

GUIDE FOR

PROPULSION AND AUXILIARY SYSTEMS FOR GAS FUELED SHIPS MARCH 2016

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GUIDE FOR

PROPULSION AND AUXILIARY SYSTEMS FOR GAS FUELED SHIPS

MARCH 2016 (Updated January 2017 – see next page)

**American Bureau of Shipping
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the State of New York 1862**

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Foreword (1 March 2016)

For over ten years, medium speed dual fuel diesel engines have been chosen to power LNG carriers in preference to the traditional steam turbine powered propulsion plant arrangements. Recent trends have seen this move towards DF diesel engines expand to include slow speed diesel engines, notably utilizing high pressure fuel gas supply systems. 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.

It is envisaged that the effect of increasingly stricter air emissions legislation implemented through IMO Annex VI and other local air quality controls, together with favorable financial conditions for the use of natural gas instead of liquid fuel oil as a bunker fuel, will see an increasing number of dual fuel diesel engine and single gas fuel engine applications to LNG carriers and other vessel types in the future.

In some cases, dependent on the bunker fuel storage configuration and the selected propulsion and power generation arrangement, there may be a need to also install a gas combustion unit or alternative system to manage excess boil-off gas.

Accordingly, this Guide has been developed in order to provide guidance for the design and construction of the aforementioned propulsion prime mover arrangements, auxiliary power generation arrangements and associated systems for gas fueled ships and may be applied to all types of vessel, other than those covered by the IMO IGC Code, that utilize natural gas as fuel.

For LNG carrier requirements see the *ABS Guide for Propulsion Systems for LNG Carriers*.

The requirements in this Guide have been developed in consideration of IMO Resolution MSC.285(86) *Interim Guidelines on Safety for Natural Gas-Fuelled Engine Installations in Ships* which was adopted 1 June 2009 and the IMO *International Code of Safety for Ships Using Gases or Other Low Flashpoint Fuels* (IGF Code), which was adopted at IMO MSC 95 held 3-12 June 2015. The IGF Code will come into effect on 1 January 2017.

Where the requirements of the Guide are proposed to be used to comply with IMO Resolution MSC.285(86), or the IMO IGF Code, such application is subject to approval by the flag Administration prior to issuance of relevant statutory certificates on behalf of the flag Administration by ABS.

The applicable edition of the *ABS Rules for Building and Classing Steel Vessels* is to be used in association with this Guide.

This Guide becomes effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of this Guide is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically to rsd@eagle.org.



GUIDE FOR

PROPULSION AND AUXILIARY SYSTEMS FOR GAS FUELED SHIPS

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SECTION 1 General

1 Scope and Application (1 March 2016)

This Guide has been developed to provide guidance for the design, construction, and survey of vessels utilizing gas as a fuel. The Guide is focused on systems and arrangements provided for the safe use of gas for propulsion and auxiliary systems. The Guide is for application to gas fueled ship types other than those falling under the scope of the IGC Code and associated ABS requirements for *Vessels Intended to Carry Liquefied Gases in Bulk* under Part 5C, Chapter 8 of the *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*. The prime movers may use either a single fuel (gas) or dual fuel (gas and fuel oil) and the gas may be stored and distributed as Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG). The use of other fuel types will be subject to special consideration.

The use of natural gas as fuel in ships other than LNG carriers is not covered by international conventions. However, the installations will still be subject to approval by the Flag Administrations. The *Interim Guidelines on Safety for Natural Gas-Fuelled Engine Installations in Ships* (hereinafter referred to as *Interim Guidelines*) were adopted by International Maritime Organization (IMO) Resolution MSC.285(86) on 1 June 2009 which invites governments to apply the *Interim Guidelines* to gas fueled ships other than those covered by the IGC Code.

Where appropriate, this Guide has been aligned with the aforementioned *Interim Guidelines* and the IMO *International Code of Safety for Ships Using Gases or Other Low Flashpoint Fuels* (IGF Code).

This Guide is to be applied to both new construction and existing vessel conversions, regardless of size, utilizing natural gas as fuel.

2 Objectives

The objective of this Guide is to provide criteria for the arrangements, construction, installation and operation of machinery, equipment and systems for vessels operating with natural gas as fuel in order to minimize risks to the vessel, crew and environment. Detailed requirements are provided in each of the Sections of this Guide to achieve this objective in accordance with the following key requirements:

- Gas fuel storage systems are to be designed in accordance with Chapter 4 of the IGC Code, as incorporated by Section 5C-8-4 of the *Steel Vessel Rules*, and as applicable the *ABS Guide for Vessels Intended to Carry Compressed Natural Gases in Bulk (CNG Guide)*.
- Gas fuel storage tank pressure, temperature and filling limits are to be maintained within the design limits of the storage tank at all times.
- Means are to be provided to evacuate, purge and gas free the gas fuel storage tank.
- Gas fuel storage tanks are to be located in a protected location.
- Gas fuel storage spaces, bunkering stations, fuel gas preparation spaces and machinery spaces containing gas utilization equipment are to be located and arranged such that the consequences of any release of gas will be minimized while providing safe access for operation and inspection.
- Gas fuel supply piping, systems and arrangements are to provide safe handling of gas fuel liquid and vapor under all operating conditions. Means are to be provided to inert and gas free piping and systems.

- Gas fuel utilization equipment and machinery is to be designed and arranged for the safe consumption of natural gas as fuel.
- Automation, instrumentation, monitoring and control systems are to be provided to enable safe carriage, conditioning and utilization of natural gas.
- (1 May 2015) The vessel and systems are to be arranged with sufficient redundancy so as to provide continuity of power for propulsion, manoeuvring and essential services, 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 Control Station (1 March 2016)

Control station means those spaces defined in SOLAS chapter II-2 and additionally for this Guide, the engine control room.

3.6 Dual Fuel Diesel Engine (1 March 2016)

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

3.7 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.

3.8 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*.

3.9 Fuel Containment System (1 March 2016)

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.

The spaces around the fuel storage tank are defined as:

3.9.1 Hold Space

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

3.9.2 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.

3.9.3 Tank Connection Space (1 February 2013)

Tank Connection Space is an enclosed gas tight space surrounding the parts of the fuel tank containing all tank connections and tank valves. The boundaries of the space provide a secondary barrier. See 2/2.2.4iv) and Subsection 3/6 of this Guide for further clarification.

3.10 Gas Combustion Unit (or Thermal Oxidizer)

A *Gas Combustion Unit (or Thermal Oxidizer)* is a system used for controlling the pressure in the LNG bunker tanks by burning the excess boil-off gas from the tanks inside an enclosed combustion chamber under controlled and safe conditions.

3.11 Hazardous Area

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. See also 4-1-1/1.9.4 and 4-8-4/27 of the *Steel Vessel Rules* and Subsection 2/8 of this Guide.

Hazardous areas are divided into zones 0, 1 and 2 as defined below:

3.11.1 Zone 0

Zone 0 is an area in which an explosive gas atmosphere is present continuously or for long periods or frequently.

3.11.2 Zone 1

Zone 1 is an area in which an explosive gas atmosphere is likely to occur in normal operation occasionally.

3.11.3 Zone 2

Zone 2 is an area in which an explosive gas atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

3.12 Non-Hazardous Area

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.

3.13 High Pressure Piping

High Pressure Piping means gas fuel piping with a maximum working pressure greater than 10 bar.

3.14 IGC Code

IGC Code means the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, as amended.

3.15 LEL

LEL means the lower explosive limit.

3.16 LNG

LNG means liquefied natural gas.

3.17 Main Tank Valve

Main Tank Valve means a remote operated shut-off valve on the gas supply line from a gas storage tank, located as close to the tank outlet as possible. See also 2/6.2.3 of this Guide.

3.18 MARVS

MARVS means maximum allowable relief valve setting.

3.19 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.

3.20 Natural Gas (1 May 2015)

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.

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

3.21 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-8-7/2 of the *Steel Vessel Rules*.

3.22 Primary Barrier

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

3.23 Recognized Standard

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

3.24 Re-Liquefaction Unit (1 March 2016)

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.

3.25 Rules

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

3.26 Secondary Barrier

Secondary Barrier is the liquid-resisting outer element of a fuel containment system designed to afford temporary containment of any envisaged leakage of LNG through the primary barrier and to prevent the lowering of the temperature of the ship's structure to an unsafe level.

3.27 Single Gas Fuel Engine

Single Gas Fuel Engine is an engine capable of operating on gas fuel only.

4 Classification Notations (1 May 2015)

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 will 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 will 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 will 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 will 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 will 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 will 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 (1 May 2015)

Detailed instruction manuals are to be provided onboard, covering the operations, safety and maintenance requirements, personal protective equipment 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 (1 March 2016)

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 IMO IGF Code, such application is subject to approval by the Flag Administration prior to issuance of relevant statutory certificates 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.



SECTION 2 Ship Arrangements and System Design

1 General

1.1 Application

The requirements specified in this Section provide general guidance on ship arrangements and system design. There are further requirements contained 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.

1.2 Plans and Data to be Submitted (1 March 2016)

Plans and specifications covering the ship arrangements are to be submitted, in addition to the requirements contained in each of the individual sections and are, as applicable, to include:

- Ship safety concept **as referenced by 2/1.3 of this Guide**
- General arrangement
- Gas fuel storage arrangements
- Fuel gas supply system arrangements
- Fuel bunkering station arrangements
- Hazardous area classification plan
- Vent mast and venting arrangements

1.3 Ship Safety Concept (1 March 2016)

The ship safety concept is a study intended to demonstrate the safety principles applied in the vessel conceptual design, for example application of double barrier principles, application of IEC standards, evaluation of specific failure modes as identified in relevant FMEAs, propulsion and auxiliary redundancy arrangements addressing failure of fuel gas supply system detailed under 2/5.1 and engineering analyses specific to the particular vessel arrangements as required by 2/2.2, 2/2.2.3iii) and 2/9.1, of this Guide.

2 Location and Separation of Spaces

2.1 General (1 February 2013)

The arrangement and location of spaces containing potential sources of fuel liquid and vapor release directly into the space together with potential ignition sources are to be such that an explosion in such spaces will not cause damage to any space other than that in which the incident occurs nor render the machinery or equipment in other spaces inoperable. Such incidents should also not cause damage that would under normal operating conditions, injure people in work areas, accommodation, service spaces, or control stations.

2.2 Gas Storage Tanks (1 March 2016)

Gas storage tanks for LNG and those for CNG may be located either on the open deck or in enclosed spaces, subject to the requirements of 2/2.2.3 or 2/2.2.4 of this Guide, as applicable. The tank location is to satisfy either 2/2.2.1 or 2/2.2.2 of this Guide.

Proposals for alternative fuel storage tank location criteria, including location adjacent to accommodation, service or control stations, will be considered on a case-by-case basis. Considerations will be made in association with an appropriate risk assessment, and provided the results are detailed in the ship safety concept, and cover subjects such as, but not limited to, protective location, fire protection, lifesaving appliance equipment and evacuation arrangements.

2.2.1 Tank Location (Deterministic Method)

The fuel tank(s) are to be protected from external damage caused by collision or grounding in the following way:

- i) The fuel tanks are to be located at a minimum distance of $B/5$ or 11.5 m, whichever is less, measured inboard from the ship side at right angles to the centerline at the level of the summer load line draft; where B is the greatest molded breadth of the ship at or below the deepest draft (summer load line draft) as defined by SOLAS regulation II-1/2.8.
- ii) The boundaries of each fuel tank are to be taken as the extreme outer longitudinal, transverse and vertical limits of the tank structure including its tank valves.
- iii) For independent tanks the protective distance is to be measured to the tank shell (the primary barrier of the fuel containment system). For membrane tanks the distance is to be measured to the bulkheads surrounding the tank insulation.
- iv) In no case is the boundary of the fuel tank to be located closer to the shell plating or aft terminal of the ship than as follows:
 - a) *For Passenger Ships:* $B/10$ but in no case less than 0.8 m. However, this distance need not be greater than $B/15$ or 2 m whichever is less where the shell plating is located inboard of $B/5$ or 11.5 m, whichever is less, as required by 2/2.2.1i) of this Guide.
 - b) *For Cargo Ships:*
 1. for V_c below or equal to 1,000 m³, 0.8 m;
 2. for $1,000 \text{ m}^3 < V_c < 5,000 \text{ m}^3$, $0.75 + V_c \times 0.2/4,000$ m;
 3. for $5,000 \text{ m}^3 \leq V_c < 30,000 \text{ m}^3$, $0.8 + V_c/25,000$ m; and
 4. for $V_c \geq 30,000 \text{ m}^3$, 2 m,where V_c corresponds to 100% of the gross design volume of the individual fuel tank at 20°C, including domes and appendages.
- v) The lowermost boundary of the fuel tank(s) is to be located above the minimum distance of $B/15$ or 2.0 m, whichever is less, measured from the molded line of the bottom shell plating at the centerline.
- vi) For multihull ships, the value of B may be specially considered.
- vii) The fuel tank(s) are to be abaft a transverse plane at $0.08L$ measured from the forward perpendicular in accordance with SOLAS regulation II-1/8.1 for passenger ships, and abaft the collision bulkhead for cargo ships.

Where L is the length as defined in the International Convention on Load Lines as defined by SOLAS regulation II-1/2.5.
- viii) For ships with a hull structure providing higher collision and/or grounding resistance, fuel tank location regulations may be specially considered in accordance with Subsection 1/7 of this Guide.

2.2.2 Tank Location (Probabilistic Method)

As an alternative to 2/2.2.1 of this Guide, the following calculation method may be used to determine the acceptable location of the fuel tanks:

- i) The value f_{CN} calculated as described in the following is to be less than 0.02 for passenger ships and 0.04 for cargo ships.

Note: The value f_{CN} accounts for collision damage that may occur within a zone limited by the longitudinal projected boundaries of the fuel tank only, and cannot be considered or used as the probability for the fuel tank to become damaged given a collision. The real probability will be higher when accounting for longer damages that include zones forward and aft of the fuel tank.

- ii) The f_{CN} is calculated by the following formulation:

$$f_{CN} = f_{\ell} \times f_t \times f_v$$

where

f_{ℓ} = calculated by use of the formulations for factor p contained in SOLAS regulation II-1/7-1.1.1.1. The value of x_1 shall correspond to the distance from the aft terminal to the aftmost boundary of the fuel tank and the value of x_2 shall correspond to the distance from the aft terminal to the foremost boundary of the fuel tank.

f_t = calculated by use of the formulations for factor r contained in SOLAS regulation II-1/7-1.1.2, and reflects the probability that the damage penetrates beyond the outer boundary of the fuel tank. The formulation is:

$$= 1 - r(x_1, x_2, b)$$

Note: When the outermost boundary of the fuel tank is outside the boundary given by the deepest subdivision waterline the value of b is to be taken as 0.

f_v = calculated by use of the formulations for factor v contained in SOLAS regulation II-1/7-2.6.1.1 and reflects the probability that the damage is not extending vertically above the lowermost boundary of the fuel tank. The formulations to be used are:

= $1.0 - 0.6[(H - d)/7.6]$, if $(H - d)$ is less than or equal to 7.8 m. f_v is not be taken greater than 1.

= $0.2 - 0.2[(H - d) - 7.8/4.7]$ in all other cases. f_v is not be taken less than 0.

H = distance from baseline, in meters, to the lowermost boundary of the fuel tank

d = deepest draft (summer load line draft)

- iii) The boundaries of each fuel tank are to be taken as the extreme outer longitudinal, transverse and vertical limits of the tank structure including its tank valves.

- iv) For independent tanks, the protective distance is to be measured to the tank shell (the primary barrier of the fuel containment system). For membrane tanks, the distance is to be measured to the bulkheads surrounding the tank insulation.

- v) In no case is the boundary of the fuel tank to be located closer to the shell plating or aft terminal of the ship than as follows:

- a) *For Passenger Ships:* $B/10$ but in no case less than 0.8 m. However, this distance need not be greater than $B/15$ or 2 m whichever is less where the shell plating is located inboard of $B/5$ or 11.5 m, whichever is less.

b) *For Cargo Ships:*

1. for V_c below or equal to $1,000 \text{ m}^3$, 0.8 m;
2. for $1,000 \text{ m}^3 < V_c < 5,000 \text{ m}^3$, $0.75 + V_c \times 0.2/4,000 \text{ m}$;
3. for $5,000 \text{ m}^3 \leq V_c < 30,000 \text{ m}^3$, $0.8 + V_c/25,000 \text{ m}$; and
4. for $V_c \geq 30,000 \text{ m}^3$, 2 m,

where V_c corresponds to 100% of the gross design volume of the individual fuel tank at 20°C , including domes and appendages.

- vi) In case of more than one non-overlapping fuel tank located in the longitudinal direction, f_{CN} is to be calculated in accordance with 2/2.2.2ii) for each fuel tank separately. The value used for the complete fuel tank arrangement is the sum of all values for f_{CN} obtained for each separate tank.
- vii) In case the fuel tank arrangement is unsymmetrical about the centerline of the ship, the calculations of f_{CN} are to be performed for both starboard and port side and the average value is to be used for the assessment. The minimum distance as set forth in 2/2.2.2v) is to be met on both sides.
- viii) For ships with a hull structure providing higher collision and/or grounding resistance, fuel tank location regulations may be specially considered in accordance with Subsection 1/7 of this Guide.

2.2.3 Gas Storage Tanks – Storage on Open Deck

- i) (1 May 2015) Gas storage tanks and their associated piping systems are to be provided with effective structural protection against mechanical damage during ship operations.
- ii) The gas storage tanks and equipment are to be located so as to facilitate sufficient natural ventilation, in order to prevent accumulation of escaped gas.
- iii) (1 February 2013) 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 leakage from the pipe connections. Tank penetrations or nozzles prior to the main tank valve are to be assessed using the same design criteria as that used for the fuel storage tank. Accordingly drip trays are not expected to be sized to contain the full fuel storage tank contents unless required by the safety concept.

The material of the drip tray is to be stainless steel, or another material suitable for the containment of LNG, 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.

Drip trays are to be provided with a means of draining rainwater, seawater, etc., at periodic intervals.

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.

Alternatively, Type C LNG storage tanks applying the safety principles and arrangements of the ‘tank connection space’ detailed under 2/2.2.4iv) of this Guide may be accepted for location on open deck.

- iv) (1 May 2015) Gas storage tanks located above deck are to be shielded with class A-60 insulation towards accommodation, service spaces, cargo spaces, machinery spaces, control stations and in way of escape routes.

Accommodation boundaries facing gas fuel tanks on the open deck are to have A-60 insulation up to the bridge windows with bridge windows rated A-0 (with fire risk from outside).

2.2.4 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 2/2.2.4iv) 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) (1 May 2015) Gas storage tanks are to be located as close as possible to the ship centerline and in accordance with 2/2.2.1 or 2/2.2.2.
- iv) (1 February 2013) 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-8-4/19.1.1 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. See also the requirements for gas fuel storage rooms and tank connection spaces given under Subsection 3/6 of this Guide.

- 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) (1 May 2015) 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 tank connection space of 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) (1 May 2015) Fuel containment systems are not to be located adjacent to category A machinery spaces or other high fire risk spaces (e.g., those spaces containing fuel treatment equipment, galleys, pantries, laundry containing drying equipment, etc.). Separation is to be by means of a cofferdam with A-60 insulation, 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.

When determining the insulation of a space containing the fuel containment system from other spaces with lower fire risks, the fuel containment system space shall be considered as a machinery space of category A, in accordance with SOLAS regulation II-2/9.

The boundary between spaces containing fuel containment systems is to be either a cofferdam of at least 900 mm or an A-60 class division. For Type C tanks, the hold space may be considered as a cofferdam.

- viii) (1 May 2015) Tank connection spaces and ventilation trunks to such spaces below the bulkhead deck are to be constructed to class A-60. However, where the tank connection space and ventilation trunks are adjacent to tanks, voids, auxiliary machinery spaces of little or no fire risk, sanitary and similar spaces, the insulation standard may be reduced to class A-0.

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-8-3/5.3.5.1, 5C-8-3/5.3.5.3 and 5C-8-3/5.3.5.4 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-8-3/5.3.5.2 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-8-3/5.3.5.5 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) (1 February 2013) 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 or another material suitable for the containment of LNG and the drainage arrangements may be temporarily fitted for bunkering operations. Drip trays are to be provided with a means of draining rainwater, seawater, etc., at periodic intervals. 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) (1 May 2015) 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. Where a bunkering station is fitted on the open deck with sufficient natural ventilation and is more than 10 m measured horizontally from a boundary in question, the insulation may be reduced from A-60 to A-0. Where required to be A-60, the boundary is to be insulated up to the navigation bridge deck or the actual height of the boundary. Any boundaries above that may be class A-0, including navigation bridge windows.

2.5 Gas Compressor and Fuel Preparation Rooms

- i) (1 March 2016) 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 2/2.2.1 or 2/2.2.2, and 2/3.2, for protective location and access from the open deck respectively, and Subsections 5/7 through 5/9 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.
- iii) (1 May 2015) Gas and LNG piping within gas compressor and fuel preparation rooms is to comply with Subsections 2/4 and 5/3 of this Guide, as applicable. The hull and surrounding deck structure under or adjacent to potential leak points is to be protected against temperatures below that for which they are designed by the provision of suitable drip trays and shielding as per 2/2.4ii) of this Guide.

2.6 Machinery Spaces Containing Gas Utilization Units (1 February 2013)

2.6.1 Where Single Wall Fuel Gas Piping Concept is Applied

- 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 separated by a single bulkhead, the bulkhead is to be class A-60.
- iii) Machinery spaces applying the single wall fuel gas piping concept for gas fueled engines detailed under 2/5.4 of this Guide are to be as simple a geometrical shape as possible and be as small in volume as practicable, without compromising maintainability, in order to facilitate effective ventilation and gas detection. See also [Appendix 2](#) of this Guide.

2.6.2 Where Double Wall Fuel Gas Piping Concept is Applied

- i) Machinery spaces in which gas fuel is utilized are to be fitted with a mechanical ventilation system and are to be arranged in such a way as to prevent the formation of dead spaces. The ventilation system is to be independent of all other ventilation systems.
- ii) (1 May 2015) The number and power of the ventilation fans should be such that if one fan, or a group of fans within a 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 50% of the total required.
- iii) (1 May 2015) Permanently installed gas detectors complying with the requirements of Subsections 2/9 and 5/8 of this Guide are to be fitted in these spaces, particularly in the zones where air circulation is reduced.

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-8-3/6.1 through 5C-8-3/6.7 of the *Steel Vessel Rules* is to be provided.
- ii) (1 March 2016) 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 A2/5 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-8-3/6.1 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) (1 May 2015) Access to the tank connection space is, as far as practicable, to be independent and direct from the open deck. 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. If access is not direct from the open deck, such access is to be arranged as a bolted hatch and the space containing the bolted hatch will be a hazardous zone 2.
- ii) (1 May 2015) Inspection openings in accordance with 5C-8-3/5.3 of the *Steel Vessel Rules* are to be provided for Type C gas fuel storage tanks. Consideration will be given to alternative arrangements which can be shown to provide for an equivalent degree of internal inspection, where internal access is not possible.
- 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 (1 March 2016)

4.1 General (1 February 2013)

- i) (1 May 2015) Gas piping is to comply with Section 5C-8-5 of the *Steel Vessel Rules*, as applicable.
- 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) (1 May 2015) An arrangement for purging gas bunkering lines and supply lines with inert gas is to be provided.
- vi) Gas piping is to be protected against mechanical damage.

- vii) Gas pipes are to be color marked based on a recognized standard.
- viii) *(1 March 2016)* Gas vent piping from tank relief valves, bunker station relief valves, **relief valves on other gas containing equipment (such as LNG pumps, heat exchangers and gas compressors)** and block and bleed valves may be single walled when located on the open deck. Such piping is not to enter or pass through accommodation spaces, service spaces, control stations or similar spaces. If such piping does enter or pass through other enclosed spaces, the arrangement would be subject to special consideration. **See also note 5 to Section 5, Table 3.**
- ix) *(1 May 2015)* Connections to fuel gas storage tanks and piping containing pressurized LNG other than those in tank connection spaces are to be provided with spray shields and drip trays at potential leak points such as flanged joints and valves.

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 dependent 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.
- viii) *(1 May 2015)* Where high pressure relief valve discharges may create noise levels exceeding those permitted for occasional exposure without ear protection by the Code on Noise Levels on Board Ships, means shall be provided to reduce such noise levels within acceptable limits.

4.3 Distribution Outside of Machinery Spaces *(1 May 2015)*

Fuel gas supply 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.

Monitoring and safety system functions are to be provided in accordance with Section 5, Table 2 of this Guide.

5 System Configuration

5.1 General

- i) (1 May 2015) 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.

Dual fuel engine installations are considered to meet this redundancy objective by their inherent provision of independent gas and liquid fuel systems.

- 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) (1 May 2015) *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.
- 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/cm², 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 the IGC Code concept referenced by 2/5.2i) of this Guide.

5.3 Double Wall Fuel Gas Piping Concept

Where the double wall fuel gas piping concept is applied, the engine room arrangement is to comply with the applicable requirements of 2/2.6.2 of this Guide and gas fuel supply and safety systems are to be in compliance with Section 5 of this Guide.

5.4 Single Wall Fuel Gas Piping Concept (1 February 2013)

Where the single wall fuel gas piping concept is applied, the engine room arrangement is to comply with the applicable requirements of 2/2.6.1 of this Guide, [Appendix 2](#) of this Guide and the fuel supply and safety systems are to be in compliance with Section 5 of this Guide.

In order to maintain propulsion capability in case a single wall fuel gas piping engine compartment is shut down, propulsion engines and necessary equipment are to be located in at least two separate compartments. These compartments are not to have common boundaries unless it can be documented that the common boundary can withstand an explosion in one of the compartments. As per 2/5.2ii) of this Guide, the engine compartment is to contain only the engine(s) and minimum necessary equipment.

6 Gas Utilization

6.1 Utilization or Management of Boil-off Gas (1 May 2015)

Unless the entire bunker tank system is designed to withstand the full gauge vapor pressure of the gas under conditions of the upper ambient design temperatures, as specified in 5C-8-7/2 of the *Steel Vessel Rules*, means are to be provided to maintain the tank pressure below the MARVS by safely utilizing or managing the natural LNG boil-off at all times, including while in port, while maneuvering, while standing by or in idle condition with only power for domestic load being generated, as per Section 5C-8-7 of the *Steel Vessel Rules*. Systems and arrangements that may be used for this purpose may include one or any combination of the following:

- i) A dual fuel diesel engine plant for propulsion and power generation
- ii) A single gas fuel engine plant for propulsion and power generation
- iii) A gas turbine plant for propulsion and power generation
- iv) A re-liquefaction system
- v) A gas combustion unit
- vi) Other approved BOG utilization units, such as an auxiliary steam boiler capable of burning boil-off vapors. Dual fuel boilers installed on gas fuelled ships are to comply with the applicable requirements from Section 4-4-1 and 5C-8-16/6 of the *Steel Vessel Rules*.
- vii) Gas fuel storage tank pressure accumulation whereby the bunker tank fuel is allowed to warm up and increase in pressure. The tank insulation or tank design pressure is to be sufficient to maintain tank pressure below the MARVS for a period of 15 days under all tank fill conditions.

The aggregate capacity of the means provided for BOG utilization/disposal is to be not less than the normal boil-off rate (NBOR).

6.2 Supply of Fuel Gas and BOG to Utilization Units

6.2.1 Master Gas Valve (1 May 2015)

The gas supply to each gas utilization unit, or set of units, as specified in 2/6.1 of this Guide, located outside the gas storage area is to be through its own individual gas shut-off valve arranged for automatic closure if leakage of gas is detected, or loss of ventilation for the duct or casing or loss of pressurization of the double wall gas fuel piping occurs.

In addition, there are safety features required in each of the individual Sections of this Guide for protection of the equipment defined in these Sections, such as the re-liquefaction plant, gas combustion unit, dual fuel diesel engines, single gas fuel engines, gas turbine and associated installation. These safety features will require each individual gas shut-off valve to close under emergency or fault conditions. Reference is to be made to these requirements in each Section.

The master gas shut-off valve for each gas utilization unit required above is to be located outside the space containing the gas utilization unit but it need not be located in the gas storage area. However, if it is located in an enclosed space such as a gas valve unit room, that space is to be protected against gas leakage by another automatic shutdown valve arranged for closure in accordance with 5C-8-16/4.6.1 of the *Steel Vessel Rules*.

6.2.2 Automatic Purge

Arrangements are to be provided such that upon closure of the master gas valve the piping between the valve and the gas utilization unit will be automatically purged with inert gas.

6.2.3 Main Tank Valve (1 May 2015)

In addition to the individual master gas valve(s) fitted to each gas utilization unit, a main tank valve is also to be fitted in those instances where there is a connection below the highest liquid level or a pressurized fuel outlet. The main tank valve is to be located on the outlet from the gas fuel storage tank as close to the tank outlet as possible. Where applicable this main tank valve is to be arranged to automatically close as required by Section 3, Table 1 of this Guide. Main tank 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.

6.2.4 Pressure Surge Protection

Where there is a risk of a pressure surge in a pipeline caused by an instantaneous closure of the gas shut-off valve or shutdown of gas utilization unit (e.g., in the pipe downstream of the compressor), the piping system is to be designed to withstand a surge of gas pressure.

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:
 - a) Electric motors driving fans are to comply with the required explosion protection in the installation area. Ventilation fans are not to produce a source of vapor ignition in either the ventilated space or the ventilation system associated with the space. Ventilation fans and fan ducts, in way of fans only, are to be of non-sparking construction defined as:
 - i) Impellers or housings of non-metallic material, due regard being paid to the elimination of static electricity;
 - ii) Impellers and housings of non-ferrous metals;
 - iii) Impellers and housings of austenitic stainless steel;
 - iv) Impellers of aluminum alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller, due regard being paid to static electricity and corrosion between ring and housing; or
 - v) Any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm tip design clearance.
 - b) In no case is the radial air gap between the impeller and the casing to be less than 0.1 of the diameter of the impeller shaft in way of the bearing but not less than 2 mm. The gap need not be more than 13 mm.
 - c) Any combination of an aluminum or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and is not to be used in these places.
 - d) The ventilation units are to be safely bonded to the hull structure.
- iii) Any loss of the required ventilating capacity is to give an audible and visual alarm at a normally manned location.
- iv) Air inlets for hazardous enclosed spaces are to be taken from areas which, in the absence of the considered inlet, would be non-hazardous. Air inlets for non-hazardous enclosed spaces are to be taken from non-hazardous areas at least 1.5 m away from the boundaries of any hazardous area. Where the inlet duct passes through a more hazardous space, the duct is to have over-pressure relative to this space, unless mechanical integrity and gas-tightness of the duct is such to prevent gases from leaking into it.
- v) Air outlets from non-hazardous spaces are to be located outside hazardous areas.

- vi) Air outlets from hazardous enclosed spaces are to be located in an open area which, in the absence of the considered outlet, would be of the same or lesser hazard than the ventilated space.
- vii) The required capacity of the ventilation plant is normally based on the total volume of the room. An increase in required ventilation capacity may be necessary for rooms having a complicated form.
- viii) Ventilation ducts are to have the same area classification as the ventilated space.

In addition there are specific ventilation requirements in each individual Section of this Guide, reference is to be made to the requirements in each section.

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) (1 February 2013) 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, see 2/8.3.3i) of this Guide);