defined in the SOLAS Convention.

2.3.4 Fuel pipes led through ro-ro spaces, on open decks and in ESD protected machinery spaces are to be protected against mechanical damage.

2.3.5 Fuel piping in ESD protected machinery spaces is to be located as far as practicable from the electrical installations and tanks containing flammable liquids.

2.4 Fuel Preparation Room Design

2.4.1 Fuel preparation rooms or tank connection spaces are normally to be situated on open deck. Fuel preparation rooms may be situated below decks, provided they meet the requirements for tank connection spaces.

2.4.2 Fuel preparation rooms are to be arranged to safely contain cryogenic leakages.

2.4.3 The material of the boundaries of the fuel preparation room is to have a design temperature corresponding with the lowest temperature it can be subject to in a probable maximum leakage scenario unless the boundaries of the space, i.e. bulkheads and decks, are provided with suitable thermal protection.

2.4.4 The fuel preparation room is to be arranged to prevent surrounding hull structure from being exposed to unacceptable cooling, in case of leakage of cryogenic liquids.

2.4.5 The fuel preparation room is to be designed to withstand the maximum pressure build up during such a leakage. Pressure relief venting to a safe location (mast) can be provided for emergency situations.

2.5 Drainage Systems

2.5.1 Drainage systems for areas where fuel gas can be present are:

a) to be independent and separate from the drainage system of areas where fuel gas cannot be present;
b) not to lead to pumps in non-hazardous areas.

2.5.2 Suitable drainage arrangements for the tank rooms that are not connected to the engine rooms are to be provided. Means of detecting any gas leakage are to be provided.

2.6 Drip Trays

2.6.1 Drip trays are to be fitted where leakage may occur which can cause damage to the ship structure or where limitation of the area which is effected from a spill is necessary.

2.6.2 Each tray is to be fitted with a drain valve to enable rain water to be drained over the ship's side.

2.6.3 If the fuel tanks are located on open deck and/ or the tank connections are below the highest liquid level of the fuel tanks, drip trays are to be placed below the tanks that meet the following requirements:

a) the capacity of the drip tray is to be sufficient to contain the volume which could escape in the event of a pipe connection failure;

b) the material of the drip tray is to be suitable stainless steel;

c) the drip tray is to be sufficiently separated or insulated from the hull or deck structures, so that the hull or deck structures are not exposed to unacceptable cooling in case of leakage of the fuel.

2.7 Arrangement of Entrances and other Openings in Enclosed Spaces

2.7.1 Entrances and other openings from a non-hazardous area to a hazardous area are only to be permitted to the extent necessary for operational reasons and these are to be provided with airlocks in accordance with 2.8.

2.7.2 If the fuel preparation room is approved located below deck, the room is to as far as practicable, have an independent access direct from the open deck. Where a separate access from deck is not practicable, an airlock which complies with 2.8 is to be provided.

2.7.3 Unless access to the tank connection space is independent and direct from open deck it is to be arranged as a bolted hatch. The space containing the bolted hatch will be a hazardous space.

2.7.4 If the access to an ESD-protected machinery space is from another enclosed space in the ship, the entrance is to be arranged with an airlock which complies with 2.8.

2.7.5 For inerted spaces access arrangements are to be such that unintended entry by personnel would be prevented. If access to such spaces is not from an open deck, sealing arrangements are to ensure that leakages of inert gas to adjacent spaces are prevented.

2.8 Airlocks

2.8.1 An airlock is a space enclosed by gastight bulkheads with two substantially gastight doors spaced at least 1.5 m and not more than 2.5 m apart. The doors are to be self-closing without any holding back arrangements.

2.8.2 Air locks are to be mechanically ventilated at an overpressure relative to the adjacent hazardous area.

2.8.3 Air locks are to be designed in a way that no gas can be released to non-hazardous areas in case of the most critical events in the hazardous areas separated by the air lock. The events are to be evaluated in the risk assessment according to Section 1/ 1.4.

2.8.4 Air locks are to be free of obstacles, provide easy passage and are not to be used for other purposes.

2.8.5 Airlocks are to have a simple geometrical form. They are to provide free and easy passage, and are to have a deck area not less than 1.5 m^2.

2.8.6 An audible and visual alarm system to give a warning on both sides of the airlock is to be provided to indicate if more than one door is moved from the closed position or if gas is detected in the air lock.

2.8.7 For non-hazardous spaces with access from hazardous spaces below deck where the access is protected by an airlock, upon loss of under pressure in the hazardous space access to the space is to be restricted until the ventilation has been reinstated. Audible and visual alarms are to be given at a manned location to indicate both loss of pressure and opening of the airlock doors when pressure is lost.

Section 3

Fuel Containment System

3.1 General Requirements

3.1.1 The fuel containment system is to be so designed that a leak from the tank or its connections does not endanger the ship, persons on board or the environment. Potential dangers to be avoided include:

.1 exposure of ship materials to temperatures below acceptable limits;

.2 flammable fuels spreading to locations with ignition sources;

.3 toxicity potential and risk of oxygen deficiency due to fuels and inert gases;

.4 restriction of access to muster stations, escape routes and life-saving appliances (LSA); and

.5 reduction in availability of LSA.

3.1.2 The pressure and temperature in the fuel tank is to be kept within the design limits of the containment system and possible carriage requirements of the fuel (also see 3.7.1).

3.1.3 The fuel containment arrangement is to be so designed that safety actions after any gas leakage do not lead to an unacceptable loss of power; and

3.1.4 If portable tanks are used for fuel storage, the design of the fuel containment system is to be equivalent to permanent installed tanks as described in this Section.

3.1.5 Natural gas in a liquid state may be stored with a maximum allowable relief valve setting (MARVS) of up to 1.0 MPa. For Inland Vessels, the MARVS may be maintained at 1.2 MPa.

3.1.6 The Maximum Allowable Working Pressure (MAWP) of the gas fuel tank shall not exceed 90% of the Maximum Allowable Relief Valve Setting (MARVS).

3.1.7 A fuel containment system located below deck is to be gas tight towards adjacent spaces.

3.1.8 All tank connections, fittings, flanges and tank valves must be enclosed in gas tight tank connection spaces, unless the tank connections are on open deck. The space shall be able to safely contain leakage from the tank in case of leakage from the tank connections.

3.1.9 Piping between the tank and the first valve which releases liquid in case of pipe failure is to have equivalent safety as the type C tank.

3.1.10 The material of the bulkheads of the tank connection space is to have a design temperature corresponding with the lowest temperature it can be subjected to in a probable maximum leakage scenario. The tank connection space is to be designed to withstand the maximum pressure build up during such a leakage. Alternatively, pressure relief venting to a safe location (for e.g. mast) can be provided. The probable maximum leakage into the tank connection space is to be determined based on detail design, detection and shutdown systems.

3.1.11 It is to be possible to safely empty the gas fuel tanks, even if the gas system is shut down.

3.1.12 It is to be possible to purge gas and vent fuel tanks including gas piping systems. It is to be possible to perform inerting with an inert gas (e.g. nitrogen or argon) prior to venting with dry air, to exclude an explosive hazardous atmosphere in fuel tanks and gas piping.

3.1.13 No secondary barrier is required for the fuel containment systems, e.g. Type C independent tanks, where the probability for structural failures and leakages through the primary barrier is extremely low and can be neglected.

3.2 Liquefied Gas Fuel Containment

3.2.1 The design life of fixed liquefied gas fuel containment system is not to be less than the design life of the ship or 20 years, whichever is greater.

3.2.2 The design life of portable tanks is not to be less than 20 years.

3.2.3 LNG tanks (Type C independent tanks) are to be designed in accordance with the requirements (like loads, loads scenarios, design conditions, materials and construction; etc.) as mentioned in IGF Code Part A-1 Sec. 6.

3.3 Pressure Relief System

3.3.1 Fuel storage tanks are to be provided with a pressure relief system. Fuel storage hold spaces, tank connection spaces and tank cofferdams, which may be subject to pressures beyond their design capabilities, are also to be provided with a suitable pressure relief system. Pressure control systems specified in 3.7.1 are to be independent of the pressure relief systems.

3.3.2 If fuel release into the vacuum space of a vacuum insulated LNG fuel tank cannot be excluded, the vacuum space is to be protected by a suitable pressure relief valve. If LNG fuel tanks are located in enclosed or semi enclosed rooms, the pressure relief device is to be connected to a vent system.

3.3.3 Each gas fuel tank is to be fitted with at least two pressure relief valves that can prevent an overpressure if one of the valves is closed off due to malfunctioning, leakage or maintenance.

3.3.4 The setting of the PRVs is not to be higher than the vapour pressure that has been used in the design of the tank. Valves comprising not more than 50% of the total relieving capacity may be set at a pressure up to 5% above MARVS to allow sequential lifting, minimizing unnecessary release of vapour.

3.3.5 The following temperature regulations apply to PRVs fitted to pressure relief systems:

.1 PRVs on fuel tanks with a design temperature below 0 [^{o}C] is to be designed and arranged to prevent their becoming inoperative due to ice formation;

.2 PRVs are to be constructed of materials with a melting point above 925 [°C]. Lower melting point materials for internal parts and seals may be accepted provided that fail-safe operation of the PRV is not compromised; and

.3 sensing and exhaust lines on pilot operated relief valves are to be of suitably robust construction to prevent damage.

3.3.6 In the event of a failure of a fuel tank PRV a safe means of emergency isolation is to be available.

.1 procedures are to be provided and included in the operation manual;

.2 the procedures are to allow only one of the installed PRVs for the liquefied gas fuel tanks to be isolated, physical interlocks are to be included to this effect; and

.3 isolation of the PRV is to be carried out under the supervision of the master. This action is to be recorded in the ship's log, and at the PRV.

3.3.7 Each pressure relief valve installed on a liquefied gas fuel tank is to be connected to a venting system, which is to be:

.1 so constructed that the discharge will be unimpeded and normally be directed vertically upwards at the exit;

.2 arranged to minimize the possibility of water entering the vent system; and

3.3.8 The exhaust outlets of the pressure relief valves are to be located not less than 3 m above the weather deck at a distance of not less than 6 m from the accommodation, passenger areas and work stations, which are located outside the hold or the cargo area. This height may be reduced when within a radius of 1 m round the pressure relief valves outlet there is no equipment, no work is being carried out, signs indicate the area and appropriate measures to protect the deck are being taken.

3.3.9 Sizing of pressure relieving system (pressure relief valves and vent pipes) is to be in accordance with IGF Code.

3.4 Portable Liquefied Gas Fuel Tanks

3.4.1 The design of the tank is to be in accordance with 3.2.3. The tank support (container frame or truck chassis) is to be designed for the intended purpose.

3.4.2 Portable fuel tanks are to be located in dedicated areas fitted with:

> .1 mechanical protection of the tanks depending on location and cargo operations;
>
> .2 if located on open deck: spill protection and water spray systems for cooling; and
>
> .3 if located in an enclosed space: the space is to be considered as a tank connection space.

3.4.3 Portable fuel tanks are to be secured to the deck while connected to the ship systems. The arrangement for supporting and fixing the tanks are to be designed for the maximum expected static and dynamic inclinations, as well as the maximum expected values of acceleration, taking into account the ship characteristics and the position of the tanks.

3.4.4 Consideration is to be given to the strength and the effect of the portable fuel tanks on the ship's stability.

3.4.5 Connections to the ship's fuel piping systems are to be made by means of approved flexible hoses or other approved means designed to provide sufficient flexibility.

3.4.6 Arrangements are to be provided to limit the quantity of fuel spilled in case of inadvertent disconnection or rupture of the non-permanent connections.

3.4.7 The pressure relief system of portable tanks is to be connected to a fixed venting system.

3.4.8 Control and monitoring systems for portable fuel tanks are to be integrated in the ship's control and monitoring system. Safety system for portable fuel tanks is to be integrated in the ship's safety system (e.g. shutdown systems for tank valves, leak / gas detection systems).

3.4.9 Safe access to tank connections for the purpose of inspection and maintenance is to be ensured.

3.4.10 After connection to the ship's fuel piping system:

.1 with the exception of the pressure relief system in 3.4.6, each portable tank is to be capable of being isolated at any time;

.2 isolation of one tank is not to impair the availability of the remaining portable tanks; and

.3 the tank is not to exceed its filling limits as given in 3.6.

3.5 CNG Fuel Containment

3.5.1 The storage tanks to be used for CNG are to be certified and approved by IRS/ Administration. The CNG storage tanks may of portable type.

3.5.2 Tanks for CNG are to be fitted with pressure relief valves with a set point below the design pressure of the tank and with outlet located as required in 3.3.7 and 3.3.8.

3.5.3 Adequate means are to be provided to depressurize the tank in case of a fire which can affect the tank.

3.5.4 Storage of CNG in enclosed spaces is normally not acceptable, but may be permitted after special consideration and approval by IRS/ Administration provided the following is fulfilled:

.1 all tank connections, fittings, flanges and tank valves are to be enclosed in gas tight tank connection spaces, unless the tank connections are on open deck. The space is to be able to safely contain leakage from the tank in case of leakage from the tank connections;

.2 piping between the tank and the first valve which release liquid in case of pipe failure is to have equivalent safety as the type C tank, with dynamic stress not exceeding the design values;

.3 adequate means are provided to depressurize and inert the tank in case of a fire which can affect the tank;

.4 all surfaces within such enclosed spaces containing the CNG storage are provided with suitable thermal protection against any lost high-pressure gas and resulting condensation unless the bulkheads are designed for the lowest temperature that can arise from gas expansion leakage; and

.5 a fixed fire-extinguishing system is installed in the enclosed spaces containing the CNG storage. Special consideration is to be given to the extinguishing of jet-fires.

3.6 Loading Limits for Liquefied Gas Fuel Tanks

3.6.1 The level of liquefied natural gas (LNG) in the LNG fuel tank is not to exceed the filling limit of 95 % full at the reference temperature. The reference temperature means the temperature corresponding to the vapour pressure of the fuel at the opening pressure of the pressure relief valves.

3.6.2 A filling limit curve for liquefied natural gas (LNG) filling temperatures is to be prepared from the following formula:

$$LL = FL\ \rho_R/\rho_L$$

where:

LL = loading limit, maximum allowable liquid volume relative to the LNG fuel tank volume to which the tank may be loaded, expressed in per cent,

FL= filling limit expressed in per cent, here 95 %,

ρR = relative density of fuel at the reference temperature,

ρL = relative density of fuel at the loading temperature.

3.7 Maintenance of Fuel Storage Condition

3.7.1 With the exception of liquefied gas fuel tanks designed to withstand the full gauge vapour pressure of the fuel under conditions of the upper ambient design temperature, LNG fuel tanks' pressure and temperature is to be maintained at all times within their design range by means acceptable to IRS/ Administration, e.g. by one of the following methods:

.1 Re-liquefaction of vapours;
.2 Thermal oxidation of vapours;
.3 Pressure accumulation; or
.4 Liquefied gas cooling

3.7.2 Venting of fuel vapours for control of the tank pressure is not acceptable except in emergency situations.

3.7.3 The overall capacity of the system is to be such that it can control the pressure within the design conditions without venting to atmosphere.

3.7.4 The method chosen in 3.7.1 is to be such that the pressure in the LNG fuel tank, is maintained below the maximum working pressure of the LNG fuel tank for a period of 15 days. It is to be assumed that LNG fuel tank was filled at filling limits according to 3.6 and that the vessel remains in idle condition.

3.8 Environmental Control of Spaces Surrounding Type C Independent Tanks

3.8.1 If condensation and icing due to cold surfaces of LNG fuel tanks may lead to safety or functional problems, appropriate preventive or remedial measures are to be taken.

Section 4

Piping Design

4.1 General Requirements

4.1.1 Fuel piping is to be capable of absorbing thermal expansion or contraction caused by extreme temperatures of the fuel without developing substantial stresses.

4.1.2 Provision is to be made to protect the piping, piping system and components and fuel tanks from excessive stresses due to thermal movement and from movements of the fuel tank and hull structure.

4.1.3 If the fuel gas contains heavier constituents that may condense in the system, means for safely removing the liquid is to be fitted.

4.1.4 Low temperature piping is to be thermally isolated from the adjacent hull structure, where necessary, to prevent the temperature of the hull from falling below the design temperature of the hull material. Protection against accidental contact is to be provided.

4.1.5 Where tanks or piping are separated from the ship's structure by thermal isolation, provision is to be made for electrically bonding to the ship's structure both the piping and the tanks. All gasketed pipe joints and hose connections are to be electrically bonded.

4.1.6 All piping and all components which can be isolated with valves from the LNG system in a liquid full condition are to be provided with pressure relief valves.

4.1.7 The design pressure of piping is not to be less than 150 % of the maximum working pressure. The maximum working pressure of piping inside rooms is not to exceed 1000 kPa (See also 6.7.1).

4.1.8 Gas piping in ESD protected engine rooms are to be located as far away as practicable from the electrical installations and tanks containing flammable liquids.

4.1.9 Piping, piping system and components are to be designed in accordance with recognized standards (e.g. IGF Code).

Section 5

Bunkering

5.1 General Requirements

5.1.1 The piping system for transfer of fuel to the storage tank is to be designed such that any leakage from the piping system cannot cause danger to personnel, the environment or the ship.

5.1.2 The bunkering piping system is to be designed for bunkering methods such as Truck to Ship Transfer, Ship to Ship Transfer or Shore to Ship transfer, as applicable for the intended operation of the ship. Relevant statutory regulations of National/ local authorities regarding bunkering operations are to be complied with in addition to these requirements.

5.1.3 The composition of natural gas supplied is to be suitable for the operation of machinery according to the manufacturer's requirements.

5.2 Bunkering Station

5.2.1 The bunkering station and all valves used for bunkering, shall be located on open deck so that sufficient natural ventilation is provided.

5.2.2 The bunkering station is to be so positioned and arranged that any damage to the gas piping does not cause damage to the vessel's natural gas fuel containment system.

5.2.3 Suitable means are to be provided to relieve the pressure and remove liquid contents from pump suctions and bunker piping.

5.2.4 Arrangements are to be made for safe management of any spilled fuel.

5.2.5 The surrounding hull or deck structures are not to be exposed to unacceptable cooling, in case of leakage of fuel.

5.3 Manifold

5.3.1 The bunkering manifold is to be designed to withstand normal mechanical loads during bunkering. The connections are to be of dry-disconnect type in accordance with a recognized standard, equipped with appropriate additional safety dry break-away couplings.

5.4 Bunkering System

5.4.1 An arrangement for purging fuel bunkering lines with inert gas (Nitrogen) is to be provided.

5.4.2 The bunkering system is to be so arranged that no gas is discharged to the atmosphere during filling of storage tanks.

5.4.3 Means are to be provided for draining any fuel from the bunkering pipes upon completion of operation.

5.4.4 In case bunkering lines are arranged with a cross-over it shall be ensured by suitable isolation arrangements that no fuel is transferred inadvertently to the ship side not in use for bunkering.

5.4.5 A manually operated stop valve and a remote operated shutdown valve in series, or a combined manually operated and remote valve shall be fitted in every bunkering line close to the connecting point. It shall be possible to operate the remote valve in the control location for bunkering operations and/or from another safe location.

5.4.6 Suitable means are to be provided to monitor and communicate with the bunkering source. The ESD is to be available at the bunkering source/ supply point.

5.5 Ship’s Fuel Hoses

5.5.1 Liquid and vapour hoses used for fuel transfer are to be compatible with the fuel and suitable for the fuel temperature.

5.5.2 Hoses subject to tank pressure, or the discharge pressure of pumps or vapour compressors, are to be designed for a bursting pressure not less than five times the maximum pressure the hose can be subjected to during bunkering.

Section 6

Fuel Supply to Consumers

6.1 General Requirements

6.1.1 The gas supply system is to be so arranged that the consequences of any release of gas will be minimized, while providing safe access for operation and inspection.

6.1.2 The piping system for fuel transfer to the consumers is to be designed in a way that a failure of one barrier cannot lead to a leak from the piping system into the surrounding area causing danger to the persons on board, the environment or the ship.

6.1.3 The parts of the gas supply system which are located outside the engine room are to be designed in a way that a failure of one barrier cannot lead to a leak from the system into the surrounding area causing immediate danger to the people on board, the environment or the ship.

6.2 Redundancy of Fuel Supply

6.2.1 For single fuel installations the fuel supply system is to be arranged with full redundancy and segregation all the way from the fuel tanks to the consumer, so that a leakage in one system does not lead to an unacceptable loss of power.

6.2.2 For single fuel installations, the fuel storage is to be divided between two or more tanks. The tanks are to be located in separate compartments. One tank may be accepted if two completely separate tank connection spaces are installed for the one tank.

6.3 Safety Functions of Gas Supply System

6.3.1 Natural gas fuel tank inlets and outlets are to be provided with valves located as close to the tank as possible.

6.3.2 The gas supply system to each engine or set of engines is to be equipped with a master gas fuel valve. The valves are to be situated as close as practicable to the gas preparation system but in any case outside the engine room.

6.3.3 The master gas fuel valve is to be operable

a) within and outside the engine room,

b) from the wheelhouse.

6.3.4 Each gas consuming equipment is to be provided with a set of double block and bleed valves to assure safe isolation of the fuel supply system. The two block valves shall be of the fail-to-close type, while the ventilation valve shall be fail-to-open type.

6.4 Fuel Distribution Outside Machinery Spaces

6.4.1 Where fuel pipes pass through enclosed spaces in the ship, they are to be protected by a secondary enclosure. This enclosure can be a ventilated duct or a double wall piping system.

6.4.2 Above requirement need not be applied for fully welded fuel gas vent pipes led through mechanically ventilated spaces

6.5 Fuel Supply in Gas Safe Machinery Spaces

6.5.1 Fuel piping in gas-safe machinery spaces are to be installed within a double walled pipe or duct. The ventilation system for the double walled pipe or duct is to be provided in accordance with 10.5.1

6.6 Fuel Supply to Consumers in ESD-Protected Machinery Spaces

6.6.1 The pressure in the gas fuel supply system is not to exceed 1.0 MPa.

6.6.2 The gas fuel supply lines are to have a design pressure not less than 1.0 MPa.

6.7 Design of Ventilated Duct, Outer Pipe against Inner Pipe Gas Leakage

6.7.1 The design pressure of the outer pipe or duct of fuel systems are not to be less than the maximum working pressure of the inner pipe. Alternatively for fuel piping systems with a working pressure greater than 1.0 MPa, the design pressure of the outer pipe or duct is not to be less than the maximum built-up pressure arising in the annular space considering the local instantaneous peak pressure in way of any rupture and the ventilation arrangements (See also 4.1.7).

6.8 Compressors and Pumps

6.8.1 Compressors and pumps are to be suitable for their intended purpose. All equipment and machinery are to be such as to be adequately tested to ensure suitability for use within a marine environment. Such items to be considered would include, but not be limited to:

- a) environmental;
- b) shipboard vibrations and accelerations;
- c) effects of pitch, heave and roll motions, etc.; and
- d) gas composition.

6.8.2 Suitable drip trays are to be provided below gas fuel compressors and pumps in accordance with 2.6.1.

Section 7

Power Generation for Propulsion and other Consumers

7.1 General Requirements

7.1.1 The safety, reliability and dependability of the systems are to be equivalent to that achieved with new and comparable oil-fueled main and auxiliary machinery.

7.1.2 Machinery, systems and components are to be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.

7.1.3 The exhaust system is to be configured to keep accumulation of unburned gaseous fuel as low as possible.

7.1.4 Engine components or systems containing or likely to contain an ignitable gas and air mixture are to be fitted with suitable pressure relief systems unless designed with the strength to withstand the worst case over pressure due to ignited gas leaks. Depending on the particular engine design this may include the air inlet manifolds and scavenge spaces.

7.1.5 The explosion venting is to be led away from where personnel may normally be present.

7.1.6 The exhaust pipes of gas or dual fuel engines are not to be connected to the exhaust pipes of other engines or systems.

7.2 Internal Combustion Engines of Piston Type

7.2.1 The exhaust system is to be equipped with explosion relief ventilation sufficiently dimensioned to prevent excessive explosion pressures in the event of ignition failure of one cylinder followed by ignition of the unburned gas in the system.

7.2.2 For engines where the space below the piston is in direct communication with the crankcase a detailed evaluation regarding the hazard potential of fuel gas accumulation in the crankcase is to be carried out and reflected in the safety concept of the engine.

7.2.3 Each engine other than two-stroke crosshead diesel engines is to be fitted with vent systems independent of other engines for crankcases and sumps.

7.2.4 Where gas can leak directly into the auxiliary system medium (lubricating oil, cooling water), an appropriate means is to be fitted after the engine outlet to extract gas in order to prevent gas dispersion. The gas extracted from auxiliary systems media is to be vented to a safe location in the atmosphere.

7.2.5 For engines fitted with ignition systems, prior to admission of gas fuel, correct operation of the ignition system on each unit is to be verified.

7.2.6 A means is to be provided to monitor and detect incorrect operation of the ignition system, poor combustion or mis-firing that may lead to unburned gaseous fuel in the exhaust system during operation.

7.2.7. If incorrect operation of the ignition system, poor combustion or mis-firing is detected, the gas supply system is to be shut down automatically. Means to ensure that any unburnt fuel mixture is purged away from the exhaust system are to be provided.

7.3 Dual Fuel Engines

7.3.1 In case of shutoff of the gas fuel supply, the engines are to be capable of continuous operation by oil fuel only without interruption.

7.3.2 An automatic system is to be fitted to change over from gas fuel operation to oil fuel operation and vice versa with minimum fluctuation of the engine power. Acceptable reliability is to be demonstrated through testing. In the case of unstable operation on engines when gas firing, the engine is to automatically change to oil fuel mode. Manual activation of gas system shutdown is to be possible always.

7.3.3 In case of a normal stop or an emergency shutdown, the gas fuel supply is to be shut off not later than the ignition source. It is not to be possible to shut off the ignition source without first or simultaneously closing the gas supply to each cylinder or to the complete engine.

7.4 Gas Only Engines

7.4.1 In case of a normal stop or an emergency shutdown, the gas fuel supply is to be shut off not later than the ignition source. It shall not be possible to shut off the ignition source without first or simultaneously closing the gas supply to each cylinder or to the complete engine.

Section 8

Fire Safety

8.1 General Requirements

8.1.1 Fire detection, protection and extinction measures appropriate to the hazards concerned are to be provided.

8.1.2 The fuel preparation system is to be regarded as an engine room for fire protection purposes.

8.1.3 The requirements given in this section are in addition to the general fire safety requirements applicable to the ship as given in the applicable Rules.

8.2 Fire Alarm System

8.2.1 A suitable fixed fire alarm system is to be provided for all rooms of the Natural gas system where fire cannot be excluded.

8.2.2 Smoke detectors alone are not sufficient for rapid detection of a fire.

8.2.3 The fire detection system is to have the means to identify each detector individually.

8.2.4 The gas safety system is to shut down the relevant parts of the gas supply system automatically, upon fire detection in rooms containing gas installations.

8.3 Fire Protection

8.3.1 Accommodation, passenger areas, engine rooms and escape routes are to be shielded with Type A60 partitions, where the distance is less than 3 m to fuel tanks and bunkering stations located on deck.

8.3.2 The boundaries of fuel tank rooms and ventilation ducts to such rooms below the bulkhead deck are to comply with Type A60. However, where the room is adjacent to tanks, voids, auxiliary engine rooms of little or no fire risk, sanitary and similar spaces, the insulation may comply with Type A0.

8.3.3 If an ESD protected machinery spaces is separated by a single boundary, the boundary is to be of A-60 class division.

8.4 Water Spray System

8.4.1 A water spray system is to be installed for cooling and fire prevention to cover exposed parts of fuel tank(s) located on open deck.

8.4.2 The water spray system is also to provide coverage for boundaries of the superstructures, unless the tank is located 3 m or more from the boundaries.

8.4.3 In case the bunkering connection is near the ship side then a water curtain is to be provided for the shipside in way of the bunkering connection.

8.4.4 The water spray system is to be designed to cover all areas as specified above with an application rate of 10 l/min/m^2 for horizontal projected surfaces and 4 l/min/m^2 for vertical surfaces.

8.4.5 The water spray system is to be capable of being put into operation from the wheelhouse and from the deck.

8.4.6 The nozzles are to be arranged to ensure an effective distribution of water throughout the area being protected.

8.4.7 If the water spray system is part of the firefighting systems of the vessel, the required fire pump capacity and working pressure is to be sufficient to ensure the operation of both the required numbers of hydrants and hoses and the water spray system simultaneously. The connection between water spray system and the firefighting systems of the vessel is to be provided through a screw-down non-return valve.

8.4.8 If firefighting systems of the vessel are installed onboard a vessel where the fuel tank is located on open deck, isolating valves are to be fitted in the firefighting systems in order to isolate damaged sections of the firefighting systems. Isolation of a section of firefighting systems is not to deprive the fire line ahead of the isolated section of water.

8.5 Fire Extinguishers

8.5.1 In addition to fire-extinguishing requirements of the vessel, two additional portable dry powder fire extinguishers of at least 12 kg capacity are to be located near the bunkering station. They are to be suitable for Class C fires.

Section 9

Explosion Prevention

9.1 General Requirements

9.1.1 The probability of explosions is to be reduced to a minimum by:

a) reducing number of sources of ignition; and

b) reducing the probability of formation of ignitable mixtures.

9.1.2 Hazardous area zones on open deck and other spaces are defined in 9.3.

9.1.3 Electrical equipment and wiring is in general not to be installed in hazardous areas unless essential for operational purposes based on a recognized standard.

9.1.4 Electrical equipment fitted in an ESD-protected machinery space is to fulfil the following:

a) in addition to fire and gas hydrocarbon detectors and fire and gas alarms, lighting and ventilation fans are to be certified safe for hazardous area zone 1; and

b) all electrical equipment in a machinery space containing gas-fueled engines, and not certified for zone 1 is to be automatically disconnected, if gas concentrations above 40% LEL is detected by two detectors in the space containing gas-fueled consumers.

9.2 Area Classification

9.2.1 Area classification is a method of analyzing and classifying the areas where explosive gas atmospheres may occur. The object of the classification is to allow the selection of electrical apparatus able to be operated safely in these areas.

9.2.2 In order to facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2.

9.2.3 Ventilation ducts are to have the same area classification as the ventilated space.

9.3 Hazardous Areas Zones

9.3.1 Zone 0 is area in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently. This zone includes, but is not limited to the interiors of fuel tanks, any pipework for pressure-relief or other venting systems for fuel tanks, pipes and equipment containing fuel.

9.3.2 Zone 1 is area in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally. This zone includes, but is not limited to:

a) tank connection spaces, fuel storage hold spaces and interbarrier spaces;

b) fuel preparation room arranged with ventilation according to Section 10;

c) areas on open deck, or semi-enclosed spaces on deck, within 3 m of any fuel tank outlet, gas or vapour outlet, bunker manifold valve, other fuel valve, fuel pipe flange, fuel preparation room ventilation outlets and fuel tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation;

d) areas on open deck or semi-enclosed spaces on deck, within 1.5 m of fuel preparation room entrances, fuel preparation room ventilation inlets and other openings into zone 1 spaces;

e) areas on the open deck within spillage coamings surrounding gas bunker manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck;

f) enclosed or semi-enclosed spaces in which pipes containing fuel are located, e.g. ducts around fuel pipes, semi-enclosed bunkering stations;

g) the ESD-protected machinery space is considered a non-hazardous area during normal operation, but will require equipment required to operate following detection of gas leakage to be certified as suitable for zone 1;

h) a space protected by an airlock is considered as non-hazardous area during normal operation, but will require equipment required to operate following loss of differential pressure between the protected space and the hazardous area to be certified as suitable for zone 1; and

i) except for type C tanks, an area within 2.4 m of the outer surface of a fuel containment system where such surface is exposed to the weather.

9.3.3 Zone 2 is area in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only. This zone includes, but is not limited to areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1.

Section 10

Ventilation

10.1 General Requirements

10.1.1 Ventilators in hazardous areas are to be of a certified safe type.

10.1.2 Electric motors driving ventilators are to comply with the required explosion protection in the installation area.

10.1.3 An audible and visual alarm is to be triggered at a permanently manned location (e.g. wheelhouse) in the event of any loss of the required ventilating capacity.

10.1.4 Any ducting used for the ventilation of hazardous areas is to be separate from that used for the ventilation of non-hazardous areas.

10.1.5 Required ventilation systems are to have at least two ventilators with independent power supply, each of sufficient capacity, to avoid any gas accumulation. At least one of the ventilation fans is to be of reversible type.

10.1.6 Air for hazardous rooms is to be taken from non-hazardous areas.

10.1.7 Air for non-hazardous rooms is to be taken from non-hazardous areas at least 1.50 m away from the boundaries of any hazardous area.

10.1.8 Where the inlet duct passes through a hazardous room, the duct is to have over-pressure relative to this room. Overpressure is not required when structural measures on the duct ensure that gases will not leak into the duct.

10.1.9 Air outlets from hazardous rooms are to be located in an open area which is of the same or less hazard than the ventilated room.

10.1.10 Air outlets from non-hazardous rooms are to be located outside hazardous areas.

10.1.11 In enclosed rooms the ventilation exhaust ducts are to be located at the top of these rooms. Air inlets are to be located at the bottom.

10.2 Ventilation for Tank Connection Space and/or Fuel Preparation Room

10.2.1 The tank connection space is to be provided with an effective mechanical forced ventilation system of extraction type. A ventilation capacity of at least 30 air changes per hour is to be provided.

10.2.2 Approved automatic fail-safe fire dampers are to be fitted in the ventilation trunk for the tank connection space

10.3 Ventilation for Machinery Spaces

10.3.1 The ventilation system is to be:

a) independent of all other ventilation systems

b) guarantee a sufficient capacity to ensure that the gross volume of air inside the engine room can be changed at least 30 times per hour, and

c) be designed to handle the probable maximum leakage scenario due to technical failures

10.3.2 Under normal operation the engine room is to be permanently ventilated with at least 15 changes of the gross volume of air inside the engine room per hour. If gas is detected in the engine room, the number of air changes are to automatically be increased to 30 changes per hour.

10.4 Ventilation for Bunkering Station (see 5.2.1)

10.5 Ventilation for Ducts and Double Pipes

10.5.1 The ventilation system of ventilated ducting is to:

a) guarantee a sufficient capacity to ensure that the gross volume of air inside the ventilated ducting can be changed at least 30 times per hour;

b) be equipped to detect gas presence continuously in the space between inner and outer pipes;

c) be independent of all other ventilation systems, in particular the ventilation system of the engine room.

Section 11

Electrical Installations

11.1 General Requirements

11.1.1 Equipment for hazardous areas are to be of an appropriate type according to zones where such equipment is installed. It is recommended that electrical equipment in hazardous areas are to be selected, installed and maintained according to recognized standards, such as IEC 60092-502:1999. Equipment for hazardous areas is to be either type approved or certified by a suitable accredited agency / testing body / RO.

11.1.2 Electrical generation, distribution systems and associated control systems are to be designed such that a single failure will not result in the release of gas and the ability to maintain fuel tank pressures and hull structure temperature within normal operating limits.

11.1.3 The installation on board of the electrical equipment units is to be such as to ensure the safe bonding to the hull of the units themselves.

11.1.4 The lighting system in hazardous areas are to be divided between at least two branch circuits. All switches and protective devices are to interrupt all poles and phases and are to be located in a non-hazardous area.

11.1.5 Submerged gas pump motors and their supply cables may be fitted in LNG containment systems. Fuel pump motors are to be capable of being isolated from their electrical supply during gas-freeing operations.

11.1.6 Arrangements are to be made to alarm in low liquid level and automatically shut down the motors in the event of low-low liquid level. The automatic shutdown may be accomplished by sensing low pump discharge pressure, low motor current, or low liquid level. This shutdown is to give an audible and visual alarm in the wheelhouse.

11.1.7 For non-hazardous spaces with access from hazardous open deck where the access is protected by an airlock, electrical equipment which is not of the certified safe type is to be de-energized upon loss of overpressure in the space.

11.1.8 Essential equipment required for safety is not to be de-energized and is to be of a certified safe type. This may include lighting, fire detection, public address, general alarms systems.

11.1.9 Electrical equipment for propulsion, power generation, manoeuvring, anchoring and mooring, as well as emergency fire pumps, that are located in spaces protected by airlocks, are to be of a certified safe type.

Section 12

Control, Monitoring and Safety Systems

12.1 General Requirements

12.1.1 Suitable control, alarm, monitoring and shutdown systems are to be provided to ensure safe and reliable operation.

12.1.2 The safety functions are to be arranged in a dedicated gas safety system that is independent of the gas control system in order to avoid possible common failures. This includes power supplies and input and output signal.

12.1.3 The gas supply system is to be fitted with its own set of independent gas control, gas monitoring and gas safety systems. All elements of these systems are to be capable of being functionally tested.

12.1.4 The gas safety system is to shut down the gas supply system automatically, upon failure in systems, as indicated in Table 12.1.5 and upon fault conditions which may develop too fast for manual intervention.

12.1.5 For ESD protected machinery configurations the safety system is to shutdown gas supply upon gas leakage and in addition disconnect all non-certified safe type electrical equipment in the machinery space.

12.1.6 Suitable instrumentation devices are to be fitted to allow a local and a remote reading of essential parameters where they are necessary to ensure a safe operation of the whole gas fuel system including bunkering.

12.2 Bunkering Monitoring

12.2.1 Each LNG fuel tank is to be fitted with:

a) at least two liquid level indicators, which are to be arranged so that they can be maintained in an operational condition;

b) a pressure indicator capable of indicating throughout the operating pressure range and which is clearly marked with the maximum working pressure of the LNG fuel tank;

c) a high liquid level alarm operating independently of other liquid level indicators which is to give an audible and visual alarm when activated;

d) an additional sensor operating independently of the high liquid level alarm which is to automatically actuate the master LNG bunkering valve in a manner that will both avoid excessive liquid pressure in the bunkering piping and prevent the tank from becoming liquid full.

12.2.2 Each pump discharge line and each liquid and vapour gas shore connection is to be provided with at least one local pressure indicator. In the pump discharge line, the indicator is to be placed between the pump and the first valve. The permissible maximum pressure or vacuum value is to be indicated on each indicator.

12.2.3 A high-pressure alarm is to be provided at the fuel containment system and at the pump. Where vacuum protection is required, a low-pressure alarm is to be provided.

12.2.4 Control of the bunkering is to be possible from a safe control station remote from the bunkering station. At this control station the fuel tank pressure and level is to be monitored. Overfill alarm, high and low-pressure alarm and automatic shutdown is to be indicated at this control station.

12.2.5 If the ventilation in the ducting enclosing the bunkering lines stops, an audible and visual alarm is to be actuated at the control station.

12.2.6 If gas is detected in the ducting enclosing the bunkering piping an audible and visual alarm and emergency shut-down is to be actuated at the control station.

12.2.7 Appropriate and sufficient suitable protective clothing and equipment for bunkering operations are to be available on board according to operating manual.

12.3 Monitoring of Engine Operations

12.3.1 Indicators are to be fitted in the wheelhouse and the engine room for:

a) operation of the engine in case of a gas-only engine, or

b) operation and mode of operation of the engine in the case of a dual fuel engine.

12.4 Gas Detection Equipment

12.4.1 Gas detection equipment is to be designed, installed and tested in accordance with a recognized standard, such as IS/ IEC 60079-29-1 : 2007.

12.4.2 Permanently installed gas detectors are to be fitted in:

a) tank connection areas including fuel tanks, pipe connections and first valves;
b) ducts around gas piping;
c) engine rooms containing gas piping, gas equipment or gas consuming equipment;
d) the room containing the gas preparation system;
e) other enclosed rooms containing gas piping or other gas equipment without ducting;
f) other enclosed or semi-enclosed rooms where gas vapours may accumulate;
g) air locks, and
h) ventilation inlets to rooms in which gas vapours may accumulate.

12.4.3 As a relaxation to 12.4.2, permanently installed sensors which detect gas by difference of pressure can be used for inter barrier spaces in double wall piping.

12.4.4 The number and redundancy of gas detectors in each room is to be considered taking size, layout and ventilation of the room into account.

12.4.5 Permanently installed gas detectors are to be located where gas may accumulate and in the ventilation outlets of these rooms.

12.4.6 An audible and visual alarm is to be activated before the gas concentration reaches 20 % of the lower explosive limit. The gas safety system is to be activated at 40 % of the lower explosive limit.

12.4.7 For ventilated ducts around gas pipes in the machinery spaces, containing gas fueled engines, the alarm limit may be set to 30% LEL. The safety system is to be activated at 60% of the LEL at two detectors.

12.4.8 Audible and visual alarms from the gas warning equipment are to be actuated in the wheelhouse.

12.5 Safety Functions of Gas Supply Systems

12.5.1 If the gas supply system is shut off due to activation of an automatic valve, it is not to be opened until the reason for the disconnection is ascertained and the necessary actions taken. Instructions to this effect are to be placed at a prominent position at the control station for the shut-off valves in the gas supply lines.

12.5.2 If the gas supply system is shut off due to a gas leak, it is not to be opened until the leak has been found and the necessary actions have been taken. Instructions to this effect are to be placed at a prominent position in the engine room.

12.5.3 The gas supply system is to be arranged for manual remote emergency stop from the following locations as applicable:

a) wheelhouse,

b) control station of the bunkering station,

c) any permanently manned location.

Table 12.1.5 : Monitoring of gas supply system to engines

Parameter	Alarm	Automatic shutdown of tank valve[5)]	Automatic shutdown of gas supply to machinery space containing gas-fuelled engines	Comments
Gas detection in tank connection space at 20% LEL	X			
Gas detection on two detectors[1)] in tank connection space at 40% LEL	X	X		
Fire detection in fuel storage hold space	X			
Fire detection in ventilation trunk to the tank connection space and in the tank connection space	X			
Bilge well high level in tank connection space	X			
Bilge well low temperature in tank connection space	X	X		
Gas detection in duct between tank and machinery space containing gas-fuelled engines at 20% LEL	X			
Gas detection on two detectors[1)] in duct between tank and machinery space containing gas-fuelled engines at 40% LEL	X	X[2)]		
Gas detection in fuel preparation room at 20% LEL	X			
Gas detection on two detectors[1)] in fuel preparation room at 40% LEL	X	X[2)]		
Gas detection in duct inside machinery space containing gas-fuelled engines at 30% LEL	X			If double pipe fitted in machinery space containing gas-fuelled engines
Gas detection on two detectors[1)] in duct inside machinery space containing gas-fuelled engines at 60% LEL	X		X[3)]	If double pipe fitted in machinery space containing gas-fuelled engines
Gas detection in ESD protected machinery space containing gas-fuelled engines at 20% LEL	X			

Parameter	Alarm	Automatic shutdown of tank valve[5)]	Automatic shutdown of gas supply to machinery space containing gas-fuelled engines	Comments
Gas detection on two detectors[1)] in ESD protected machinery space containing gas-fuelled engines at 40% LEL	X		X	It shall also disconnect non certified safe electrical equipment in machinery space containing gas-fuelled engines
Loss of ventilation in duct between tank and machinery space containing gas-fuelled engines	X		X[2)]	
Loss of ventilation in duct inside machinery space containing gas-fuelled engines	X		X[3)]	If double pipe fitted in machinery space containing gas-fuelled engines
Loss of ventilation in ESD protected machinery space containing gas-fuelled engines	X		X	
Fire detection in machinery space containing gas-fuelled engines	X			
Abnormal gas pressure in gas supply pipe	X			
Failure of valve control actuating medium	X		X[4)]	Time delayed as found necessary
Automatic shutdown of engine (engine failure)	X		X[4)]	
Manually activated emergency shutdown of engine	X		X	

1) Two independent gas detectors located close to each other are required for redundancy reasons. If the gas detector is of self-monitoring type the installation of a single gas detector can be permitted.

2) If the tank is supplying gas to more than one engine and the different supply pipes are completely separated and fitted in separate ducts and with the master valves fitted outside of the duct, only the master valve on the supply pipe leading into the duct where gas or loss of ventilation is detected shall close.

3) If the gas is supplied to more than one engine and the different supply pipes are completely separated and fitted in separate ducts and with the master valves fitted outside of the duct and outside of the machinery space containing gas-fuelled engines, only the master valve on the supply pipe leading into the duct where gas or loss of ventilation is detected shall close.

4) Only double block and bleed valves to close.
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5) Valves referred to in 6.3.1.