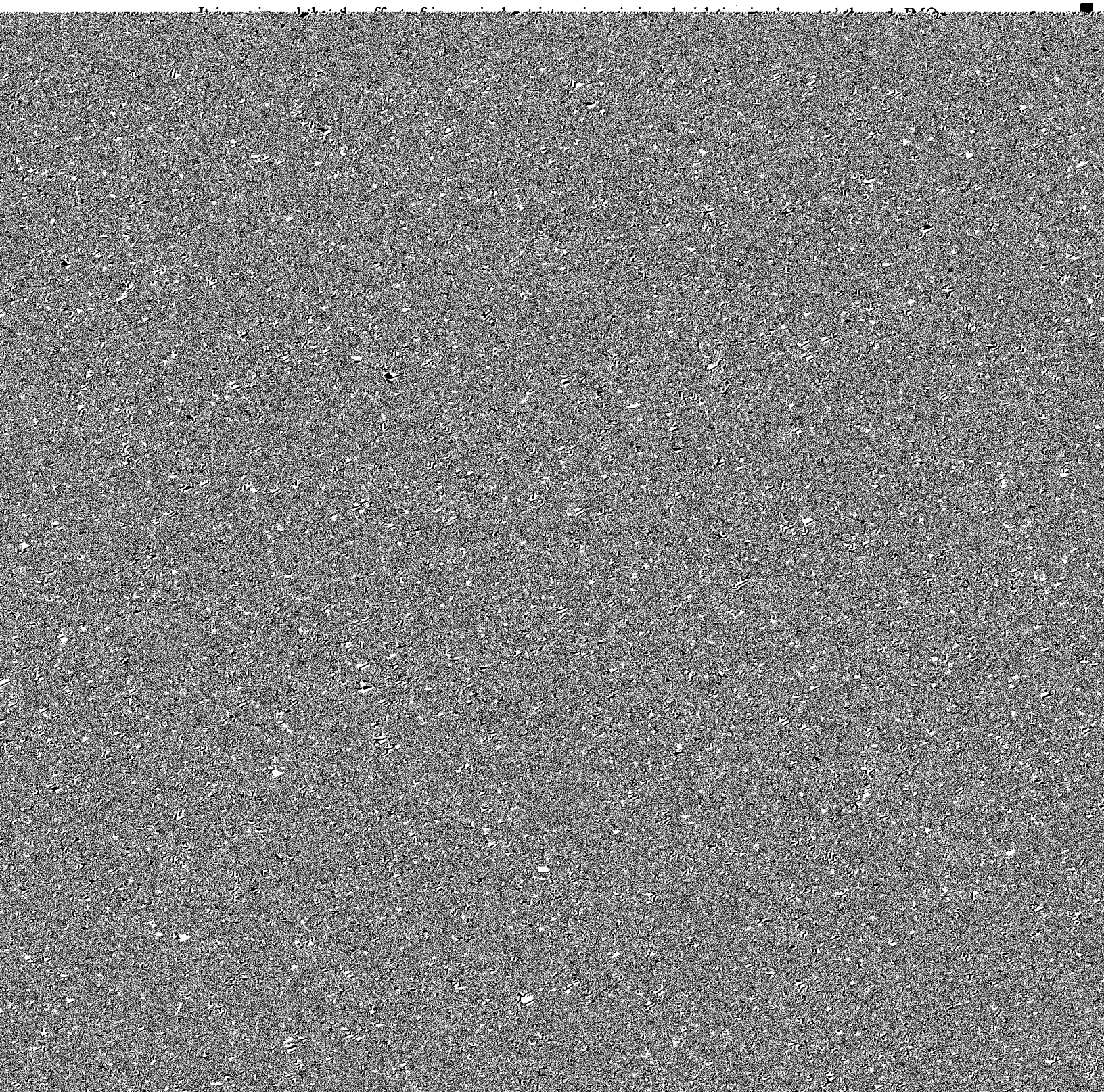
Foreword

In recent years, medium speed dual fuel diesel engines have been chosen to power a number of new LNG carriers in preference to the traditional steam turbine powered propulsion plant arrangements. This has improved operational efficiency and reduced engine room space requirements. Furthermore dual fuel and single fuel engines have been successfully installed and operated in a number of offshore support vessel and ferry applications.



- The vessel and systems are to be arranged with sufficient redundancy so as to provide continuity of electrical and propulsion power in the event of an automatic safety shut down of fuel gas supply.
- Explosion protection and fire protection, detection and extinguishing arrangements and systems are to be provided to protect the vessel and crew from possible hazards associated with using natural gas as fuel.

3 Definitions

3.1 Block and Bleed Valve

Block and Bleed Valve means a set of two valves located in series to the fuel supply to each of the gas utilization units with a third valve that vents that portion of the gas fuel piping that is between the two valves in series. See also 5/3.1ii) of this Guide. This set of valves is referred to as "Double Block and Bleed" by the *Interim Guidelines*.

3.2 BOG Utilization System

A *BOG (boil-off gas) Utilization System* is an arrangement of BOG consumers (e.g., gas combustion unit, re- Liquefaction units, dual fuel auxiliary generator) including piping systems, electrical systems, control and safety systems, which may be used for controlling gas fuel storage tank pressure and maintaining it below the maximum allowable relief valve setting.

3.3 Certified Safe Type

Certified Safe Type means electrical equipment that is certified safe by a competent, independent testing laboratory based on a recognized standard. The certification of electrical equipment is to be suitable for the category and group for methane gas. See also 4-8-3/13 of the *Steel Vessel Rules*.

3.4 CNG

CNG means compressed natural gas.

3.5 Dual Fuel Diesel Engine

Dual Fuel Diesel Engine is a diesel engine that can burn natural gas as fuel simultaneously with liquid (pilot) fuel and also have the capability of running on liquid fuel only.

3.6 Dual Fuel Propulsion or Auxiliary Gas Turbine

Dual Fuel Gas Turbine, Propulsion or Auxiliary is a gas turbine using natural gas as fuel and also having the capability of running on liquid fuel.

3.7 Enclosed Space

Enclosed Space means any space within which, in the absence of artificial ventilation, the ventilation will be limited and any explosive atmosphere will not be dispersed naturally. See also 4-8-4/27 of the *Steel Vessel Rules*.

3.8 Fuel Containment System

Fuel Containment System is the arrangement for containment of fuel including, as applicable, a primary and secondary barrier, associated insulation and any intervening spaces, and adjacent structure if necessary for the support of these elements. If the secondary barrier is part of the hull structure it may be a boundary of the hold space.

The spaces around the fuel storage tank are defined as:

3.8.1 Hold Space

Hold Space is the space enclosed by the ship's structure in which a fuel containment system is located.

3.8.2 Interbarrier Space

Interbarrier Space is the space between a primary and secondary barrier, whether or not completely or partially occupied by insulation or other material.

3.8.3 Tank Connection Space

Tank Connection Space is a gas tight space surrounding the parts of the fuel tank containing all tank connections and tank valves.

3.9 Gas Combustion Unit (or Thermal Oxidizer)

3.18 Master Gas Valve

Master Gas Valve means an automatic gas shut-off valve in the gas supply line to each individual gas utilization unit and which is located outside the machinery space of the gas utilization unit. See also 2/6.2.1 of this Guide.

3.19 Natural Gas

Natural Gas (dry) is defined as gas without condensation at common operating pressures and temperatures where the predominant component is methane with some ethane and small amounts of heavier hydrocarbons (mainly propane and butane). The gas composition can vary depending on the source of natural gas and the processing of the gas. Typical composition in volume %:

Methane (C_1)	94.0%
Ethane (C_2)	4.7%
Propane (C_3)	0.8%
Butane (C_4+)	0.2%
Nitrogen	0.3%

Density gas	0.73 kg/Sm^3
Density liquid	0.45 kg/dm^3
Calorific value (low)	49.5 MJ/kg
Methane number	83

The gas may be stored and distributed as CNG or LNG.

3.20 Normal Boil-off Gas Rate (NBOR)

For the purposes of this Guide, the *Normal Boil-off Rate* is the specified BOR in the shipbuilding or manufacturer contract, conforming to the design boil-off rate at the upper ambient design temperatures as specified in 5C-8-7/1.2 of the *Steel Vessel Rules*.

3.21 Primary Barrier

Primary Barrier is the inner element designed to contain the fuel when the fuel containment system includes two boundaries.

3.22 Recognized Standard

A *Recognized Standard* is an international or national standard acceptable to ABS.

3.23 Re-Liquefaction Unit

A *Re-liquefaction Unit* is a system used for taking the boil-off gas from bunker tanks and condensing it in a refrigeration system. LNG is then returned to the tanks. A typical re-liquefaction plant will comprise an electric motor-driven boil-off gas compressor, cryogenic heat exchangers, pre-coolers, separator, nitrogen storage tanks, an LNG transfer system, electric-driven refrigeration compressors/expanders with interstage coolers, a discharge cooler and associated control systems.

3.24 Rules

Rules means the applicable edition of the ABS *Rules for Building and Classing Steel Vessels (Steel Vessel*

4 Classification Notations

4.1 Gas Fueled Ship

Where a vessel is arranged to burn natural gas as fuel for propulsion or auxiliary purposes the requirements for gas fuel storage, fuel bunkering systems, fuel gas preparation rooms and fuel gas supply system arrangements are to be designed, constructed and tested in accordance with Sections 2, 3, 4, and 5 of this Guide. The **GFS** notation may be assigned in association with one or more of the following additional notations (e.g., **GFS(DFD, GCU)**).

4.2 Re-Liquefaction Unit

Where a Re-Liquefaction Unit is designed, constructed and tested in accordance with Section 2 and Section 6 of this Guide, the **RELIQ** notation may be assigned.

4.3 Gas Combustion Unit

Where a Gas Combustion Unit is designed, constructed and tested in accordance with Section 2 and Section 7 of this Guide, the **GCU** notation may be assigned.

4.4 Dual Fuel Diesel Engine Power Plant

Where a dual fuel diesel engine power plant is designed, constructed and tested in accordance with Section 2 and Section 8 of this Guide, the **DFD** notation may be assigned.

4.5 Single Gas Fuel Engine Power Plant

Where a single gas fuel engine power plant is designed, constructed and tested in accordance with Section 2 and Section 8 of this Guide, the **SGF** notation may be assigned.

4.6 Dual Fuel Gas Turbine Power Plant

Where a dual fuel gas turbine power plant is designed, constructed and tested in accordance with Section 2 and Section 9 of this Guide, the **DFGT** notation may be assigned.

5 Materials of Construction

Materials in general are to comply with the requirements of the ABS *Rules for Materials and Welding (Part 2)*.

Materials used in gas tanks, gas piping, process pressure vessels and other components in contact with cryogenic liquids or gases are to be in compliance with Section 5C-8-6 of the *Steel Vessel Rules*.

For CNG tanks, the use of alternative materials not covered by Section 5C-8-6 of the *Steel Vessel Rules* may be accepted provided such materials are approved in connection with the design and that they are verified or tested by a Surveyor, as applicable, as complying with the approved specifications. For further guidance on CNG tanks, see the *CNG Guide*.

6 Operating and Maintenance Instruction Manuals

Detailed instruction manuals are to be provided onboard, covering the operations, safety and maintenance requirements and occupational health hazards relevant to the use of gas as a fuel.

The manuals are to include, but not be limited to, the regular test and maintenance procedures for the gas detection systems, safety shut-off systems and the integrity of backup systems.

In addition there is further guidance regarding the contents of the operating and maintenance manuals in each of the individual sections of this Guide such as the gas fuel storage, fuel bunkering and fuel gas supply systems. Reference is to be made to the requirements in each section of this Guide. Inspection and maintenance of certified safe electrical equipment is to be in accordance with the applicable requirements of Section 9 and 10 of IEC 60092-502.

7 Alternatives

Equipment, components, and systems for which there are specific requirements in this Guide, or its associated references, may incorporate alternative arrangements or comply with the requirements of alternative recognized standards, in lieu of the requirements in this Guide. This, however, is subject to such alternative arrangements or standards being determined by ABS as being not less effective than the overall safety and strength requirements of this Guide or associated references. Where applicable, requirements may be imposed by ABS in addition to those contained in the alternative arrangements or standards so that the intent of this Guide is met. In all cases, the equipment, component or system is subject to design review, survey during construction, tests and trials, as applicable, by ABS for purposes of verification of its compliance with the alternative arrangements or standards. The verification process is to be to the extent as intended by this Guide.

Where these alternative or equivalent equipment, components and systems are intended to be used in lieu of the requirements of IMO Resolution MSC.285(86), or the to be developed IMO IGF Code, such application is subject to approval by the Flag Administration prior to issuance of a Certificate of Fitness on behalf of the Flag Administration by ABS.

8 Certification

Design review, survey, testing, and the issuance of reports or certificates constitute the certification of machinery, equipment and systems; see also 4-1-1/3 of the *Steel Vessel Rules*. There is guidance on the certification requirements for machinery, equipment and systems in each of the applicable individual sections of this Guide. The applicable edition of the *Steel Vessel Rules* is to be used in association with the subject Guide.

iv) LNG storage tanks with a connection below the highest liquid level, (see 3/3iii) of this Guide) are to be fitted with drip trays below the connections which are to be of sufficient capacity to contain the volume which could escape in the event of a leakage from pipe connection. The material of the drip tray is to be stainless steel, and there is to be efficient separation or isolation so that the hull or deck structures are not subjected to low temperatures below the allowable design temperature of the material, in case of leakage of LNG.

The drip trays located below the tank connections and other sources of vapor release on the tanks are to be located not less than 3 m from entrances, air inlets and openings to accommodation spaces, services spaces, cargo spaces, machinery spaces and control stations.

v) Gas storage tanks located above deck are to be shielded with class A-60 insulation towards accommodation, service spaces, cargo spaces, machinery spaces and control stations.

2.2.2 Gas Storage Tanks – Storage in Enclosed Spaces

i) LNG fuel may be stored in enclosed spaces, with a maximum allowable working pressure of 10 bar.

ii) Storage of compressed gas in enclosed spaces is to be in accordance with the *CNG Guide*.

The location of compressed gas storage tanks with a design pressure greater than 10 bar in enclosed spaces would be acceptable, provided the following is fulfilled in addition to 2/2.2.2iv) of this Guide:

a) Adequate means are to be provided to depressurize the tank in case of fire which could affect the tank; and

b) All surfaces within such enclosed spaces are to be provided with suitable thermal protection against any high pressure gas leakage and resulting condensation unless the bulkheads are designed for the lowest temperature that can arise from gas expansion leakage; and

c) A fixed fire extinguishing system is installed in such enclosed spaces; and

d) Means are to be provided to relieve pressure resulting from a catastrophic failure of the containment system so that hull structural integrity can be maintained.

iii) Gas storage tanks are to be located as close as possible to the ship centerline and:

a) Minimum, the lesser of $B/5$ and 11.5 m from the ship side measured inboard from the ship's side at right angles to the centerline at the level of the summer load line; and

b) Minimum, the lesser of $B/15$ and 2 m from the bottom plating; and nowhere to be less than 800 mm from the shell plating..

c) Gas storage tanks for ships other than passenger vessels, or where gas storage tanks are not located adjacent to accommodation, service or control stations, may be located closer than $B/5$ from the ship side provided the following criteria is applied:

d) Minimum, the lesser of $B/15$ and 2 m from the bottom plating; and

e) Nowhere less than d, where d is as follows:

1. For storage tanks $V \leq 1{,}000$ m^3 $\quad d = 0.8$ m
2. For 1,000 m^3 $\leq V \leq$ 5,000 m^3 $\quad d = 0.75 + V \times 0.20/4{,}000$ m
3. For 5,000 m^3 $\leq V \leq$ 30,000 m^3 $\quad d = 0.8 + V/25{,}000$ m

Where V corresponds to 100% of the gross design volume of the individual storage tank at 20°C, including domes and appendages and d is measured at any cross section at a right angle from the molded line of the outer shell.

iv) Gas storage tanks located in enclosed spaces are to be arranged in accordance with the fuel containment and secondary barrier principles of the IGC Code Chapter 4, as incorporated by Section 5C-8-4 of the *Steel Vessel Rules*. Arrangements are to be such that the effects of any release of gas or liquid are mitigated while providing safe access for operation and inspection.

All tank connections, fittings, flanges and associated valves are to be located on the open deck except that for Type C independent tanks, such connections may be located in a gas tight space. This tank connection space is to be arranged to safely contain any leakage from the tank connections, without this leakage spreading to other spaces, or leading to hazardous incidents. Tank connection space boundaries including access doors are to be gastight.

The material of this space which may come into contact with liquid or gaseous fuel is to have the same minimum design temperature as the gas storage tank, and the space is to be designed to withstand the maximum pressure build up. Alternatively, pressure relief venting to a safe location (mast) may be provided.

The space is to be isolated thermally so that the surrounding hull is not exposed to unacceptable cooling, in case of leakage of the liquid or compressed gas. Calculations in accordance with 5C-8-4/8.2 of the *Steel Vessel Rules* are to be undertaken so that the temperature of the hull structure cannot fall below the allowable design temperature for the material.

v) Where LNG is carried in a storage tank requiring a complete or partial secondary barrier (storage tanks other than Type C) hold spaces are to be segregated from the sea by a double hull space.

vi) Bilge systems installed in areas where gas fuel may be present due to leakage from the storage or piping systems are not to be connected to the bilge system for the rest of the ship.

A bilge well in each gas containing system surrounding an independent liquid gas storage tank is to be provided with both a level indicator and a temperature sensor. An alarm is to be provided to indicate a high liquid level in the bilge well. The temperature sensor low temperature indication is to lead to automatic closing of the main tank valve.

vii) Fuel containment systems are not to be located adjacent to category A machinery spaces. Separation is to be by means of a cofferdam, the separation is to be at least 900 mm.

However, a hold space containing a Type C fuel storage tank with no connections to the tank inside the hold space may be separated from a category A machinery space by a single gas tight class A-60 bulkhead.

viii) Tank connection spaces and ventilation trunks to such spaces below the bulkhead deck are to be constructed to class A-60.

2.3 Access in way of Gas Storage Tanks

i) Where access is required for inspection between the gas storage tank surface (flat or curved), and structural elements (such as deck beams, stiffeners, frames, girders, etc.), the distance between that surface and the free edge of the structural elements is to be at least 380 mm. The distance between the surface to be inspected and the surface to which the above structural elements are fitted (e.g., deck, bulkhead or shell) is to be at least 450 mm for a curved tank surface or 600 mm for a flat tank surface. See also 5C-8-3/5.2.1, 5C-8-3/5.2.3 and 5C-8-3/5.2.4 of the *Steel Vessel Rules*.

ii) Where access is not practical between the surface to be inspected and any structural elements, the distance between the free edge of the structural element and the surface to be inspected is to be at least 50 mm or half the breadth of the structure's face plate, whichever is the larger. See also 5C-8-3/5.2.2 of the *Steel Vessel Rules*.

iii) Where applicable the minimum distance between the plane surfaces of a bunker tank sump and adjacent double bottom structure in way of a suction well is not to be less than 150 mm and that the clearance between the edge between the inner bottom plate, and the vertical side of the well and the knuckle point between the spherical or circular surface and sump of the tank is to be at least 380 mm. If there is no suction well, the distance between the bunker tank sump and the inner bottom is not to be less than 50 mm. See also 5C-8-3/5.2.5 of the *Steel Vessel Rules*.

2.4 Fuel Bunkering Station

i) The bunkering station(s) and manifold(s) are to be located on the open deck so that sufficient natural ventilation is provided. Alternatively closed or semi-enclosed bunkering stations may be approved subject to the provision of effective mechanical ventilation.

The bunkering station is to be physically separated or structurally shielded from adjacent normally manned areas such as accommodation, cargo/working deck and control stations. Particular consideration is to be made to the provision of adequate structural protection where vessel cargo handling operations increase the risk of mechanical impact damage. Connections and piping are to be positioned and arranged so that any damage to the gas piping does not cause damage to the vessel's gas storage tank arrangement leading to uncontrolled gas discharge.

ii) In case of leakage of LNG the surrounding hull or deck structures are not to be exposed to low temperatures below the allowable design temperature of the material. Accordingly drip trays are to be fitted below liquid gas bunkering connections and where leakage may occur. The drip trays are to be made of stainless steel and the drainage arrangements may be temporarily fitted for bunkering operations. Where the leakage containment arrangements are such that damage to the hull structure from accidental spillage of LNG during bunkering operations cannot be precluded, additional measures such as a low-pressure water curtain, are to be fitted under the bunkering station to provide for additional protection of the hull steel and the ship's side structure.

For compressed gas bunkering stations, low temperature steel shielding is to be provided as necessary to prevent possible cold jet impingement on the hull structure.

iii) Bunkering stations are to be shielded with class A-60 insulation towards other spaces, except for spaces such as tanks, voids, auxiliary machinery spaces of little or no fire risk, sanitary and similar spaces where the insulation may be reduced to A-0 class.

2.5 Gas Compressor and Fuel Preparation Rooms

i) Compressor and fuel preparation rooms are to be in compliance with 5C-8-3/3 of the *Steel Vessel Rules*. Compressor or fuel preparation rooms may be located below the open deck provided the arrangements are in accordance with the applicable requirements of 2/2.2.2, 2/3.3, and Subsection 3/6 of this Guide. Particular consideration is to be made to the provision of adequate structural protection where vessel cargo handling operations increase the risk of mechanical impact damage.

ii) Gas compressor or fuel preparation rooms are to be treated as if they were category A machinery spaces for the purposes of fire protection.

2.6 Machinery Spaces Containing Gas Utilization Units

i) When more than one machinery space is required for gas fueled engines (see 2/5.4 of this Guide) and these spaces are separated by a single bulkhead, in order to maintain continuity of power, the arrangements are to be such that the effects of a gas explosion in either space can be contained or vented without affecting the integrity of the adjacent space and equipment within that space.

ii) When more than one machinery space is required (see 2/5.4 of this Guide) and these spaces are

3 Arrangement of Entrances and Other Openings

3.1 General

i) Direct access through doors, gastight or otherwise, from a hazardous area classified as zone 0 or zone 1 to a non-hazardous area is generally not permitted. Where such openings are necessary for operational reasons, an air lock which complies with the requirements of 5C-8-3/6.2 through 5C-8-3/6.7 of the *Steel Vessel Rules* is to be provided.

ii) Access to a single wall fuel gas piping concept machinery space is to be by self-closing gastight doors. An audible and visual alarm is to be provided at a permanent manned location. Alarm is to be given if the door is open continuously for more than 60 seconds. As an alternative, an arrangement with two self-closing doors in series may be acceptable. See also 8/2.5 of this Guide.

3.2 Gas Compressor and Fuel Preparation Rooms

If the compressor or fuel preparation room is located below deck, the room is, as far as practicable, to have an independent access direct from the open deck. Where a separate access from the open deck is not practicable, an air lock which complies with the requirements of 5C-8-3/6.2 through 5C-8-3/6.7 of the *Steel Vessel Rules* is to be provided.

3.3 Gas Storage Tanks and Fuel Containment Systems

i) Access to the tank connection space is, as far as practicable, to be independent and direct from the open deck. If the tank connection space is only partially covering the tank, this requirement is also to apply to the space surrounding the tank and where the opening to the tank is located. Where a separate access from the open deck is not practicable, an air lock which complies with the requirements of 5C-8-3/6.2 through 5C-8-3/6.7 of the *Steel Vessel Rules* is to be provided. The access trunk is to be fitted with separate ventilation. The dimensions of horizontal and vertical openings are to be in accordance with 5C-8-3/5.3.1.2 and 5C-8-3/5.3.1.3 of the *Steel Vessel Rules*. Arrangements are to be such that it is not possible to have unauthorized access to the tank connection space during normal operation of the gas system.

ii) Inspection openings in accordance with 4-4-1/17.3 of the *Steel Vessel Rules* are to be provided for Type C gas fuel storage tanks. Where applicable, circular access openings are not to have diameters less than 600 mm, as per 5C-8-3/5.3.3 of the *Steel Vessel Rules*. Consideration will be given to alternative arrangements which can be shown to provide for an equivalent degree of internal inspection.

iii) For independent tanks operating with inerted interbarrier spaces, access arrangements are to be such that unintended entry by personnel is to be prevented. If access to such spaces is not from the open deck, sealing arrangements are to prevent leakage of inert gas to adjacent spaces.

4 Gas Pipe Design and Arrangements

4.1 General

i) Gas piping is to comply with 5C-8-5/2.1.2, 5C-8-5/2.1.4, 5C-8-5/2.1.6, 5C-8-5/2.2.1, 5C-8-5/2.3.2, 5C-8-5/2.4.1 through 5C-8-5/4, 5C-8-5/2.5, 5C-8-5/4.2 through 5C-8-5/4, and 5C-8-5/4.6.2 of the *Steel Vessel Rules*.

ii) Gas pipes are not to be located less than 800 mm from the ship's side. Where necessary, low temperature piping is to be thermally isolated from the adjacent hull structure to prevent the temperature of the hull from falling below the design temperature of the hull material.

iii) The piping system is to be of welded construction and flange joints are to be kept to a minimum. Gaskets are to be protected against blow-out. Where liquid piping is dismantled regularly, or where liquid leakage may be anticipated, such as at shore connections or pump seals, protection for the hull beneath is to be provided.

iv) The gas piping system is to be installed with sufficient flexibility to accommodate the oscillating movements that may be applicable without risk of fatigue failure. Arrangement for provision of the necessary flexibility is to be demonstrated to maintain the integrity of the piping system in normally foreseen service situations.

v) An arrangement for purging gas bunkering lines and supply lines with nitrogen is to be provided.

vi) If the fuel gas contains heavier components that may condense in the system, a vapor-liquid separator or equivalent means for safely removing the liquid is to be fitted.

vii) Gas piping is to be protected against mechanical damage.

viii) Gas pipes are to be color marked based on a recognized standard.

4.2 High Pressure Gas Piping

i) The arrangement and installation of high pressure gas piping is to provide the necessary flexibility for the gas supply piping to accommodate the oscillating movements of the main engine, without running the risk of fatigue problems. The length and configuration of the branch lines are important factors in this regard.

ii) High pressure gas piping systems are to have sufficient constructive strength which is to be confirmed by carrying out stress analysis taking into account the stresses due to the weight of the piping system including acceleration load when significant, internal pressure and loads induced by hog and sag of the ship.

iii) All valves and expansion joints used in high pressure gas fuel supply lines are to be of an approved type.

iv) Joints on the entire length of high pressure gas fuel supply lines are to be butt-welded joints with full penetration and are to be fully radiographed, except where specially approved.

v) Pipe joints other than welded joints at the specially approved locations identified under 2/4.2iv) of this Guide are to comply with recognized standards or may be accepted subject to specific approval on a case by case basis.

vi) For all butt-welded joints of high pressure gas fuel supply lines, post-weld heat treatment is to be performed dependant on the type of material.

vii) High pressure installations are to be provided with means for rapid detection of a rupture in the gas supply line. When rupture is detected, a valve is to automatically close. This valve is to be located outside but as close as possible to the machinery space; it can be a separate valve or combined with other functions such as the master gas valve. Acceptable means of detection are:

a) An orifice or flow fuse detecting excess flow and located close to the point of entry to the machinery space;

b) A combined excess flow detector with automatic shut off valve located as close as possible to the point of entry to the machinery space;

c) A low pressure detector located close to the engine inlet connection.

4.3 Distribution Outside of Machinery Spaces

Gas piping is not to be led through other machinery or enclosed spaces. Alternatively, double wall fuel gas piping may be approved, provided the danger of mechanical damage is considered negligible, the gas piping has no discharge sources and the space is equipped with a gas detection alarm. See also Subsection 5/4 of this Guide.

5 System Configuration

5.1 General

i) The propulsion and auxiliary arrangements and fuel supply systems are to be arranged so that in the case of emergency shutdown of the fuel gas supply the propulsion and maneuvering capability, together with power for essential services, can be maintained. Under such a condition the remaining power is to be sufficient to provide for a speed of at least 7 knots or half of the design speed, whichever is the lesser.

ii) Automatic means are to be provided to stop the supply of natural gas into an area or space where a gas release has been detected.

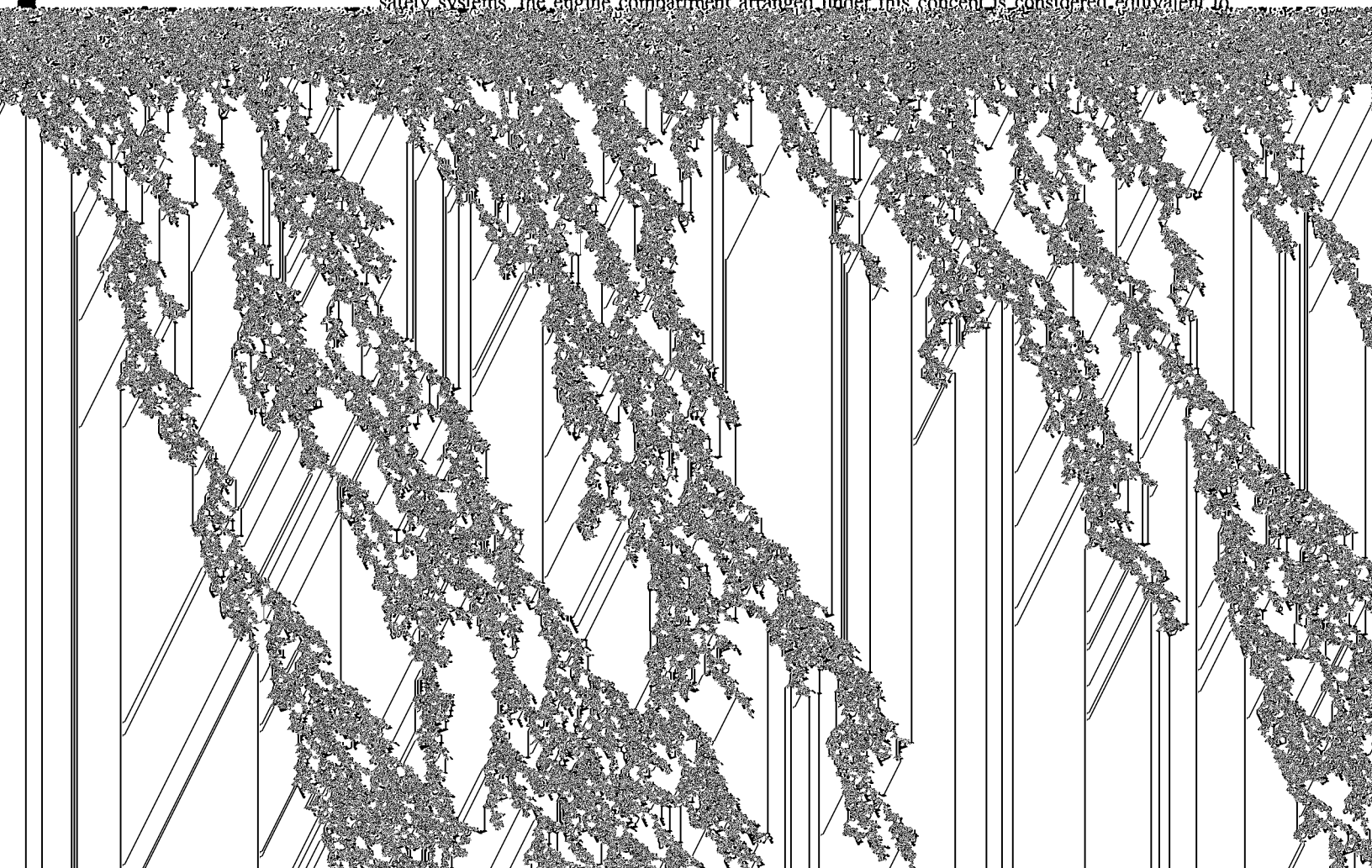
iii) Means are to be provided to control the pressure and temperature of the fuel gas delivered to each gas utilization unit.

5.2 Alternative System Configurations

Two alternative system configurations may be accepted:

i) *Double Wall Fuel Gas Piping Concept.* Arrangements in machinery spaces are such that the spaces are considered non-hazardous under all conditions, normal as well as abnormal conditions. This concept is in accordance with the principles of the IGC Code, which relies on encased gas fuel pipes and a ventilation duct or hood over the potential sources of leakage.

ii) *Single Wall Fuel Gas Piping Concept.* This concept may only be applied to machinery spaces containing dual fuel or single fuel engines using low pressure, 10 bar (10.2 kgf/cm^2, 145 psi) or less, fuel gas supply systems. The entire engine compartment is to contain only the engine(s) and minimum necessary equipment. The machinery space, or engine compartment, is to be as small in volume as practicable without compromising maintainability, in order to facilitate effective ventilation and gas detection. By the adoption of redundant ventilation systems, gas detection and associated safety systems, the engine compartment arranged under this concept is considered equivalent to



i) A dual fuel diesel engine plant for propulsion and power generation

ii) A single fuel engine plant for propulsion and power generation

7 Ventilation Systems – General

i) Any ducting used for the ventilation of hazardous spaces is to be separate from that used for the ventilation of non-hazardous spaces. Ventilation ducting arrangements are to be of a gas tight construction. The ventilation is to function at all temperature conditions the ship will be operating in. Electric fan motors are not to be located in ventilation ducts for hazardous spaces unless the motor is certified for the same hazard zone as the space served.

ii) Design of ventilation fans serving spaces containing gas sources are to fulfill the following:

8 Electrical Systems

8.1 General

i) The electrical requirements in this Subsection and in each individual Section of this Guide are to be applied in conjunction with the requirements of Part D of SOLAS Chapter II-1 and Chapter 8 of Part 4 of the *Steel Vessel Rules*.

ii) Electrical equipment and wiring is in general not to be installed in hazardous areas unless essential for operational purposes.

iii) Hazardous areas on open deck and other spaces not defined under 2/8.3 of this Guide are to be determined based on a recognized standard (e.g., IEC 60092-502 or IEC 60079-10-1). Installed electrical equipment is to be of a certified safe type based on that standard.

iv) Cable penetrations are to satisfy the requirements regulating the dispersion of gas.

v) An inspection and maintenance manual is to be prepared for electrical equipment that is installed in explosion hazardous spaces and areas in accordance with Section 9 and 10 of IEC 60092-502.

8.2 Area Classification

i) Hazardous areas are spaces where flammable or explosive gases, vapors or dust are normally present, or likely to be present. Hazardous areas are to be classified based on the likelihood of presence and the concentration and type of flammable atmosphere, as well as in terms of the extent of the space.

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

In order to facilitate the selection of the appropriate electrical equipment and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2 in accordance with recognized standard IEC publication 60079-10-1.

ii) Area classification of a space may be dependent on ventilation. A space with opening to an adjacent hazardous area on open deck, may be made into a less hazardous or non-hazardous space, by means of overpressure.

8.3 Hazardous Area Zones

8.3.1 Hazardous Area Zone 0

Hazardous Area Zone 0 includes:

i) The interiors of gas tanks, any pipework of pressure relief or other venting systems for gas tanks, pipes and equipment containing gas.

8.3.2 Hazardous Area Zone 1

Hazardous Area Zone 1 includes:

i) Fuel containment system spaces (except spaces containing Type C fuel storage tanks with no connections to the tank in the space, which are considered zone 2);

ii) Gas compressor or fuel preparation room with ventilation arranged according to Subsection 5/7 of this Guide;

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

iv) Areas on open deck or semi-enclosed spaces on deck, within 1.5 m of gas compressor, gas pump or fuel preparation room entrances, gas compressor, gas pump or fuel preparation room ventilation inlets and other openings into zone 1 spaces;

v) 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; and

vi) Enclosed or semi-enclosed spaces in which pipes containing gas are located (e.g., ducts around gas pipes, semi-enclosed bunker stations).

8.3.3 Hazardous Area Zone 2

Hazardous Area Zone 2 includes:

i) Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1.

2 Storage Tank Operation

In accordance with Subsection 1/6 of this Guide detailed instruction manuals are to be provided onboard, covering the operations, safety and maintenance requirements and occupational health hazards relevant to

4 CNG Storage Tanks

i) The storage tanks used for compressed gas are to be designed in accordance with the *CNG Guide.*

ii) Tanks for compressed gas are to be fitted with pressure relief valves with a set point below the design pressure of the tank and with the outlet located as required in 3/3v) of this Guide.

5 Gas Storage Tank Monitoring

i) Gas storage tanks are to be monitored and protected against overfilling as required by 5C-8-13/2 and 5C-8-13/3 of the *Steel Vessel Rules.*

ii) Each tank is to be monitored with at least one local indicating instrument for pressure and remote pressure indication at the control position. The manometers and indicators are to be clearly marked with the highest and lowest pressure permitted in the tank. In addition, high-pressure alarm, and if vacuum protection is required, low pressure alarm are to be provided on the bridge. The alarms are to be activated before the set pressures of the safety valves are reached.

iii) Each tank is to be provided with at least two devices for indicating temperature, one placed at the bottom of the tank and the second near the top of the tank, below the highest allowable liquid level. The lowest temperature for which the tank has been designed is to be clearly indicated on the tank itself, or by means of a sign on or near the temperature indicating devices.

The temperature indicating devices are to be capable of providing temperature indication across the expected operating temperature range of the tanks.

Where thermowells are fitted they are to be designed so that failure will not occur due to fatigue in normal service.

iv) For storage tanks requiring a full or partial secondary barrier, means are to be provided to detect leakage from the primary barrier.

v) The monitoring and safety shutdowns for gas storage tanks and gas fuel storage rooms are to be in accordance with Section 3, Table 1 of this Guide.

6 Gas Fuel Storage Room and Tank Connection Space

6.1 General

The requirements of 3/6.2 through 3/6.4 of this Guide are applicable to Type C tanks with connections below the highest liquid level. Where the tank connection space is only partially covering the tank these requirements are also to apply to the gas fuel storage room surrounding the tank and where the opening to the tank is located.

6.2 Ventilation

i) The tank connection space located below deck is to be provided with an effective mechanical forced ventilation system of the under pressure type, providing a ventilation capacity of at least 30 air changes per hour.

ii) Approved automatic fail-safe fire dampers are to be fitted in the ventilation trunk for the tank connection space. In the event of fire detection the ventilation should stop and the fire dampers should close automatically.

6.3 Gas Detection

i) Permanently installed gas detectors are to be fitted in the tank connection space.

ii) Audible and visible alarms from the gas detection equipment are to be located on the bridge and in the control room.

iii) Tank connection space gas detection is to be continuous without delay.

6.4 Fire Detection

i) An approved fixed fire detection system is to be provided for the tank connection space and the ventilation trunk for the tank connection space below deck.

ii) Smoke detectors alone are not to be considered sufficient for rapid fire detection.

iii) Where the fire detection system does not include means of remotely identifying each detector individually, the detectors are to be arranged on separate loops.

6.5 Alternative Arrangements

Inert gas or dry air filling of the hold or void spaces surrounding gas storage tanks, as an alternative means of providing a non combustible environment in accordance with IGC Code principles, may be accepted. Such arrangements are to be in accordance with the applicable environmental control, ventilation and gas detection requirements of Sections 5C-8-9, 5C-8-12, and 5C-8-13, respectively, of the *Steel Vessel Rules*.

7 Fire Extinguishing Systems

7.1 General

i) The requirements for gas fuel storage fire extinguishing systems given in this Subsection are to be regarded as additional to the requirements of SOLAS Chapter II-2.

7.2 Fire Main

i) The water spray system required below may be part of the fire main system provided that the required fire pump capacity and pressure are sufficient for operation of both the required numbers of hydrants and hoses and the water spray system simultaneously.

ii) When the storage tank is located on open deck, isolating valves are to be fitted in the fire main in order to isolate damaged sections of the fire main. Isolation of a section of fire main is not to deprive the fire line ahead of the isolated section from the supply of water.

7.3 Water Spray Systems

i) A water spray system is to be fitted for cooling and fire prevention and to cover exposed parts of storage tanks located above deck.

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

iii) For the purpose of isolating damaged sections, stop valves are to be fitted or the system may be divided into two or more sections with control valves located in a safe and readily accessible position not likely to be cut-off in case of fire.

iv) The capacity of the water spray pump is to be sufficient to deliver the required amount of water to the hydraulically most demanding area as specified above.

v) A connection to the ship's fire main through a stop valve is to be provided.

vi) Remote start of pumps supplying the water spray system and remote operation of any normally closed valves to the system are to be located in a readily accessible position which is not likely to be cut off in case of fire in the areas protected.

vii) The nozzles are to be of an approved full bore type and they are to be arranged to provide an effective distribution of water throughout the space being protected.

viii) An equivalent system to the above detailed water spray system may be accepted by special consideration and subject to satisfactory demonstration of its on deck cooling capability.

8 Surveys during Construction

8.1 General

This Subsection pertains to surveys during fabrication at the manufacturer's facility and installation and testing of gas storage tanks and associated systems onboard the vessel. For surveys at the manufacturer's facility, the scope of the survey will be confined to only those items that are supplied by the manufacturer.

8.2 Surveys at Manufacturer's Facility

Construction and testing of gas storage tanks, valves, pumps and associated piping is to be in accordance with 5C-8-4/10, 5C-8-4/11, 5C-8-5/3, 5C-8-5/4, and 5C-8-6/3 of the *Steel Vessel Rules*, as applicable.

Certification of the complete gas storage tank and associated systems cannot be accepted based only on the ABS Type Approval Program and therefore ABS Surveyor's attendance is required during fabrication for

v) Control system and shutdowns are to be tested for proper operation.

vi) The gas storage tank and gas fuel storage room operation systems are to be checked for proper operation in accordance with the ABS approved installation test procedure.

8.4 Surveys During Trials

During the initial gas trials, the gas storage tank and associated systems are to be confirmed for satisfactory operation, including associated controls, alarms and shutdowns. The tests are to be conducted in accordance with the ABS approved testing procedure during gas trials.

TABLE 1
Monitoring and Safety System Functions for Gas Fuel Storage Tanks and Gas Fuel Storage Rooms

Monitored Parameters	*Alarm*	*Automatic Shutdown of the Main Tank Valve*
High or low liquid level in gas fuel storage tank	X	
High or low pressure in gas fuel storage tank	X	
High or low temperature in gas fuel storage tank	X	
Gas detection in tank connection space above 20% LEL [(1)]	X	
Gas detection in tank connection space above 40% LEL [(1)]	X	X
Fire detection in tank connection space [(1, 2)]	X	X
Bilge well high level in gas fuel storage room	X	
Bilge well low temperature in gas fuel storage room	X	X

Notes:

1 Where the tank connection space is only partially covering the tank these requirements are also to apply to the gas fuel storage room, see 3/6.1 of this Guide.

2 Ventilation is to be stopped and fire dampers closed automatically, see 3/6.2ii) of this Guide.

TABLE 2
Certification of Gas Fuel Storage Tanks and Gas Fuel Storage Rooms

This Table has been prepared for guidance only and annotated to agree with the *Steel Vessel Rules*, IMO IGC Code and other IMO requirements. The list is not to be considered exhaustive; should additional equipment not listed be fitted onboard, same will be subject to special consideration for compliance with the *Steel Vessel Rules*, the IGC Code and other IMO requirements. This list is not to be considered as substitutive or integrative of the content of the *Steel Vessel Rules* and/or other applicable Regulations. In case of conflict between the content of this list and the applicable *Steel Vessel Rules* and regulations, the latter are to be considered applicable.

Code	*Explanation*
MD	*Manufacturer's Documentation* – Manufacturer should supply documentation as evidence that the material or the equipment complies with an acceptable standard (e.g., standard tests reports, ex certification, etc.).
DR	*Design Review* – Design review required.
MT	*Material Testing* – Material testing is to be witnessed by the Surveyor.
MS	*Manufacture Survey* – Product is to be surveyed during fabrication stages by the Surveyor.
FS	*Final Survey* – Finished product is to be subject to final hydrostatic, nondestructive, operational testing, or any other required tests, and witnessed by the Surveyor at manufacturer's facility.

Equipment	*MD*	*DR*	*MT*	*MS*	*FS*
LNG/CNG tanks		X	X	X	X
LNG pumps		X			X
Pump motors (rated at 100 kW and over)		X			X
Main tank valve and associated piping		X (1)	X	X	X
Pressure relief valves and associated piping		X (1)	X	X	X
Fuel gas piping system in tank connection space and gas fuel storage room, as applicable		X	X	X	X
Fuel gas piping ventilation system		X (1)			
Ventilation system and fire dampers in tank connection space and gas fuel storage room, as applicable		X			X
Hold space inert gas system		X			X
Gas storage pressure vessels (2)					
Tank monitoring system		X			X
Fire detection system		X			X
Fire extinguishing system		X			X
Gas detection system		X			X
Automatic shutdown system		X			X

Notes:

1 Design verification only.

2 See Appendix 1, Table 1 of this Guide.

3 Fuel Bunkering Operation

In accordance with Subsections 1/6 and 3/2 of this Guide detailed instruction manuals are to be provided onboard, covering the operations, safety and maintenance requirements and occupational health hazards relevant to the use of gas as a fuel.

The fuel bunkering operation aspects of the manuals are to include, but not be limited to, the instructions for connecting, inerting, warming up/cooling down, pumping bunker, draining, purging, disconnecting, emergency shutdown procedures and emergency ship to ship transfer.

The manuals are to be submitted for review solely to verify the presence of all the information required by this Section.

4 Fuel Bunkering Station

Fuel bunkering station arrangements are to be in accordance with 2/2.4 of this Guide.

5 Fuel Bunkering System

5.1 General

i) The bunkering system is to be arranged so that no gas is discharged to air during the gas storage tank filling operations.

ii) A manually operated stop valve and a remote operated shutdown valve in series, or a combined manually operated and remote valve, are to be fitted in every bunkering line close to the bunker supplier connecting point. It is to be possible to release the remote operated valve in the control location for bunkering operations and/or another safe location.

iii) Means are to be provided for draining the liquid from the bunkering pipes at bunkering completion.

iv) Bunkering lines are to be arranged for inerting and gas freeing. During operation of the vessel the bunkering pipes are to be gas free.

5.2 Fuel Bunkering Manifolds

i) The bunker manifold(s) are to be arranged for one or more bunkering lines. Filters are to be fitted

5.4 Emergency Shutdown System

i) An emergency shutdown system is to be fitted to stop bunker flow in the event of an emergency. The design of the ESD system is to avoid the potential generation of surge pressures within bunker transfer pipe work.

ii) The ESD system is to be activated by the manual and automatic inputs listed in Section 4, Table 1 of this Guide. Any additional inputs should only be included in the ESD system if it can be shown their inclusion does not reduce the integrity and reliability of the system overall.

iii) A functional flow chart of the ESD system and related systems is to be provided in the fuel bunkering control station and on the bridge.

iv) One ESD valve is to be provided at each manifold connection. The ESD valve may also be the remote operated valve required by 4/5.1ii) of this Guide.

v) ESD valves are to be remotely operated, be of the fail closed type (closed on loss of actuating power), are to be capable of local manual closure and have positive indication of the actual valve position.

vi) ESD valves in liquid piping systems are to close fully and smoothly under all service conditions within 30 seconds of actuation. Information about the closure time of the valves and their operating characteristics is to be available onboard, and the closing time is to be verifiable and reproducible.

vii) The closing time of the valve referred to in 4/5.4vi) (i.e., time from shutdown signal initiation to

7 Ventilation System

i) Where gas bunkering lines pass through enclosed spaces they are to be installed within a ventilated pipe or duct. The air space between the gas fuel piping and the wall of the outer pipe or duct is to be equipped with mechanical under pressure ventilation having a capacity of at least 30 air changes per hour.

ii) The duct should be dimensioned according to 5/3.2iii) or 5/3.2iv) of this Guide.

iii) The ventilation inlet for the duct is to always be located in open air, away from ignition sources.

iv) The fan motors are to be placed outside the ventilated pipe or duct.

v) The ventilation outlet is to be covered by a protection screen and placed in a position where no gas-air mixture may be ignited.

vi) The ventilation is to always be in operation during bunkering operations.

10.2 Surveys at Manufacturer's Facility

Construction and testing of fuel bunkering components and associated piping is to be in accordance with 5C-8-5/3, 5C-8-5/4 and 5C-8-6/3 of the *Steel Vessel Rules*, as applicable.

Certification of the complete fuel bunkering system cannot be accepted based only on the ABS Type Approval Program, and therefore ABS Surveyor's attendance is required during fabrication for unit certification. However, component parts of the unit can be certified in accordance with ABS Product Quality Assurance (PQA) Certification system outlined in Appendix 1-1-A3 of the ABS *Rules for Conditions of Classification (Part 1)*.

When Surveyor's attendance at the shop of the manufacturer and at the assembly site is required by the applicable Rules or this Guide, the manufactured/assembled system components will be verified to be satisfactorily in compliance with a recognized standard. Surveyor's attendance is required typically for the following purposes:

i) To confirm that the facility to manufacture, fabricate or repair gas storage tanks or its components do have and maintain a quality-control program effectively covering design, procurement, manufacturing and testing, as applicable, and meeting the requirements of a recognized standard applicable to their product.

ii) To qualify or verify welder's qualifications, welding procedure specifications and corresponding weld procedure qualification records to the extent deemed necessary by the attending Surveyor.

iii) To verify material certificates/documentations, particularly for materials of piping, main pressure retaining parts of valves, including safety valves that have flanged or threaded ends or other specialty fittings. Witness of material testing where required by the *Steel Vessel Rules*.

iv) To survey final weldments.

v) To witness, as far as deemed necessary, weld nondestructive examination tests and to review records of nondestructive examinations.

vi) To witness pressure and/or proof-load testing of equipment components and as a unit, as applicable and as called for in the fabrication procedures.

vii) To witness testing of subassemblies and completed units as called for in the fabrication procedures.

viii) To verify all certified safe systems, motor controllers, consoles and instrumentation and control panels are in compliance with approved drawings.

ix) To carry out other inspections and to witness the final Factory Acceptance Test (FAT) as agreed upon during prefabrication meeting.

10.3 Surveys During Installation

The following surveys are to be carried out to the satisfaction of the attending Surveyor on the gas fuel bunkering components, piping and associated systems during installation and testing:

i) Piping systems are to be visually examined and pressure-tested, as required by 5C-8-5/5 of the *Steel Vessel Rules.*

ii) Electrical wiring and connections are to be in accordance with Part 4, Chapter 8 of the *Steel Vessel Rules* and checked for continuity and proper workmanship.

iii) Instrumentation is to be tested to confirm proper operation as per its predetermined set points.

iv) Pressure relief and safety valves are to be tested.

v) Control system and shutdowns are to be tested for proper operation.

vi) The fuel bunkering systems are to be checked for proper operation in accordance with the ABS approved installation test procedure.

10.4 Surveys During Trials

During the initial gas trials, the gas fuel bunkering components and associated systems are to be confirmed for satisfactory operation, including associated controls, alarms and shutdowns. The tests are to be conducted in accordance with the ABS approved testing procedure during gas trials.

TABLE 1
Monitoring and Safety System Functions for Fuel Bunkering Systems

Monitored Parameters	*Alarm*	*Automatic Shutdown of the Manifold ESD Valves* [1]
Gas detection at enclosed or semi enclosed bunker station above 20% LEL	X	
Gas detection at enclosed or semi enclosed bunker station above 40% LEL	X	X
Fire detection at bunker station	X	X
Fire detection in gas fuel storage room, compressor room or fuel preparation rooms	X	X
Loss of ventilation in ducting around the gas bunkering lines	X	
Gas detection in ducting around gas bunkering lines above 20% LEL	X	
Gas detection in ducting around gas bunkering lines above 40% LEL	X	X
High level in gas storage tank	X	X
High pressure in gas storage tank	X	X
Manual ESD shutdowns	X	X
Manual or automatic ESD signal from bunker supplier	X	X
Loss of ESD valve motive power [2]	X	X

Notes:

1 ESD signal and automatic activation of the ESD valves on the bunker receiving ship to activate automatic shutdown of the ESD valves and supply pumps at the bunker supplier.

2 ESD valves are to be of fail closed type as per 4/5.4 v) of this Guide.

TABLE 2
Certification of Fuel Bunkering Systems

This Table has been prepared for guidance only and annotated to agree with the *Steel Vessel Rules*, IMO IGC Code and other IMO requirements. The list is not to be considered exhaustive; should additional equipment not listed be fitted onboard, same will be subject to special consideration for compliance with the *Steel Vessel Rules*, the IGC Code and other IMO requirements. This list is not to be considered as substitutive or integrative of the content of the *Steel Vessel Rules* and/or other applicable Regulations. In case of conflict between the content of this list and the applicable *Steel Vessel Rules* and regulations, the latter are to be considered applicable.

Code	*Explanation*
MD	*Manufacturer's Documentation* – Manufacturer should supply documentation as evidence that the material or the equipment complies with an acceptable standard (e.g., standard tests reports, ex certification, etc.).
DR	*Design Review* – Design review required.
MT	*Material Testing* – Material testing is to be witnessed by the Surveyor.
MS	*Manufacture Survey* – Product is to be surveyed during fabrication stages by the Surveyor.
FS	*Final Survey* – Finished product is to be subject to final hydrostatic, nondestructive, operational testing, or any other required tests, and witnessed by the Surveyor at manufacturer's facility.

Equipment	*MD*	*DR*	*MT*	*MS*	*FS*
Bunker manifolds		X	X	X	X
Manifold valves, ESD valves and associated piping		X (1)	X	X	X
Fuel gas bunker piping system		X	X	X	X
Fuel gas bunker piping ventilation system		X (1)			
Monitoring system		X			X
Fire detection system		X			X
Fire extinguishing system		X			X
Gas detection system		X			X
Automatic shutdown system		X			X

Notes:

1 Design verification only.

- Failure Modes and Effects Analysis (FMEA) to determine possible failures and their effects in the safe operation of the fuel gas supply system (see 5/6.1ii) of this Guide)
- Emergency shutdown arrangements
- Operating and maintenance instruction manuals
- Forced and natural boil-off gas supply system from the tanks to the consumers
- Testing procedures during sea/gas trials.

2 Fuel Gas Supply System Operation

In accordance with Subsections 1/6, 3/2, and 4/3 of this Guide detailed instruction manuals are to be provided onboard, covering the operations, safety and maintenance requirements and occupational health hazards relevant to the use of gas as a fuel. The manuals are to include maintenance procedures for all technical gas-related installations, and are to comply with the recommendations of the suppliers of the equipment. The intervals for and the extent of the overhaul or replacement/approval of gas valves are to be established. The maintenance procedure is to specify who is qualified to carry out maintenance.

The fuel gas supply operation aspects of the manuals are to include, but not be limited to, the instructions for BOG management, LNG pumping, vaporization, warming up/cooling down, gas compression and emergency shutdown procedures.

The manuals are to be submitted for review solely to verify the presence of the information required by this Section.

3 Gas Supply Systems in Machinery Spaces

3.1 General

i) The main gas supply line to each engine or set of engines is to be equipped with a manually operated stop valve and an automatically operated gas valve (master gas valve) coupled in series or a combined manually and automatically operated valve. The valves are to be situated in the part of the piping that is outside the machinery space containing the gas fueled engines. The master gas valve is to automatically cut off the gas supply as per Section 5, Table 2 of this Guide.

The master gas valve is to be operable from at least two separate locations in the machinery space containing gas fueled engines, from a suitable location outside the space and from the navigation bridge.

ii) Each natural gas utilization unit is to be provided with a set of three automatic valves. Two of these valves are to be in series in the gas fuel pipe to the gas utilization unit. The third valve is to be in a pipe that vents to a safe location in the open air, or to an alternative acceptable location to safely dispose of the gas, that portion of the gas fuel piping that is between the two valves in series.

These valves are to be arranged so that when automatic shutdown is initiated as per Section 5, Table 2 of this Guide, this will cause the two gas fuel valves that are in series to close automatically and the ventilation valve to open automatically.

Alternatively, the function of one of the valves in series and the ventilation valve may be incorporated into one valve body, so arranged that the flow to the gas utilization unit will be blocked and the ventilation opened.

The three shut off valves are to be arranged for manual reset either locally or remotely. Where remote reset is fitted, the control system is to be arranged such that the natural gas utilization unit cannot be made operational in gas mode until the abnormal conditions that caused the shut-off of the valves in the UMS have been cleared and safe operation can be resumed.

iii) Provision is to be made for inerting and gas-freeing the gas fuel piping system. An automatic purge is to be activated upon automatic closure of the master gas valve. Arrangements are to be such that a ventilation valve will ventilate the gas fuel piping between the master gas valve and the block and bleed valve. Discharges are to be led to a safe location in the open air. See also 2/6.2.2 of this Guide.

For high pressure systems the system is to be arranged so that the gas fuel pipe between the master gas valve and the gas injection valves is automatically purged with inert gas when the master gas valve is closed.

For normal stop of engine on high pressure systems the gas piping between the block and bleed valve and gas injection valves are to be automatically vented.

iv) There is to be one manually operated shutdown valve in the gas supply to each engine to provide safe isolation during maintenance of the engine.

v) For single engine installations and multi-engine installations where a separate master gas valve is provided for each engine the master gas valve and the block and bleed valve functions may be combined.

3.2 Gas Supply System for Double Wall Fuel Gas Piping Concept

i) Gas supply lines passing through enclosed spaces are to comply with Subsection 2/4 of this Guide and are to be completely enclosed by a double pipe or duct. This double pipe or duct is to fulfill one of the following:

a) The gas piping is to be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes is to be pressurized with inert gas at a

iii) For high pressure piping the design of the ducting is to be taken as the higher of the following:

a) The maximum built up pressure: static pressure in way of the rupture resulting from the gas flowing in the annular space; or

b) Local instantaneous peak pressure in way of the rupture: this pressure is to be taken as the critical pressure and is given by the following expression:

$$p^* = p_o\left(\frac{2}{k+1}\right)^{\frac{k}{k-1}}$$

where:

p_o = maximum working pressure of the pipe

k = C_p/C_v constant pressure specific heat divided by the constant volume specific heat

k = 1.31 for CH_4

As an alternative to using the peak pressure from the above formula, the peak pressure found from representative tests may be used. Test reports are then to be submitted.

The tangential membrane stress of a straight pipe is not to exceed the tensile strength divided by 1.5 when subjected to the above pressures. The pressure ratings of all other piping components are to reflect the same level of strength as straight pipes.

iv) Ducting for high pressure piping is to be pressure tested to at least 10 bar.

v) For low pressure piping the duct is to be dimensioned for a design pressure not less than the maximum working pressure of the gas pipes.

vi) Permanently installed gas detectors complying with the requirements of Subsection 5/8 of this Guide are to be fitted in all ducts around gas pipes applying the ventilated duct arrangement of 5/3.2i)b)

c) Gas risers located in open air are to be located so that they are not likely to be damaged by

iii) The fuel gas compressor and fuel gas supply are to be arranged for manual remote emergency stop from the following locations:

a) Cargo control room (relevant for cargo ships only);

b) Navigation bridge;

c) Engine control room; and

d) Fire control station.

iv) High pressure gas compressors are to be approved and certified by ABS.

v) Where pumps or compressors are driven by shafting passing through a bulkhead or deck, gastight seals with efficient lubrication or other means of ensuring the permanence of the gas seal are to be fitted in way of the bulkhead. Temperature sensing devices are to be provided for bulkhead shaft glands, bearings and casings for pumps or compressors located in the pump or compressor room. High temperature audible and visual alarms are to be provided at a normally manned control station.

5.5 Ancillary Systems

Where cooling/heating mediums are required in fuel gas supply or ancillary systems, the supply is to be arranged as follows:

i) A minimum of two pumps are to be provided, one of which is to be exclusively provided for this duty.

ii) Where seawater is used, each pump is to have at least two sea suction lines, where practicable leading from sea chests, one port and one starboard.

6 Instrumentation and Safety Systems

6.1 General

i) The control system for the fuel gas supply system may be connected to an integrated control system or be a stand-alone system.

ii) An analysis is to be carried out for the fuel gas supply system identifying component criticality.

iii) The overall system design is to be based on single-fault criteria. The system is to be designed such that a single fault of a component will not lead to serious consequences.

6.2 Control and Monitoring System

i) Automatic control, alarm and safety functions are to be provided so that operations remain within preset parameters for all gas storage tank filling and gas demand conditions.

ii) The temperature and pressures in the fuel gas supply system are to be controlled as follows:

a) A control and monitoring system is to be provided in the control room.

b) The design of the control system is to be such as to ensure identification of faults in the equipment, as well as the process system. The control and monitoring systems are to comply with the requirements of 4-9-1/9 of the *Steel Vessel Rules*, as applicable.

c) Indications of parameters necessary for the safe and effective operation of the process are to be provided, as per Section 5, Tables 1 and 2 of this Guide.

d) The computer-based control systems are to comply with the applicable requirements of

iv) Gas compressors are to be fitted with audible and visual alarms both on the bridge and at the control station. As a minimum the alarms are to be in relation to low gas input pressure, low gas output pressure, high gas output pressure and compressor operation.

v) LNG pumps are to be fitted with audible and visual alarms both on the bridge and at the control station. As a minimum the alarms are to indicate low LNG discharge pressure, high LNG inlet temperature, high LNG discharge pressure and LNG pump operation.

6.3 Safety Shutdown System

An independent shutdown system is to be provided. This safety shutdown system is to be based on the following principles:

i) Means are to be provided to indicate the parameters causing shutdown.

ii) Upon activation of the safety shutdown system, alarms are to be given at the normal control position and at the local control position.

iii) In the event where shutdown by the safety shutdown system is activated the restart should not occur automatically, unless after the system is reset.

Monitoring and safety shutdowns are to be in accordance with Section 5, Tables 1 and 2 of this Guide.

7 Ventilation System

i) Pump, compressor and fuel preparation rooms are to be fitted with an effective mechanical ventilation system of the under pressure type, providing a ventilation capacity of at least 30 air changes per hour.

ii) The number and power of the ventilation fans should be such that if one fan, or a group of fans with common circuit from the main switchboard or emergency switchboard, are out of service the capacity of the remaining ventilation fan(s) is not to be less than 100% of the total required.

iii) Operating manual required by Subsection 1/5 is to indicate that ventilation systems for pump, compressor and fuel preparation rooms are to be in operation when pumps or compressors are working.

8 Gas Detection

i) Permanently installed gas detectors are to be fitted in pump, compressor and fuel preparation rooms.

ii) Audible and visible alarms from the gas detection equipment are to be located on the bridge and in the control room(s).

iii) Pump, compressor and fuel preparation room gas detection is to be continuous without delay.

9 Fire Protection and Fire Extinguishing System

Fuel gas supply pump, compressor and fuel preparation rooms are to be provided with fire detection, protection and extinguishing systems complying with the requirements of Part 4, Chapter 7 and Section 5C-8-11/5.1 of the *Steel Vessel Rules* and SOLAS Chapter II-2.

10 Surveys During Construction

10.1 General

10.2 Surveys at Manufacturer's Facility

Construction and testing of fuel gas supply components and associated piping is to be in accordance with the applicable parts of 5C-8-4/10, 5C-8-4/11, 5C-8-5/3, 5C-8-5/4 and 5C-8-6/3 of the *Steel Vessel Rules*.

Certification of the complete fuel gas supply system cannot be accepted based only on the ABS Type Approval Program, and therefore ABS Surveyor's attendance is required during fabrication for unit certification. However, component parts of the unit can be certified in accordance with ABS Product Quality Assurance (PQA) Certification system outlined in Appendix 1-1-A3 of the ABS *Rules for Conditions of Classification (Part 1)*.

When Surveyor's attendance at the shop of the manufacturer and at the assembly site is required by the applicable Rules or this Guide, the manufactured/assembled system components will be verified to be satisfactorily in compliance with a recognized standard. Surveyor's attendance is required typically for the following purposes:

i) To confirm that the facility to manufacture, fabricate or repair gas storage tanks or its components do have and maintain a quality-control program effectively covering design, procurement, manufacturing and testing, as applicable, and meeting the requirements of a recognized standard applicable to their product.

ii) To qualify or verify welder's qualifications, welding procedure specifications and corresponding weld procedure qualification records to the extent deemed necessary by the attending Surveyor.

iii) To verify material certificates/documentations, particularly for materials of piping, main pressure retaining parts of valves, including safety valves that have flanged or threaded ends or other specialty fittings. Witness of material testing where required by the *Steel Vessel Rules*.

iv) To survey final weldments.

v) To witness, as far as deemed necessary, weld nondestructive examination tests and to review records of nondestructive examinations.

vi) To witness pressure and/or proof-load testing of equipment components and as a unit, as applicable and as called for in the fabrication procedures.

vii) To witness testing of subassemblies and completed units as called for in the fabrication procedures.

viii) To verify all certified safe systems, motor controllers, consoles and instrumentation and control panels are in compliance with approved drawings.

ix) To carry out other inspections and to witness the final Factory Acceptance Test (FAT) as agreed upon during prefabrication meeting.

10.3 Surveys During Installation

The following surveys are to be carried out to the satisfaction of the attending Surveyor on the fuel gas supply components and associated systems during installation and testing:

i) Piping systems are to be visually examined and pressure-tested, as required by 5C-8-5/5 of the *Steel Vessel Rules*.

ii) Electrical wiring and connections are to be in accordance with Part 4, Chapter 8 of the *Steel Vessel Rules* and checked for continuity and proper workmanship.

TABLE 1
Instrumentation and Alarms in Centralized Control Stations for the Fuel Gas Supply System

Item			*Display*	*Alarm Activated*	*Automatic Shut Down*
BOG Compressor	Driving motors [2]		Running	Stop	
	LO Temperature			High	
	LO Pressure			Low	
	Sealing gas pressure, if applicable			Low	
	Control air pressure loss, if applicable			Failed	X
	Suction line	Pressure	X	High/Low	X (High-High)
		Temperature	X	High	X (High-High)
	Discharge line	Pressure	X	High/Low	X (Low-Low)
		Temperature	X	High/Low	X (High-High)
LNG Pumps	Driving motors [2]		Running	Stop	
	Inlet	Temperature	X	High/Low	X (High-High)
	Discharge line	Pressure	X	High/Low	X (High-High)
Recondenser/Suction Drum	Temperature		X		
	Level low		X	Low	X (Low-Low)
	Level high		X	High	X (High-High)
	Pressure high		X	High	X (High-High)
Vaporizer/Heater	LNG Inlet	Temperature	X	High/Low	X (High-High)
	LNG Discharge line	Pressure	X	High/Low	X (High-High)
		Temperature	X	High/Low	X (High-High)
Heating circuit for LNG Vaporizer/ Heaters	Tank fluid level		X	High/Low	X (Low-Low)
	Gas detection in tank [1]		X	X	
	Pump driving motor		Running	Stop	
	Pump discharge line	Pressure	X	High/Low	X (Low-Low)
	Electric heater		Running	Stop	
	Inlet	Temperature	X	High/Low	X (Low-Low)
Control System	Control power supply			Failed	
	Emergency Shutdown			X	

Notes:

1 See 5/5.2iv) of this Guide.

2 See 5/5.4v) of this Guide for gland, bearing and casing temperature monitoring, as applicable.

TABLE 2
Monitoring and Safety System Functions for Fuel Gas Supply Systems

Monitored Parameters	*Alarm*	*Automatic Shutdown of the Main Tank Valve*	*Automatic Shut-off of the Master Gas Fuel Valve and Automatic Activation of the Block and Bleed Valves*
Gas detection in duct between tank and machinery space containing gas fueled prime movers above 20% LEL	X		
Gas detection in duct between tank and machinery space containing gas fueled prime movers above 40% LEL	X	X(1)	
Gas detection in compressor, pump or fuel preparation room above 20% LEL	X		
Gas detection in compressor, pump or fuel preparation room above 40% LEL	X	X(1)	
Gas detection in duct inside machinery space containing gas fueled prime movers above 30% LEL	X		
Gas detection in duct inside machinery space containing gas fueled prime movers above 40% LEL	X		X(2)
Gas detection in machinery space containing gas fueled prime movers above 20% LEL	X		
Gas detection in machinery space containing gas fueled prime movers above 40% LEL	X		X(3)
Loss of ventilation in duct between tank and machinery space containing gas fueled prime movers (4)	X		X(1)
Loss of ventilation in duct inside machinery space containing gas fueled prime movers (4)	X		X(2)
Loss of ventilation in machinery space containing gas fueled prime movers (6)	X		X
Fire detection in machinery space containing gas fueled prime movers	X		X
Abnormal pressures in the gas fuel supply line	X		X
Failure of valve control actuating medium	X		X(5)
Automatic shutdown of engine (engine failure)	X		X(5)
Emergency shutdown of engine manually released	X		X

Notes:

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

2 If the gas is supplied to more than one prime mover and the different supply pipes are completely separated and fitted in separate ducts and with the master gas valves fitted outside of the duct and outside of the machinery space containing gas fueled prime movers, only the master gas valve on the supply pipe leading into the duct where gas or loss of ventilation is detected is to close.

3 When a gas leakage is detected in a gas fueled prime mover machinery space and before the gas concentration detected reaches 60% of the LEL, all the electrical equipment inside the machinery space, other than certified safe type, is to be automatically isolated from its electrical supply and all the engines in that machinery space are to be shutdown.

4 If the duct is protected by inert gas (see 5/3.2i)a) of this Guide) then loss of inert gas overpressure is to lead to the same actions as given in this table.

5 Only block and bleed valves to close.

6 Single wall fuel gas piping machinery spaces only.