Rules for Classification and Construction

VI Additional Rules and Guidelines

3 Machinery Installations

1 Guidelines for the Use of Gas as Fuel for Ships

Edition 2010

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Preamble

1. These Guidelines refer to the IMO Interim Guidelines for gas as ship fuel (Resolution MSC.285(86)) which have been developed to provide an international standard for ships, other than vessels covered by the IGC-Code (I – Ship Technology, Part 1 – Seagoing Ships, Chapter 6 – Liquefied Gas Carriers), with natural gas fuelled engine installations. They incorporate the text of Resolution MSC.285(86) in full and provide additional guidance and recommendations on their application. Paragraphs that contain such guidance information or recommendations are marked by a vertical line on the side as this paragraph 1.

In the following the term Guidelines refers to VI – Additional Rules and Guidelines, Part 3 – Machinery Installations, Chapter 1 – Guidelines for the Use of Gas as Fuel for Ships.

2. The goal of Resolution MSC.285(86) is to provide criteria for the arrangement and installation of machinery for propulsion and auxiliary purposes, using natural gas as fuel, which will have an equivalent level of integrity in terms of safety, reliability and dependability as that which can be achieved with a new and comparable conventional oil fuelled main and auxiliary machinery.

3. To achieve this goal, the functional and technical requirements described below are embodied in the relevant parts of these Guidelines:

.1 Minimize hazardous areas as far as is practicable to reduce the potential risks that might affect the safety of the ship, personnel and equipment.

.2 Minimize equipment installed in hazardous areas to that required for operational purposes. Equipment installed in hazardous areas should be suitable and appropriately certified.

.3 Arrange propulsion and electrical power generating installation to be capable of sustained or restored operation in the event that a gas fuelled essential service becomes inoperative.

.4 Explosions or hazardous consequences of explosions must be prevented.

.5 This includes the following technical requirements:

.1 Arrange hazardous areas in such a way as to ensure that gas cannot accumulate under normal and foreseeable failure conditions.

.2 Provide ventilation to reduce the risk of the accumulation of explosible atmosphere and to protect personnel from an oxygen deficient atmosphere in the event of a gas leakage.

.3 Minimize the number of ignition sources in hazardous spaces by design, arrangements and selection of suitable equipment.

.4 Provide gas detection and sampling systems suitable for the space concerned together with monitoring, alarm and shutdown arrangements.

.5 Provide protection against the potential effects of a gas-fuel explosion.

.6 Arrange safe and suitable gas fuel storage and bunkering arrangements capable of taking on board and containing the gas fuel in the required state without leakage and excessive overpressure.

.7 Provide gas piping systems, containment and overpressure relief arrangements that are of suitable design, construction and installation for their intended application.

.8 Design, construct, install, operate and protect gas- fuelled machinery, gas system and components to achieve safe and reliable operation consistent with that of oil-fuelled machinery.

.9 Arrange and locate gas storage tank rooms and machinery spaces such that a fire or explosion in either will not render the machinery/equipment in other compartments inoperable.

.10 A safe and reliable technical control system is required. This includes that safe and reliable gas-fuel control engineering arrangements consistent with those of oil-fuelled machinery are provided.

.11 Provide appropriate selection of certified equipment and materials that are suitable for use within gas systems.

.12 Minimize the effects of a hazard. This includes the following technical requirement:

.1 Provide fire protection, detection and extinction measures appropriate to the hazards concerned.

.13 Provide a level of confidence in a gas-fuelled unit that is equivalent to that for an oil-fuelled unit.

.14 Ensure that survey, commissioning, trials and maintenance of gas utilization machinery satisfy the goal in terms of reliability, availability and safety.

.15 Provide provision for procedures detailing the guidelines for safe routine and unscheduled inspection and maintenance.

.16 Provide operational safety through appropriate training and certification of crew.

.17 Provide for submission of technical documentation in order to permit an assessment of the compliance of the system and its components with the applicable rules and guidelines, applied design standards and the principles related to safety, availability and reliability.

.18 Provide adequate measures minimize the risk to personnel.

.19 Protect gas system components against external damages. The potential risks must be limited as far as possible.

4. Resolution MSC.285(86) addresses the safety of ships utilizing natural gas as fuel.

5. 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).

6. The gas composition can vary depending on the source of natural gas and the processing of the gas. A typical composition in volume % is:

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 Compressed Natural Gas (CNG) or Liquefied Natural Gas (LNG).

7. Demonstrating compliance with functional requirements

The functional requirements described in x.x are to be demonstrated by compliance with the requirements of these Guidelines. Alternative equivalent arrangements may be accepted by GL if the requirements of GL Rules, Guidelines for the Analysis of Alternative Design and Arrangements (V-2-1) are fulfilled.

Section 1

General

1.1 Application

1.1.1 Resolution MSC.285(86) applies to internal combustion engine installations in ships using natural gas as fuel. The engines may use either a single fuel (gas) or dual fuel (gas and oil fuel), and the gas may be stored in gaseous or liquid state.

1.1.2 Resolution MSC.285(86) should be applied in addition to the relevant provisions of the International Convention for the Safety of Life at Sea (SOLAS), 1974 and the Protocol of 1988 relating thereto, as amended.

1.1.3 Resolution MSC.285(86) is applicable to new ships. Application to existing ships should be decided by the Administration to the extent it deems necessary.

1.1.4 Rules for Classification and Construction

In addition to the following Rules for Classification and Construction shall be observed:

– I – Ship Technology, Part 1 – Seagoing Ships, Chapter 1 – Hull Structures

– I – Ship Technology, Part 1 – Seagoing Ships, Chapter 2 – Machinery Installations

– I – Ship Technology, Part 1 – Seagoing Ships, Chapter 3 – Electrical Installations

– I – Ship Technology, Part 1 – Seagoing Ships, Chapter 4 – Automation

1.1.5 Class Notation GF

Notation to Character of Class for ships fitted with engine installations suitable for operation with natural gas as fuel and complying with the requirements of these Guidelines.

1.2 Hazards

These Guidelines address the hazards related to the arrangements for the storage, distribution and use of natural gas as a fuel.

1.3 Definitions

Note

Unless otherwise stated below, definitions are as defined in SOLAS chapter II-2.

1.3.1 *Accidents* mean uncontrolled events that may entail the loss of human life, personal injuries, environmental damage or the loss of assets and financial interests.

1.3.2 *Certified safe type* means electrical equipment that is certified safe by a recognized body based on a recognized standard. [1] The certification of electrical equipment is to correspond to the category and group for methane gas.

1.3.3 *CNG* means compressed natural gas.

1.3.4 *Control stations* mean those spaces defined in SOLAS chapter II-2 and additionally for these Guidelines, the engine control room.

1.3.5 *Double block and bleed valve* means a set of three automatic valves located at the fuel supply to each of the gas engines.

1.3.6 *Dual fuel engines* mean engines that can burn natural gas and oil fuel simultaneously or operate on oil fuel or gas only.

1.3.7 *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. [2]

1.3.8 *ESD* means emergency shutdown.

1.3.9 *Explosion* means a deflagration event of uncontrolled combustion.

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

1.3.11 *Gas* means a fluid having a vapour pressure exceeding 2.8 bar absolute at a temperature of 37.8 °C.

1.3.12 *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 electrical apparatus (cf. GL Rules, Electrical Installations (I-1-3), Section 1, K.3.).

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1 Refer to IEC 60079 series, Explosive atmospheres and IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features.

2 See also definition in IEC 60092-502:1999.

Hazardous areas are divided into zones 0, 1 and 2 as defined below. [3]

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

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

.3 *Zone 2* is an area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only.

1.3.13 *Non-hazardous area* means an area which is not considered to be hazardous, i.e., gas safe, provided certain conditions are being met.

1.3.14 *High-pressure piping* means gas fuel piping with maximum working pressure greater than 10 bar.

1.3.15 *IEC* means the International Electrotechnical Commission.

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

1.3.17 *LEL* means the lower explosive limit.

1.3.18 LNG means liquefied natural gas (ref. 1.3.22).

1.3.19 *Main tank valve* means a remote operated shut-off valve on the gas outlet from a gas storage tank, located as close to the tank outlet point as possible.

1.3.20 *MARVS* means the maximum allowable relief valve setting of a gas tank.

MARVS is a general term and therefore also given for other equipment than a tank such as pressure vessels, heat exchangers or piping.

1.3.21 *Master gas fuel valve* means an automatic shut-off valve in the gas supply line to each engine, located outside the machinery space for gas fuelled engines, and as close to the gas heater (if fitted) as possible.

1.3.22 *Natural gas* means a 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).

1.3.23 *Open deck* means a deck that is open on both ends, or is open on one end and equipped with adequate natural ventilation that is effective over the entire length of the deck through permanent openings distributed in the side panels or in the deck above.

1.3.24 *Organization* means the International Maritime Organization (IMO).

1.3.25 *Risk* means the expression of the danger that an undesired event represents to persons, to the environment or to material property. The risk is expressed by the probability and consequences of an accident.

1.3.26 *Recognized standards* means applicable international or national standards acceptable to the Administration or standards laid down and maintained by an Organization which complies with the standards adopted by the Organization and which is recognized by the Administration.

1.3.27 *Safety management system* means the international safety management system as described in the ISM Code.

1.3.28 *Second barrier* means a technical measure which prevents the occurrence of a hazard if the first barrier fails. E.g. second housing of a tank protecting the surroundings from the effect of tank leaks.

1.3.29 *Semi-enclosed space* means a space limited by decks and or bulkheads in such manner that the natural conditions of ventilation are notably different from those obtained on open deck. [4]

1.3.30 *Single gas fuel engine* means a power generating engine capable of operating on gas-only, and not able to switch over to oil fuel operation.

1.3.31 *SOLAS Convention* means the International Convention for the Safety of Life at Sea, 1974, as amended.

1.3.32 *Source of release* means any valve, detachable pipe joint, pipe packing, compressor or pump seal in the gas fuel system.

1.3.33 *Tank room* means the gas-tight space surrounding the parts of the bunker tank, containing all tank connections and all tank valves.

1.4 Survey requirements

1.4.1 Surveys should be performed and certification issued in accordance with the provisions of SOLAS 1974, as modified by its 1988 Protocol and as amended, Section 1, Part B, regulation 6 or 7, as applicable. [5]

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3 Refer also to the area classification specified in Sec. 2.5 of IEC 60079-10-1:2008 Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres.

4 Refer also to IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features.

5 Refer to resolution A.997(25) Revised survey guidelines under the harmonized system of survey and certification.

Section 2

Ship Arrangements and System Design

2.0 Documents for approval

The following documents related to Section 2 are to be submitted electronically via GLOBE[1] or in paper form in triplicate. GLOBE submission is the preferred option.

- General Arrangement
- Documents about LNG storage Tank according to I – Ship Technology, Part 1 – Seagoing Ships, Chapter 6 – Liquefied Gas Carriers
- Specifications of gas piping according to I – Ship Technology, Part 1 – Seagoing Ships, Chapter 6 – Liquefied Gas Carriers
- Specifications for safety relief valves according to I – Ship Technology, Part 1 – Seagoing Ships, Chapter 6 – Liquefied Gas Carriers
- Specifications of ventilation systems in spaces covering gas fuel system
- Specifications of piping systems
- P&I Gas Storage and Supply System including part list
- Documentation of pressure vessels of the gas supply system
- P&I Ventilation System belonging to the gas system including part list
- Safety Concept
- Operational handbook
- Functional description
- Specification of materials, welding, post-weld heat treatment

GL reserves the right to request additional documentation as necessary.

2.1 General

2.1.1 For any new or altered concept or configuration a risk analysis should be conducted in order to ensure that any risks arising from the use of gas-fuelled engines affecting the structural strength and the integrity of the ship are addressed. Consideration should be given to the hazards associated with installation, operation, and maintenance, following any reasonably foreseeable failure.

2.1.2 The risks should be analysed using acceptable and recognized risk analysis techniques and loss of function, component damage, fire, explosion and electric shock should as a minimum be considered. The analysis should ensure that risks are eliminated wherever possible. Risks which cannot be eliminated should be mitigated as necessary. Details of risks, and the means by which they are mitigated, should be included in the operating manual.

2.1.3 An explosion in any space containing open gas sources should not:

.1 cause damage to any space other than that in which the incident occurs;

.2 disrupt the proper functioning of other zones;

.3 damage the ship in such a way that flooding of water below the main deck or any progressive flooding occur;

.4 damage work areas or accommodation in such a way that people who stay in such areas under normal operating conditions are injured;

.5 disrupt the proper functioning of control stations and switchboard rooms for necessary power distribution;

.6 damage life-saving equipment or associated launching arrangements;

.7 disrupt the proper functioning of fire-fighting equipment located outside the explosion-damaged space; or

.8 affect other areas in the vessel in such a way that chain reactions involving, inter alia, cargo, gas and bunker oil may arise.

2.2 Material requirements

2.2.1 Materials used in gas tanks, gas piping, process pressure vessels and other components in contact with gas should be in accordance with GL Rules, Liquefied Gas Carriers (I-1-6), Section 6. For CNG tanks, the use of materials not covered may be spe-

[1] Detailed information about GLOBE submission can be found on GL's website www.gl-group.com.

cially considered by I – Ship Technology, Part 1 – Seagoing Ships, Chapter 6 – Liquefied Gas Carriers.

2.2.2 Materials for piping system for liquefied gases should comply with the requirements of GL Rules, Liquefied Gas Carriers (I-1-6), Section 2. Some relaxation may, however, be permitted in the quality of the material of open ended vent piping, provided the temperature of the gas at atmospheric pressure is -55 °C or higher, and provided no liquid discharge to the vent piping can occur. Materials should in general be in accordance with recognized standards.

2.2.3 Materials having a melting point below 925 °C should not be used for piping outside the gas tanks except for short lengths of pipes attached to the gas tanks, in which case the low melting point materials should be wrapped in class A-60 insulation.

2.3 Location and separation of spaces

2.3.1 The arrangement and location of spaces

The arrangement and location of spaces for gas fuel storage, distribution and use should be such that the number and extent of hazardous areas is kept to a minimum.

2.3.2 Gas compressor room

2.3.2.1 Compressor rooms, if arranged, should be located above freeboard deck, unless those rooms are arranged and fitted in accordance with the requirements of these guidelines for tank rooms.

2.3.2.2 If compressors are driven by shafting passing through a bulkhead or deck, the bulkhead penetration should be of gastight type.

2.3.3 Machinery spaces containing gas-fuelled engines

2.3.3.1 When more than one machinery space is required for gas-fuelled engines and these spaces are separated by a single bulkhead, the arrangements should 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.

2.3.3.2 ESD-protected machinery spaces for gas fuelled engines should have as simple geometrical shape as possible.

2.3.4 Tank rooms

2.3.4.1 Tank room boundaries including access doors should be gas tight.

2.3.4.2 The tank room should not be located adjacent to machinery spaces of category A. If the separation is by means of a cofferdam the separation should be at least 900 mm and insulation to class A-60 should be fitted on the engine-room side.

2.4 Arrangement of entrances and other openings

2.4.1 Direct access through doors, gastight or otherwise, should generally not be permitted from a gas-safe space to a gas-dangerous space. Where such openings are necessary for operational reasons, an air lock which complies with the requirements of GL Rules, Liquefied Gas Carriers (I-1-6), Section 3, 3.6 (2-7) should be provided.

2.4.2 If the compressor room is approved located below deck, the room should, as far as practicable, have an independent access direct from the open deck. Where a separate access from deck is not practicable, an air lock which complies with the requirements of GL Rules, Liquefied Gas Carriers (I-1-6), Section 3, 3.6 (2-7) should be provided.

2.4.3 The tank room entrance should be arranged with a sill height of at least 300 mm.

2.4.4 Access to the tank room should as far as practicable be independent and direct from open deck. If the tank room is only partially covering the tank, this requirement should also apply to the room surrounding the tank and where the opening to the tank room is located. Where a separate access from deck is not practicable, an air lock which complies with the requirements of GL Rules, Liquefied Gas Carriers (I-1-6), Section 3, 3.6 (2-7) should be provided.

The access trunk should be fitted with separate ventilation. It should not be possible to have unauthorized access to the tank room during normal operation of the gas system.

2.4.5 If the access to an ESD-protected machinery space is from another enclosed space in the ship, the entrances should be arranged with self-closing doors. An audible and visual alarm should be provided at a permanent manned location. Alarm should be given if the door is open continuously for more than 1 min. As an alternative, an arrangement with two self-closing doors in series may be acceptable.

2.5 General pipe design

2.5.1 The requirements of this section apply to gas piping. The Administration may accept relaxation from these requirements for gas piping inside gas tanks and open ended piping after special consideration, such as risk assessment.

2.5.2 Gas piping should be protected against mechanical damage and the piping should be capable of assimilating thermal expansion without developing substantial tension.

2.5.3 The piping system should be joined by welding with a minimum of flange connections. Gaskets should be protected against blow-out.

2.5.4 The wall thickness of pipes should be calculated according to GL Rules, Liquefied Gas Carriers (I-1-6), Section 5, 5.2.2. The allowable stress (K) should be calculated according to 2.5.6.

2.5.5 The greater of the following design conditions should be used for piping, piping system and components as appropriate:

.1 for systems or components which may be separated from their relief valves and which contain only vapour at all times, the superheated vapour pressure at 45 °C or higher or lower if agreed upon by the Administration (ref. GL Rules, Liquefied Gas Carriers (I-1-6), Section 4, 4.2.6.2), assuming an initial condition of saturated vapour in the system at the system operating pressure and temperature; or

.2 the MARVS of the gas tanks and gas processing systems; or

.3 the pressure setting of the associated pump or compressor discharge relief valve if of sufficient capacity; or

.4 the maximum total discharge or loading head of the gas piping system; or

.5 the relief valve setting on a pipeline system if of sufficient capacity; or

.6 a pressure of 10 bar except for open ended lines where it is not to be less than 5 bar.

2.5.6 For pipes made of steel including stainless steel, the allowable stress to be considered in the formula of the strength thickness in 2.5.4 is the lower of the following values:

$$K = \frac{R_m}{A} \text{ or } \frac{R_e}{B}$$

where:

R_m = specified minimum tensile strength at room temperature [N/mm^2].

R_e = specified lower minimum yield stress or 0,2 % proof stress at room temperature [N/mm^2].

A = 2,7

B = 1,8

The permissible stress to be considered for the calculation of the minimum wall thickness should comply with GL Rules, Liquefied Gas Carriers (I-1-6), Section 5, 5.2.4.

For pipes made of materials other than steel, the allowable stress should be considered by the Administration.

2.5.7 Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipe due to superimposed loads from supports, ship deflection or other causes, the wall thickness should be increased over that required by 2.5.4 or, if this is impractical or would cause excessive local stresses, these loads should be reduced, protected against or eliminated by other design methods.

2.5.8 Gas piping systems should have sufficient constructive strength. For high pressure gas piping systems this should be confirmed by carrying out stress analysis and taking into account:

.1 stresses due to the weight of the piping system;

.2 acceleration loads when significant; and

.3 internal pressure and loads induced by hog and sag of the ship.

2.5.9 Flanges, valves, fittings, etc. should be in accordance with recognized standards taking into account the design pressure defined in 2.5.5. For bellows and expansion joints used in vapour service, a lower minimum design pressure than defined in 2.5.5 may be accepted.

2.5.10 All valves and expansion joints used in high pressure gas systems should be of an approved type.

2.5.11 The following types of connections may be considered for direct connection of pipe lengths (without flanges):

.1 Butt welded joints with complete penetration at the root may be used in all applications. For design temperature below -10 °C, butt welds should be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a use of a inert gas back-up on the first pass.

.2 Slip-on welded joints with sleeves and related welding, having dimensions satisfactory to the Administration, should only be used for open-ended lines with external diameter of 50 mm or less and design temperatures not lower than -55 °C.

.3 Screwed couplings should only be used for accessory lines and instrumentation lines with external diameters of 25 mm or less.

2.5.12 Flanges should be of the welding neck, slip-on or socket welding type. For all piping (except open ended lines), the following apply:

.1 For design temperatures < -55 °C only welding neck flanges should be used.

.2 For design temperatures < -10 °C slip-on flanges should not be used in nominal sizes above 100 mm and socket welding flanges should not be used in nominal sizes above 50 mm.

2.5.13 Piping connections other than those mentioned above may be accepted upon consideration in each case.

2.5.14 Postweld heat treatment should be required for all butt welds of pipes made with carbon, carbon-manganese and low-alloy steels. The Administration may waive the requirement for thermal stress relieving of pipes having wall thickness less than 10 mm in relation to the design temperature and pressure of the piping system concerned.

2.5.15 When the design temperature is -110 °C or lower, a complete stress analysis for each branch of the piping system should be submitted. This analysis should take into account all stresses due to weight of pipes with cargo (including acceleration if significant), internal pressure, thermal contraction and loads induced by movements of the ship. For temperatures above -110 °C, a stress analysis may be required by the Administration. In any case, consideration should be given to thermal stresses, even if calculations need not be submitted. The analysis should be carried out according to a recognized code of practice.

2.5.16 Gas pipes should not be located less than 760 mm from the ship's side.

2.5.17 Gas piping should not be led through other machinery spaces. Alternatively, double gas piping or a ventilated duct may be approved, provided the danger of mechanical damage is negligible, the gas piping has no discharge sources and the room is equipped with a gas alarm.

2.5.18 An arrangement for purging gas bunkering lines and supply lines (only up to the double block and bleed valves if these are located close to the engine) with nitrogen should be provided.

2.5.19 The gas piping system should be installed with sufficient flexibility. Arrangement for provision of the necessary flexibility should be demonstrated to maintain the integrity of the piping system in all foreseen service situations.

2.5.20 Gas pipes should be colour marked based on a recognized standard. [2]

2.5.21 If the fuel gas contains heavier components that may condense in the system, knock out drums or equivalent means for safely removing the liquid should be fitted.

2.5.22 All pipelines and components which may be isolated containing liquid gas should be provided with relief valves.

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

2.6 System configuration

2.6.1 Alternative system configurations

2.6.1.1 Two alternative system configurations may be accepted:

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

.2 *ESD-protected machinery spaces:* Arrangements in machinery spaces are such that the spaces are considered non-hazardous under normal conditions, but under certain abnormal conditions may have the potential to become hazardous. In the event of abnormal conditions involving gas hazards, emergency shutdown (ESD) of non-safe equipment (ignition sources) and machinery is to be automatically executed while equipment or machinery in use or active during these conditions are to be of a certified safe type.

2.6.2 Gas safe machinery spaces

2.6.2.1 All gas supply piping within machinery space boundaries should be enclosed in a gas tight enclosure, i.e., double wall piping or ventilated ducting.

2.6.2.2 In case of leakage in a gas supply pipe making shutdown of the gas supply necessary, a secondary independent fuel supply should be available. Alterna-

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2 Refer to EN ISO 14726:2008 Ships and marine technology – Identification colours for the content of piping systems.

tively, in the case of multi-engine installations, independent and separate gas supply systems for each engine or group of engines may be accepted.

2.6.2.3 For single fuel installations (gas only), the fuel storage should be divided between two or more tanks of approximately equal size. The tanks should be located in separate compartments.

2.6.3 ESD-protected machinery spaces

2.6.3.1 Gas supply piping within machinery spaces may be accepted without a gastight external enclosure on the following conditions:

.1 Engines for generating propulsion power and electric power should be located in two or more machinery spaces not having any common boundaries unless it can be documented that the common boundary can withstand an explosion in one of the rooms. Distribution of engines between the different machinery spaces should be such that in the case of shutdown of fuel supply to any one machinery space it is possible to maintain at least 40 % of the propulsion power plus normal electrical power supply for sea going services. Incinerators, inert gas generators or other oil fired boilers should not be located within an ESD-protected machinery space.

.2 The gas machinery, tank and valve installation spaces should contain only a minimum of such necessary equipment, components and systems as are required to ensure that any piece of equipment in each individual space maintains its principal function.

.3 Pressure in gas supply lines within machinery spaces should be less than 10 bar, e.g., this concept can only be used for low pressure systems.

.4 A gas detection system arranged to automatically shutdown the gas supply (also oil fuel supply if dual fuel) and disconnect all non-explosion protected equipment or installations should be fitted, as outlined in 5.5 and 5.6.

2.6.3.2 For single fuel installations (gas only), the fuel storage should be divided between two or more tanks of approximately equal size. The tanks should be located in separate compartments.

2.7 Gas supply system in gas machinery spaces

2.7.1 Gas supply system for gas safe machinery spaces

2.7.1.1 Gas supply lines passing through enclosed spaces should be completely enclosed by a double pipe or ventilated duct. This double pipe or ventilated duct should fulfil one of the following:

.1 The gas piping should be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes should be pressurised with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms should be provided to indicate a loss of inert gas pressure between the pipes. Alternative arrangements like monitored evacuated double wall pipes can be accepted by GL. When the inner pipe contains high pressure gas, the system should be so arranged that the pipe between the master gas valve and the engine is automatically purged with inert gas when the master gas valve is closed; or

.2 The gas fuel piping should 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 should be equipped with mechanical under pressure ventilation having a capacity of at least 30 air changes per hour. This ventilation capacity may be reduced to 10 air changes per hour provided automatic filling of the duct with nitrogen upon detection of gas is arranged for. The fan motors should comply with the required explosion protection in the installation area. The ventilation outlet should be covered by a protection screen and placed in a position where no flammable gas-air mixture may be ignited.

2.7.1.2 The connecting of gas piping and ducting to the gas injection valves should be so as to provide complete coverage by the ducting. The arrangement should facilitate replacement and/or overhaul of injection valves and cylinder covers. The double ducting should be required also for gas pipes on the engine itself, and all the way until gas is injected into the chamber. [3]

2.7.1.3 For high-pressure piping the design pressure of the ducting or of the outer pipe of a double wall piping should be taken as the higher of the following:

.1 the maximum built up pressure: static pressure in way of the rupture resulting from the gas flowing in the annular space;

.2 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:

$$p^* = p_0 \left(\frac{2}{k+1} \right)^{\frac{k}{k-1}}$$

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[3] If gas is supplied into the air inlet on a low pressure engine, double ducting may be omitted on the air inlet pipe on the condition that a gas detector is fitted above the engine.

where:

p_0 = maximum working pressure of the inner pipe

$k = \frac{C_p}{C_v}$ constant pressure specific heat divided by the constant volume specific heat

k = 1.31 for CH_4

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

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

2.7.1.4 For low pressure piping the duct should be dimensioned for a design pressure not less than the maximum working pressure of the gas pipes. The duct should also be pressure tested to show that it can withstand the expected maximum pressure at gas pipe rupture.

2.7.1.5 The arrangement and installation of the high-pressure gas piping should 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.

2.7.2 Gas supply system for ESD-protected machinery spaces

2.7.2.1 The pressure in the gas supply system should not exceed 10 bar.

2.7.2.2 The gas supply lines should have a design pressure not less than 10 bar.

2.8 Gas fuel storage

2.8.1 Liquefied gas storage tanks

2.8.1.1 The storage tank used for liquefied gas should be an independent tank designed in accordance with GL Rules, Liquefied Gas Carriers (I-1-6), Section 4.

2.8.1.2 Pipe connections to the tank should normally be mounted above the highest liquid level in the tanks. However, connections below the highest liquid level may be accepted after special consideration by the Administration.

2.8.1.3 Pressure relief valves as required in the GL Rules, Liquefied Gas Carriers (I-1-6), Section 8 should be fitted.

2.8.1.4 The outlet from the pressure relief valves should normally be located at least B/3 or 6 m, whichever is greater, above the weather deck and 6 m above the working area and gangways, where B is the greatest moulded breadth of the ship in metres. The outlets should normally be located at least 10 m from the nearest:

.1 air intake, air outlet or opening to accommodation, service and control spaces, or other gas safe spaces; and

.2 exhaust outlet from machinery or from furnace installation.

2.8.1.5 Storage tanks for liquid gas should not be filled to more than 98 % full at the reference temperature, where the reference temperature is as defined in GL Rules, Liquefied Gas Carriers (I-1-6), Section 15, 15.1.4. A filling limit curve for actual filling temperatures should be prepared from the formula given in GL Rules, Liquefied Gas Carriers (I-1-6), Section 15, 15.1.2. However, when the tank insulation and tank location makes the probability very small for the tank contents to be heated up due to external fire, special considerations may be made to allow a higher filling limit than calculated using the reference temperature, but never above 95 %.

2.8.1.6 Means that are not dependent on the gas machinery system should be provided whereby liquid gas in the storage tanks can be emptied in an emergency situation.

2.8.1.7 It should be possible to empty, purge gas and vent bunker tanks with gas piping systems. Procedures should be prepared for this. Inerting should be performed with, for instance, nitrogen, CO_2 or argon prior to venting with air to avoid an explosion hazardous atmosphere in tanks and gas pipes.

2.8.2 Compressed gas storage tanks

2.8.2.1 The storage tanks to be used for compressed gas should be certified and approved by GL.

2.8.2.2 Tanks for compressed gas should be fitted with pressure relief valves with a set point below the design pressure of the tank and with outlet located as required in 2.8.1.4.

2.8.3 Storage on open deck

2.8.3.1 Both gases of the compressed and the liquefied type may be accepted stored on open deck.

2.8.3.2 The storage tanks or tank batteries should be located at least B/5 from the ship's side. For ships other than passenger ships a tank location closer than B/5 but not less than 760 mm from the ship's side may be accepted.

2.8.3.3 The gas storage tanks or tank batteries and equipment should be located to assure sufficient natural ventilation, so as to prevent accumulation of escaped gas.

2.8.3.4 Tanks for liquid gas with a connection below the highest liquid level, (see 2.8.1.2) should be fitted with drip trays below the tank which should be of sufficient capacity to contain the volume which could escape in the event of a pipe connection failure. The material of the drip tray should be stainless steel, and there should be efficient separation or isolation so that the hull or deck structures are not exposed to unacceptable cooling, in case of leakage of liquid gas.

2.8.4 Storage in enclosed spaces

2.8.4.1 Gas in a liquid state may be stored in enclosed spaces, with a maximum acceptable working pressure of 10 bar. Storage of compressed gas in enclosed spaces and location of gas tanks with a higher pressure than 10 bar in enclosed spaces is normally not acceptable, but may be permitted after special consideration and approval by GL provided the following is fulfilled in addition to 2.8.4.3:

.1 Adequate means are provided to depressurize the tank in case of a fire which can affect the tank; and

.2 all surfaces within the tank room are provided with suitable thermal protection against any lost high-pressure gas and resulting condensation unless the bulkheads are designed for the lowest temperature that can arise from gas expansion leakage; and

.3 a fixed fire extinguishing system is installed in the tank room.

2.8.4.2 The gas storage tank(s) should be placed as close as possible to the centreline of the ship:

.1 minimum, the lesser of B/5 and 11,5 m from the ship side;

.2 minimum, the lesser of B/15 and 2 m from the bottom plating;

.3 not less than 760 mm from the shell plating.

For ships other than passenger ships and multihulls, a tank location closer than B/5 from the ship side may be accepted.

2.8.4.3 The storage tank and associated valves and piping should be located in a space designed to act as a second barrier, in case of liquid or compressed gas leakage. The material of the bulkheads of this space should have the same design temperature as the gas tank, and the space should be designed to withstand the maximum pressure build up. Alternatively, pressure relief venting to a safe location (mast) can be provided. The space should be capable of containing leakage, and 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. This second barrier space is in other parts of these guidelines called "tank room". When the tank is double walled and the outer tank shell is made of cold resistant material, a tank room could be arranged as a box fully welded to the outer shell of the tank, covering all tank connections and valves, but not necessarily all of the outer tank shell.

.1 As equivalent alternative it will be considered acceptable to arrange the secondary barrier of the independent gas tank in accordance with the IGC code Chapter 4 and in addition cover all tank connections located in enclosed spaces in a way that will confine any leakage from the tank through a failure of the tank connections in the same manner as outlined in 2.8.4.3 [4]

2.8.4.4 The tank room may be accepted as the outer shell of a stainless steel vacuum insulated tank in combination with a stainless steel box welded to the outer shell, containing all tank pipe connections, valves, piping etc. In this case the requirements for ventilation and gas detection should be made applicable to the box, but not to the double barrier of the tank.

2.8.4.5 Bilge suctions from the tank room, if provided, should not be connected to the bilge system for the rest of the ship.

2.9 Fuel bunkering system and distribution system outside machinery spaces

2.9.1 Fuel bunkering station

2.9.1.1 The bunkering station should be so located that sufficient natural ventilation is provided. Closed or semi-enclosed bunkering stations should be subject to special consideration. The bunkering station should be physically separated or structurally shielded from accommodation, cargo/working deck and control stations. Connections and piping should be so positioned and arranged that any damage to the gas piping does not cause damage to the vessel's gas storage tank arrangement leading to uncontrolled gas discharge.

2.9.1.2 Drip trays should be fitted below liquid gas bunkering connections and where leakage may occur.

[4] cf. BLG 14/WP.5

The drip trays should be made of stainless steel, and should be drained over the ship's side by a pipe that preferably leads down near the sea. This pipe could be temporarily fitted for bunkering operations. The surrounding hull or deck structures should not be exposed to unacceptable cooling, in case of leakage of liquid gas. For compressed gas bunkering stations, low temperature steel shielding should be provided to prevent the possible escape of cold jets impinging on surrounding hull structure.

2.9.1.3 Control of the bunkering should be possible from a safe location in regard to bunkering operations. At this location tank pressure and tank level should be monitored. Overfill alarm and automatic shutdown should also be indicated at this location.

2.9.2 Bunkering system

2.9.2.1 The bunkering system should be so arranged that no gas is discharged to air during filling of storage tanks.

2.9.2.2 A manually operated stop valve and a remote operated shutdown valve in series, or a combined manually operated and remote valve should be fitted in every bunkering line close to the shore connecting point. It should be possible to release the remote operated valve in the control location for bunkering operations and or another safe location.

2.9.2.3 If the ventilation in the ducting around the gas bunkering lines stops, an audible and visual alarm should be provided at bunkering control location.

2.9.2.4 If gas is detected in the ducting around the bunkering lines an audible and visual alarm should be provided at the bunkering control location.

2.9.2.5 Means should be provided for draining the liquid from the bunkering pipes at bunkering completion.

2.9.2.6 Bunkering lines should be arranged for inerting and gas freeing. During operation of the vessel the bunkering pipes should be gas free.

2.9.3 Distribution outside of machinery spaces

2.9.3.1 Gas fuel piping should not be led through accommodation spaces, service spaces or control stations.

2.9.3.2 Where gas pipes pass through enclosed spaces in the ship, they should be enclosed in a duct. This duct should be mechanically under pressure ventilated with 30 air changes per hour, and gas detection as required in 5.5 should be provided.

.1 Double wall pipe is regarded as an equivalent solution to the ventilated duct.

2.9.3.3 The duct should be dimensioned according to 2.7.1.3 and 2.7.1.4.

2.9.3.4 The ventilation inlet for the duct should always be located in open air, away from ignition sources.

2.9.3.5 Gas pipes located in open air should be so located that they are not likely to be damaged by accidental mechanical impact.

2.9.3.6 High-pressure gas lines outside the machinery spaces containing gas fuelled engines should be installed and protected so as to minimise the risk of injury to personnel in case of rupture.

2.10 Ventilation system

2.10.1 General

2.10.1.1 Any ducting used for the ventilation of hazardous spaces should be separate from that used for the ventilation of non-hazardous spaces. The ventilation should function at all environmental conditions the ship will be operating in.

Electric fan motors should not be located in ventilation ducts for hazardous spaces unless the motor is certified for the same hazard zone as the space served.

2.10.1.2 Design of ventilation fans serving spaces containing gas sources should fulfil the following:

.1 Electric motors driving fans should comply with the required explosion protection in the installation area. Ventilation fans should not produce a source of vapour ignition in either the ventilated space or the ventilation system associated with the space. Ventilation fans and fan ducts, in way of fans only, should be of non sparking construction defined as:

- **.1** impellers or housings of non-metallic material, due regard being paid to the elimination of static electricity;
- **.2** impellers and housings of non-ferrous metals;
- **.3** impellers and housing of austenitic stainless steel;
- **.4** impellers of aluminium 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

.5 any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm tip design clearance.

.2 In no case should the radial air gap between the impeller and the casing 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.

.3 Any combination of an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and should not be used in these places.

.4 The installation on board of the ventilation units should be such as to ensure the safe bonding to the hull of the units themselves.

2.10.1.3 Any loss of the required ventilating capacity should give an audible and visual alarm at a permanently manned location.

2.10.1.4 Required ventilation systems to avoid any gas accumulation should consist of independent fans, each of sufficient capacity, unless otherwise specified in these Guidelines.

2.10.1.5 Air inlets for hazardous enclosed spaces should be taken from areas which, in the absence of the considered inlet, would be non-hazardous. Air inlets for non-hazardous enclosed spaces should 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 should have over-pressure relative to this space, unless mechanical integrity and gas tightness of the duct will ensure that gases will not leak into it.

.1 Air inlets for non-hazardous enclosed spaces should 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 should have over-pressure relative to the hazardous space, unless mechanical integrity and gas tightness of the duct will ensure that gases will not leak into it.

2.10.1.6 Air outlets from non-hazardous spaces should be located outside hazardous areas.

2.10.1.7 Air outlets from hazardous enclosed spaces should 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.

2.10.1.8 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.

2.10.1.9 Non-hazardous spaces with entry openings to a hazardous area should be arranged with an air-lock and be maintained at overpressure relative to the external hazardous area. The overpressure ventilation should be arranged according to the following requirements:

.1 During initial start-up or after loss of overpressure ventilation, before energizing any electrical installations not certified safe for the space in the absence of pressurization, it should be required to:

.1 proceed with purging (at least 5 air changes) or confirm by measurements that the space is non-hazardous; and

.2 pressurize the space.

.2 Operation of the overpressure ventilation should be monitored.

.3 In the event of failure of the overpressure ventilation:

.1 an audible and visual alarm should be given at a manned location; and

.2 if overpressure cannot be immediately restored, automatic or programmed disconnection of electrical installations according to a recognized standard. [5]

2.10.2 Tank room

2.10.2.1 The tank room for gas storage should be provided with an effective mechanical forced ventilation system of under pressure type, providing a ventilation capacity of at least 30 air changes per hour. The rate of air changes may be reduced if other adequate means of explosion protection are installed. The equivalence of alternative installations should be demonstrated by a safety analysis.

.1 As equivalent alternative it will be considered acceptable to arrange the secondary barrier of the independent gas tank in accordance with the IGC code Chapter 4 and in addition cover all tank connections located in enclosed spaces in a way that will confine any leakage from the tank through a failure of the tank connections. [6]

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5 Refer to IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features, Table 5.

6 cf. BLG 14/WP.5

2.10.2.2 Approved automatic fail-safe fire dampers should be fitted in the ventilation trunk for tank room.

2.10.3 Machinery spaces containing gas‑fuelled engines.

2.10.3.1 The ventilation system for machinery spaces containing gas‑fuelled engines should be independent of all other ventilation systems.

2.10.3.2 ESD‑protected machinery spaces should have ventilation with a capacity of at least 30 air changes per hour. The ventilation system should ensure a good air circulation in all spaces, and in particular ensure that any formation of gas pockets in the room are detected.

As an alternative, arrangements whereby under normal operation the machinery spaces is ventilated with at least 15 air changes an hour is acceptable provided that, if gas is detected in the machinery space, the number of air changes will automatically be increased to 30 an hour.

2.10.3.3 The number and power of the ventilation fans should be such that the capacity is not reduced by more than 50 % of the total ventilation capacity, if a fan with a separate circuit from the main switch-board or emergency switchboard or a group of fans with common circuit from the main switchboard or emergency switchboard, is out of action.

2.10.4 Pump and compressor rooms

2.10.4.1 Pump and compressor rooms should be fitted with effective mechanical ventilation system of the under pressure type, providing a ventilation capacity of at least 30 air changes per hour.

2.10.4.2 The number and power of the ventilation fans should be such that the capacity is not reduced by more than 50 %, if a fan with a separate circuit from the main switchboard or emergency switch-board or a group of fans with common circuit from the main switchboard or emergency switchboard, is out of action.

2.10.4.3 Ventilation systems for pump and compressor rooms should be in operation when pumps or compressors are working.

2.10.4.4 When the space is dependent on ventilation for its area classification, the following should apply:

.1 During initial start-up or after loss of ventilation, the space should be purged (at least 5 air changes), before connecting electrical installations which are not certified for the area classification in absence of ventilation. Warning notices to this effect should be placed in an easily visible position near the control stand.

.2 Operation of the ventilation should be monitored.

.3 In the event of failure of ventilation, the following should apply:

- **.1** an audible and visual alarm should be given at a manned location;
- **.2** immediate action should be taken to restore ventilation; and
- **.3** electrical installations should be disconnected [7] if ventilation cannot be restored for an extended period. The disconnection should be made outside the hazardous areas, and be protected against unauthorised reconnection, e.g., by lockable switches.

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7 Intrinsically safe equipment suitable for zone 0 is not required to be switched off. Certified flameproof lighting may have a separate switch-off circuit.

Section 3

Fire Safety

3.0 Documents for approval

The following documents related to Section 3 are to be submitted electronically via GLOBE[1] or in paper form in triplicate. GLOBE submission is the preferred option.

– Specification of water spray system, including tanks, pumps, pipes, valves, nozzles and fittings

– Specification of fire detection system for storage tank, ventilation trunk, refuelling station and process plant

– Specification of dry chemical powder installation

GL reserves the right to request additional documentation as necessary.

3.1 General

3.1.1 The requirements in this chapter are additional to those given in GL Rules, Machinery Installations (I-1-2) and Electrical Installations (I-1-3).

3.1.2 A compressor room should be regarded as a machinery space of category A for fire protections purposes.

For fire insulation requirements of the compressor room see 3.2.6

3.2 Fire protection

3.2.1 Tanks or tank batteries located above deck should be shielded with class A-60 insulation towards accommodation, service spaces, cargo spaces and machinery spaces.

3.2.2 The tank room boundaries and ventilation trunks to such spaces below the bulkhead deck should be constructed to class A-60 standard. However, where the room is 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.

3.2.3 The fire and mechanical protection of gas pipes leading through ro-ro spaces on open deck should be subject to special consideration by the Administration depending on the use and expected pressure in the pipes. Gas pipes leading through ro-ro spaces on open deck should be provided with guards or bollards to prevent vehicle collision damage.

3.2.4 The bunkering station should be separated by class A-60 divisions 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 standard may be reduced to class A-0.

3.2.5 When more than one machinery space is required and these spaces are separated by a single bulkhead, the bulkhead should be class A-60.

3.2.6 A compressor room in a ship not subject to GL Rules, Liquefied Gas Carriers (I-1-6) should be regarded as a machinery space of category A for fire insulation requirements.

3.3 Fire extinction

3.3.1 Fire main

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

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

3.3.2 Water spray systems

3.3.2.1 A water spray system should be fitted for cooling and fire prevention and to cover exposed parts of gas storage tank located above deck.

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

1 Detailed information about GLOBE submission can be found on GL's website www.gl-group.com.

3.3.2.3 For the purpose of isolating damaged sections, stop valves should be fitted at least every 40 m 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.

3.3.2.4 The capacity of the water spray pump should be sufficient to deliver the required amount of water to the hydraulically most demanding area as specified in 3.3.2.2.

3.3.2.5 A connection to the ship's fire main through a srew-down non-return valve should be provided.

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

3.3.2.7 The nozzles should be of an approved full bore type and they should be arranged to ensure an effective distribution of water throughout the space being protected.

3.3.2.8 An equivalent system to the water spray system may be fitted provided it has been tested for its on-deck cooling capability to the satisfaction of the Administration.

3.3.3 Dry chemical powder fire-extinguishing equipment

3.3.3.1 In the bunkering station area a permanently installed dry chemical powder fire extinguishing system should cover all possible leak points. The capacity should be at least 3,5 kg/s for a minimum of 45 s discharges. The system should be arranged for easy manual release from a safe location outside the protected area.

3.3.3.2 One portable dry powder fire extinguisher of at least 5 kg capacity should be located near the bunkering station.

3.4 Fire detection and alarm system

3.4.1 Detection

3.4.1.1 A type approved fixed fire detection system should be provided for the tank room and the ventilation trunk for tank room below deck and for all other rooms of the fuel gas system where a fire can not be excluded.

3.4.1.2 Smoke detectors alone should not be considered sufficient for rapid fire detection.

3.4.1.3 Where the fire detection system does not include means of remotely identifying each detector individually, the detectors should be arranged on separate loops.

3.4.2 Alarms and safety actions

3.4.2.1 Required safety actions at fire detection in the machinery space containing gas-fuelled engines and tank room are given in Table 5.1 of Section 5. In addition, the ventilation system of the affected spaces should stop automatically and related fire dampers are to be closed automatically.

Section 4

Electrical Systems

4.0 Documents for approval

The following documents related to Section 4 are to be submitted electronically via GLOBE[1] or in paper form in triplicate. GLOBE submission is the preferred option.

– Explosion prevention documentation

– Gas detection system

– Test program

GL reserves the right to request additional documentation as necessary.

4.1 General

4.1.1 The provisions of this Section should be applied in conjunction with applicable electrical requirements of part D of SOLAS chapter II-1.

4.1.2 Hazardous areas on open deck and other spaces not defined in this chapter should be decided based on a recognized standard.[2] The electrical equipment fitted within hazardous areas should be according to the same standard.

4.1.3 Electrical equipment and wiring should in general not be installed in hazardous areas unless essential for operational purposes based on a recognized standard. [3]

4.1.4 Electrical equipment fitted in an ESD-protected machinery space should fulfil the following:

.1 In addition to fire and gas detectors and fire and gas alarms, lighting and ventilation fans should be certified safe for hazardous area zone 1.

.2 All electrical equipment in a machinery space containing gas-fuelled engines, and not certified for zone 1 should be automatically disconnected, if gas concentrations above 20 % LEL is detected on two detectors in the space containing gas-fuelled engines.

4.1.5 There should be a potential equalization connection between the bunker supplier and the bunkering station on the ship when a flammable gas/liquid is transferred.

4.1.6 Cable penetrations should satisfy the requirements regulating the dispersion of gas.

4.2 Area Classification

4.2.1 General

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

4.2.1.2 In order to facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2 [4]. See also 4.3. below.

4.2.1.3 Area Classification of a space may be dependent on ventilation. [5]

4.2.1.4 A space with entry opening to an adjacent hazardous area on open deck, may be made into a less hazardous or non-hazardous space, by means of overpressure. Requirements to such pressurization are given in 2.10.

4.2.1.5 Ventilation ducts should have the same area classification as the ventilated space.

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1 Detailed information about GLOBE submission can be found on GL's website www.gl-group.com.

2 Refer to IEC standard 60092-502, part 4.4: Tankers carrying flammable liquefied gases as applicable.

3 The type of equipment and installation requirements should comply with IEC standard 60092-502:
IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features and IEC 60079-10-1:2008 Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres, according to the area classification.

4 Refer to standards IEC 60079-10-1:2008 Explosive atmospheres Part 10-1: Classification of areas – Explosive gas atmospheres and guidance and informative examples given in IEC 60092-502:1999, Electrical Installations in Ships - Tankers - Special Features for tankers.

5 Refer to standard IEC 60092-502:1999 Electrical Installations in Ships - Tankers - Special Features for tankers, Table 1.

4.3 Definition of hazardous area zones

4.3.1 Hazardous area zone 0

This zone includes:

.1 the interiors of gas tanks, any pipework of pressure-relief or other venting systems for gas tanks, pipes and equipment containing gas. [6]

4.3.2 Hazardous area zone 1

This zone includes: [7]

.1 tank room;

.2 gas compressor room arranged with ventilation according to 2.10.4;

.3 areas on open deck, or semi-enclosed spaces on deck, within 3 m of any gas tank outlet, gas or vapour outlet [8], 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 vapour mixtures caused by thermal variation;

.4 areas on open deck or semi-enclosed spaces on deck, within 1,5 m of gas compressor and pump room entrances, gas pump and compressor room ventilation inlets and other openings into zone 1 spaces;

.5 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;

.6 enclosed or semi-enclosed spaces in which pipes containing gas are located, e.g., ducts around gas pipes, semi-enclosed bunkering stations; and

.7 the ESD-protected machinery space is considered as non-hazardous area during normal operation, but changes to zone 1 in the event of gas leakage.

4.3.3 Hazardous area zone 2

This zone includes: [9]

.1 areas within 1,5 m surrounding open or semi-enclosed spaces of zone 1. [10]

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6 Instrumentation and electrical apparatus in contact with the gas or liquid gas should be of a type suitable for zone 0. Temperature sensors installed in thermo wells, and pressure sensors without additional separating chamber should be of intrinsically safe type Ex-ia.

7 Instrumentation and electrical apparatus installed within these areas should be of a type suitable for zone 1.

8 Such areas are, for example, all areas within 3 m of gas tank hatches, ullage openings or sounding pipes for gas tanks located on open deck and gas vapour outlets.

9 Instrumentation and electrical apparatus installed within these areas should be of a type suitable for zone 2.

10 Refer to IEC 60092-502:1999 Electrical Installations in Ships - Tankers - Special Features or IEC 60079-10-1:2008 Explosive atmospheres – Part 10-1: Classification of areas, according to the area classification., as applicable if not otherwise specified in this standard.

Section 5

Control, Monitoring and Safety Systems

5.0 Documents for approval

The following documents related to Section 5 are to be submitted electronically via GLOBE[1] or in paper form in triplicate. GLOBE submission is the preferred option.

- Functional description
- Hardware description
- Software description (general)
- Software quality assurance
- Type Approval / Approval with respect to ship specific condition
- Test plan for Hard and Software
- For fixed gas detection and alarm systems: specification and location of detectors
- Description of the safety chain including part list

GL reserves the right to request additional documentation as necessary.

5.1 General

5.1.1 A local reading pressure gauge should be fitted between the stop valve and the connection to shore at each bunker pipe.

5.1.2 Pressure gauges should be fitted to gas pump discharge lines and to the bunkering lines.

5.1.3 A bilge well in each tank room surrounding an independent liquid gas storage tank should be provided with both a level indicator and a temperature sensor. Alarm should be given at high level in bilge well. Low temperature indication is to lead to automatic closing of main tank valve.

5.2 Gas tank monitoring

5.2.1 Gas tanks should be monitored and protected against overfilling as required in GL Rules, Liquefied Gas Carriers (I-1-6), Section 13, 13.2 and 13.3.

5.2.2 Each tank should be monitored with at least one local indicating instrument for pressure and remote pressure indication at the control position. The pressure indicators should 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 should be provided on the bridge. The high pressure alarm should be activated before the set pressures of the safety valves are reached.

5.3 Gas compressor monitoring

Gas compressors should be fitted with audible and visual alarms both on the bridge and in the engine room. As a minimum the alarms should be in relation to low gas input pressure, low gas output pressure, high gas output pressure and compressor operation.

5.4 Gas engine monitoring

5.4.1 Additional to the instrumentation provided in accordance with SOLAS re, II-1 Part C, indicators should be fitted on the navigation bridge, the engine control room and the manoeuvring platform for:

.1 operation of the engine in case of gas-only engines; or

.2 operation and mode of operation of the engine in the case of dual fuel engines.

5.4.2 Auxiliary systems where gas may leak directly into the system medium (lubricating oil, cooling water) should be equipped with appropriate gas extraction measures fitted directly after the outlet from the engine in order to prevent gas dispersion. The gas extracted from auxiliary systems media should be vented to a safe location in the open.

5.5 Gas detection

5.5.1 Permanently installed gas detectors should be fitted in the tank room, in all ducts around gas pipes, in machinery spaces of the ESD-protected type, compressor rooms and other enclosed spaces containing gas piping or other gas equipment without ducting. In each ESD-protected machinery space, two independent gas detector systems should be required.

5.5.2 The number of detectors in each space should be considered taking size, layout and ventilation of the space into account.

5.5.3 The detection equipment should be located where gas may accumulate and/or in the ventilation outlets. Gas dispersal analysis or a physical smoke test should be used to find the best arrangement.

5.5.4 An audible and visible alarm should be activated before the gas concentration reaches 20 % of the lower explosion limit (LEL). For ventilated ducts around gas pipes in the machinery spaces containing gas-fuelled engines, the alarm limit can be set to 30 % LEL. The protective system should be activated at a LEL of 40 %.

[1] Detailed information about GLOBE submission can be found on GL's website www.gl-group.com.

5.5.5 Audible and visible alarms from the gas detection equipment should be located on the bridge and in the engine control room.

5.5.6 Gas detection for gas pipe ducts and machinery spaces containing gas-fuelled engines should be continuous without delay.

5.6 Safety functions of gas supply systems

5.6.1 Each gas storage tank should be provided with a tank valve capable of being remote operated and is to be located as close to the tank outlet as possible.

5.6.2 The main gas supply line to each engine or set of engines should be equipped with a manually operated stop valve and an automatically operated "master gas fuel valve" coupled in series or a combined manually and automatically operated valve. The valves should be situated in the part of the piping that is outside machinery space containing gas fuelled engines, and placed as near as possible to the installation for heating the gas, if fitted. The master gas fuel valve should automatically cut off the gas supply as given in Table 5.1.

5.6.2.1 The automatic master gas fuel valve should be operable from a reasonable number of places in the machinery space containing gas fuelled engines, from a suitable location outside the space and from the bridge.

5.6.3 Each gas consuming equipment should be provided with a set of "double block and bleed" valves. These valves should be arranged as outlined in .1 or .2 (respectively shown as alternatives 1 and 2 in Figure 1) so that when automatic shutdown is initiated as given in Table 5.1, this will cause the two gas fuel valves that are in series to close automatically and the ventilation valve to open automatically and:

.1 the two shut-off valves should be in series in the gas fuel pipe to the gas consuming equipment. The bleed valve should be in a pipe that vents to a location in the open air that portion of the gas fuel piping that is between the two valves in series; or

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

5.6.3.1 The two block valves should be of the fail-to-close type, while the ventilation valve should be fail-to-open.

5.6.3.2 The double block and bleed valves should also be used for normal stop of the engine.

5.6.4 In cases where the master gas fuel valve is automatically shutdown, the complete gas supply branch downstream of the double block and bleed valve should be ventilated, if reverse flow from the engine to the pipe must be assumed.

5.6.5 There should be one manually operated shutdown valve in the gas supply line to each engine upstream of the double block and bleed valves to assure safe isolation during maintenance on the engine.

5.6.6 For one-engine installations and multi-engine installations, where a separate master valve is provided for each engine, the master gas fuel valve and the double block and bleed valve functions can be combined. Examples for the high-pressure system are shown in Figures 5.1 and 5.2.

The examples are similar for low pressure systems.

5.6.7 The total loss of ventilation in a machinery space for a single fuelled gas system should, additionally to what is given in Table 5.1, lead to one of the following actions:

.1 *For a gas electric propulsion system with more than one machinery space:* Another engine should start. When the second engine is connected to bus-bar, the first engine should be shutdown automatically.

.2 *For a direct propulsion system with more than one machinery space:* The engine in the room with defect ventilation should be manually shutdown, if at least 40 % propulsion power is still available after such a shutdown.

If only one machinery space for gas‑fuelled engines is fitted and ventilation in one of the enclosed ducts around the gas pipes is lost, the master gas fuel and double block and bleed valves in that supply line should close automatically provided the other gas supply unit is ready to deliver.

5.6.8 If the gas supply is shut off due to activation of an automatic valve, the gas supply should not be opened until the reason for the disconnection is ascertained and the necessary precautions taken. A readily visible notice giving instruction to this effect should be placed at the operating station for the shut-off valves in the gas supply lines.

5.6.9 If a gas leak leading to a gas supply shutdown occurs, the gas fuel supply should not be operated until the leak has been found and dealt with. Instructions to this effect should be placed in a prominent position in the machinery space.

5.6.10 A signboard should be permanently fitted in the machinery space containing gas‑fuelled engines stating that heavy lifting, implying danger of damage to the gas pipes, should not be done when the engine(s) is running on gas.

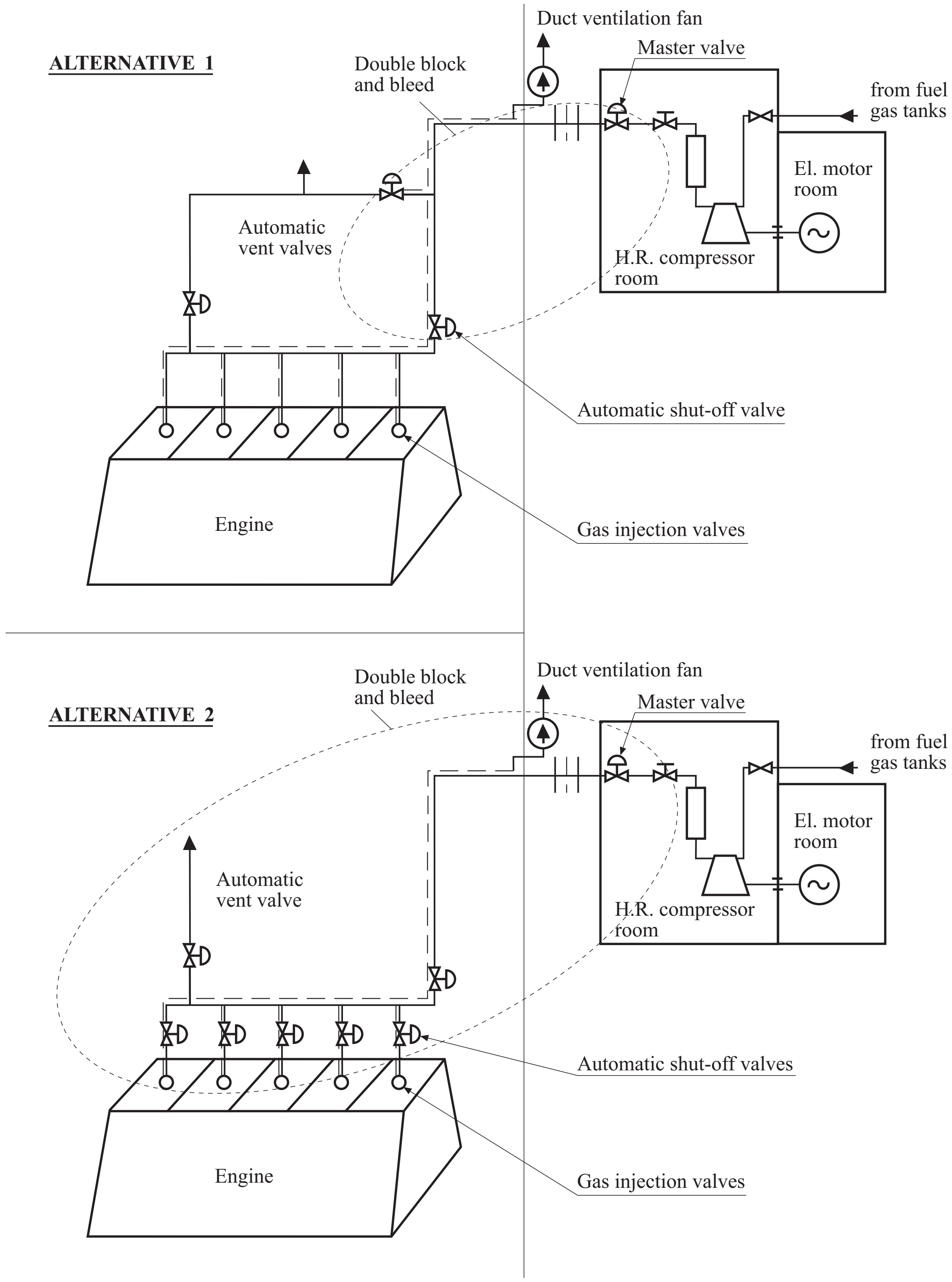

Fig. 5.1 Alternative supply valve arrangements for high-pressure installations (single engine or separate master valve arrangement)

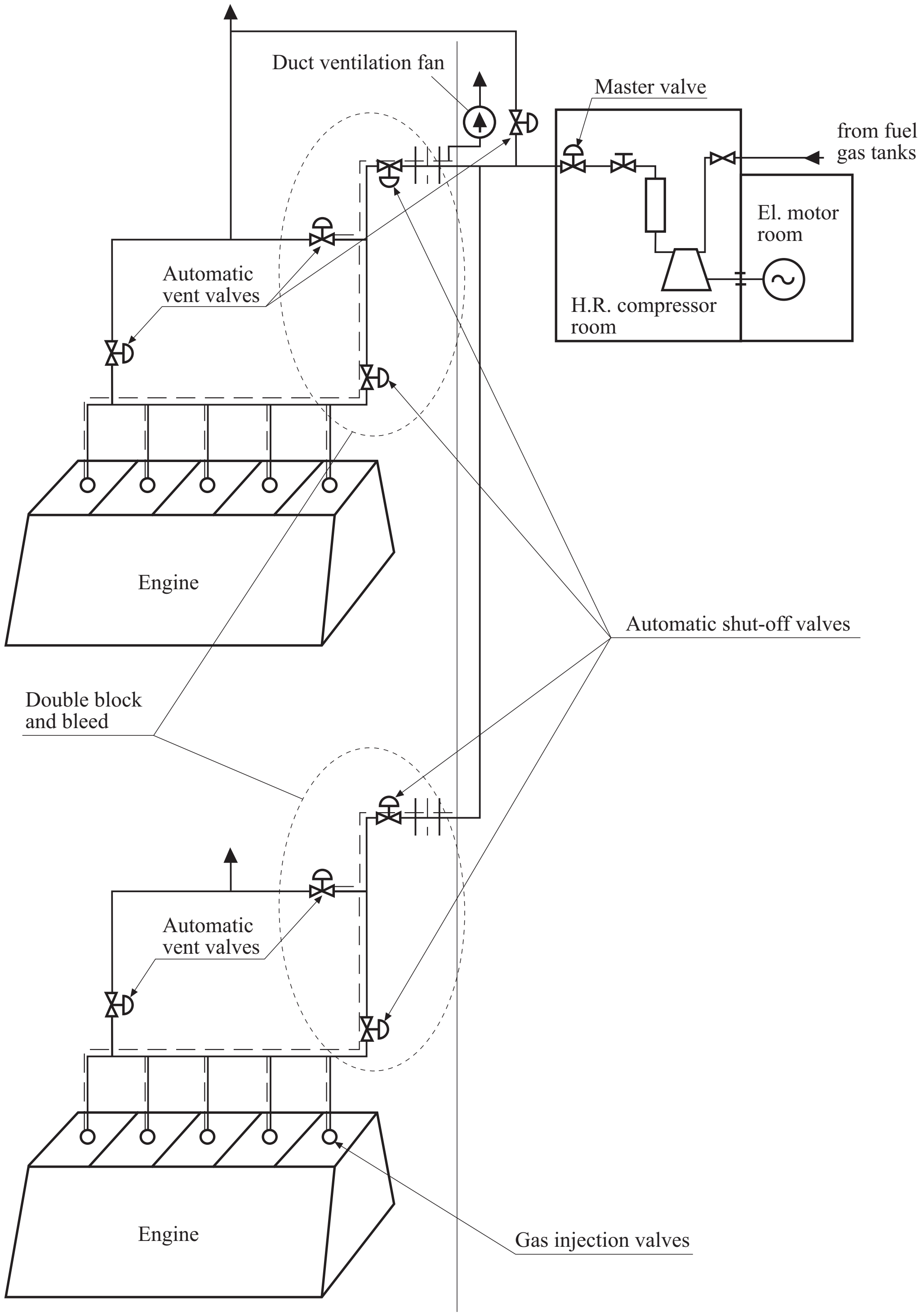

Fig. 5.2 Alternative supply valve arrangements for high-pressure installations (multi-engine installation)

Table 5.1 Monitoring of gas supply system to engines

Parameter	Alarm	Automatic shutdown of main tank valve	Automatic shutdown of gas supply to machinery space containing gas-fuelled engines	Comment
Gas detection in tank room above 20 % LEL	X			
Gas detection on two detectors [1] in tank room above 40 % LEL	X	X		
Fire detection in tank room	X	X		
Bilge well high level tank room	X			
Bilge well low temperature in tank room	X	X		
Gas detection in duct between tank and machinery space containing gas-fuelled engines above 20 % LEL	X			
Gas detection on two detectors [1] in duct between tank and machinery space containing gas-fuelled engines above 40 % LEL	X	X [2]		
Gas detection in compressor room above 20 % LEL	X			
Gas detection on two detectors [1] in compressor room above 40 % LEL	X	X [2]		
Gas detection in duct inside machinery space containing gas-fuelled engines above 30 % LEL	X			If double pipe fitted in machinery space containing gas-fuelled engines
Gas detection on two detectors [1] in duct inside machinery space containing gas-fuelled engines above 40 % LEL	X		X [3]	If double pipe fitted in machinery space containing gas-fuelled engines
Gas detection in machinery space containing gas-fuelled engines above 20 % LEL	X			Gas detection only required for ESD protected machinery space
Gas detection on two detectors [1] in machinery space containing gas-fuelled engines above 40 % LEL	X		X	Gas detection only for ESD protected machinery space containing gas-fuelled engines. It should also disconnect non certified safe electrical equipment in machinery space containing gas-fuelled engines
Loss of ventilation in duct between tank and machinery space containing gas-fuelled engines [6]	X		X [2, 4]	

Table 5.1 Monitoring of gas supply system to engines *(continuous)*

Parameter	**Alarm**	**Automatic shutdown of main tank valve**	**Automatic shutdown of gas supply to machinery space containing gas-fuelled engines**	**Comment**
Loss of ventilation in duct inside machinery space containing gas-fuelled engines [6]	X		X [3, 4]	If double pipe fitted in machinery space containing gas-fuel-led engines
Loss of ventilation in machinery space containing gas-fuelled engines	X		X	ESD protected machinery space containing gas-fuel-led engines only
Fire detection in machinery space containing gas-fuelled engines	X		X	
Abnormal gas pressure in gas supply pipe	X		X [4]	
Failure of valve control actuating medium	X		X [5]	Time delayed as found necessary
Automatic shutdown of engine (engine failure)	X		X [5]	
Emergency shutdown of engine manually released	X		X	

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

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

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

4 This parameter is not to lead to shutdown of gas supply for single fuel gas engines, only for dual engines.

5 Only double block and bleed valves to close.

6 If the duct is protected by inert gas (see 2.7.1) then loss of inert gas overpressure is to lead to the same actions as given in this Table.

Section 6

Compressors and Gas Engines

6.0 Documents for approval

The following documents related to Section 6 are to be submitted electronically via GLOBE[1] or in paper form in triplicate. GLOBE submission is the preferred option.

- Engine concept
- Exhaust gas system
- Gas pump and compressor rooms

GL reserves the right to request additional documentation as necessary.

6.1 Gas compressors

Gas fuelled compressors and engines have to be designed to operate safely with any gas composition within the ship specification range, taking into account the possible variations of the gas composition during the voyage.

Arrangements are to be made to ensure that under no circumstances introduction of liquid gas in the gas control section or gas fuelled machinery may occur unless the machinery is designed to operate with gas in liquid state.

After each gas operation of gas fuelled machinery not followed by an oil fuel operation, the machinery including the exhaust system is to be purged in a sufficient way in order to discharge the gas which may be present.

6.1.1 The fuel gas compressor should be fitted with accessories and instrumentation necessary for efficient and reliable function.

6.1.2 The gas compressor and fuel gas supply should be arranged for manual remote emergency stop from the following locations:

.1 cargo control room (relevant for cargo ships only);

.2 navigation bridge;

.3 engine control room; and

.4 fire control station.

1 Detailed information about GLOBE submission can be found on GL's website www.gl-group.com.

6.2 Gas engine design general

6.2.1 The last gas valve prior to the gas engine should be controlled by the engine control system or by the engine gas demand.

All gas engine components, gas engine systems and gas engine subsystems should be designed to:

.1 exclude any explosion at all possible situations; or

.2 to allow explosions without detrimental effect and to discharge the combustion products safely. The explosion event should not interrupt the safe operation of the engine unless other safety measures allow the shutdown of the affected engine.

6.2.1.3 When gas is supplied in a mixture with air through a common manifold, sufficient flame arrestors should be installed before each cylinder head. The mixture inlet system should be designed to withstand explosions of mixture by means of:

.1 explosion relief venting to prevent excessive explosion pressures. It should be ensured that the explosion relief venting is installed in a way that it discharges the combustion products safely; or

.2 documentation demonstrating that the mixture inlet system has sufficient strength to contain the worst case explosion.

The requirements from 6.2.1.1 and 6.2.1.2 can be omitted if the gas concentration within the manifolds is controlled and if combustion of unburned charge within the manifolds can be excluded. A justification how this can be achieved is to be submitted.

6.2.1.4 The exhaust system should be designed to withstand explosions of unburned mixture by means of:

.1 explosion relief venting to prevent excessive explosion pressures. It should be ensured that the explosion relief venting is installed such that the combustion products are discharged safely; or

.2 documentation showing that the exhaust system has sufficient strength to contain the worst case explosion.

The requirements from 6.2.1.1 and 6.2.1.2 can be omitted if the gas concentration within the manifolds is controlled and if combustion of unburned charge within the manifolds can be excluded. A justification how this can be achieved is to be submitted.

6.2.1.5 The crankcase of gas engines should be provided with:

.1 crankcase explosion relief valves of a suitable type with sufficient relief area. The relief valves should be installed in way of each crank throw and should be arranged or provided with means to ensure that discharge from them is so directed as to minimize the possibility of injury to personnel. Refer to SOLAS Chapter II-1/27 and 47.2; or

.2 documentation showing that the crankcase has sufficient strength to contain the worst case explosion.

6.2.1.6 It should be ensured that the explosion of unburned mixture within the exhaust system or the crankcase or the explosion of mixture within the mixture inlet is allowed without detrimental effect.

.1 For trunk piston type engines monitoring sensors or equivalent devices for engine bearing temperatures, liner temperatures and other equivalent temperatures of possible ignition sources are to be fitted to engines with a cylinder bore of > 200 mm or a crankcase volume of ≥ 0,6 m^3.

.2 The crankcase of trunk piston type engines is to be continuously vented. In case of ventilation by induced draught fans the negative pressure must not exceed 2,5 mbar. The outlet of the vent line is to be led to a safe location through a flame arrester.

.3 The crankcase of trunk piston type engines is to be fitted with means for the injection of inert gas.

6.2.2 The design of piping on gas engines should follow the requirements in Section 2.6 "System configuration" and Section 2.7 "Gas supply system in gas machinery spaces".

6.2.3 The combustion of the gas mixture should be monitored. This can be achieved by monitoring of the exhaust gas or combustion chamber temperature.

6.2.4 The exhaust pipes of gas fuelled engines should not be connected to the exhaust pipes of other engines or systems.

6.2.5 The combustion of each cylinder is to be monitored to detect knocking combustion and misfiring.

6.3 Requirements dual fuel engines

6.3.1 Start and normal stop should be on oil fuel only. Gas injection should not be possible without a corresponding pilot oil injection. The amount of pilot fuel fed to each cylinder should be sufficient to ensure a positive ignition of the gas mixture.

6.3.2 In case of shut-off of the gas fuel supply, the engines should be capable of continuous operation by oil fuel only.

6.3.3 Changeover to and from gas fuel operation should only be possible at a power level and under conditions where it can be done with acceptable reliability as demonstrated through testing. On power reduction the changeover to oil fuel is to be automatic. The changeover process itself from and to gas operation should be automatic. Manual interruption should be possible in all cases.

6.3.4 On normal stop as well as emergency shutdown, gas fuel supply should be shut-off not later than simultaneously with the oil fuel. It should not be possible to shut-off the supply pilot fuel without first or simultaneously closing the gas supply to each cylinder or to the complete engine.

6.4 Requirements gas-only engines

6.4.1 The starting sequence should be such that fuel gas is not admitted to the cylinders until ignition is activated and the engine has reached an engine and application specific minimum rotational speed.

6.4.2 If ignition has not been detected by the engine monitoring system within an engine specific time after opening of the gas supply valve the gas supply valve should be automatically shut-off and the starting sequence terminated. It should be ensured by any mean that any unburned gas mixture is flushed away from the exhaust system.

6.4.3 On normal stop as well as emergency shutdown, gas fuel supply should be shut-off not later than simultaneously with the ignition. It should not be possible to shut-off the ignition without first or simultaneously closing the gas supply to each cylinder or to the complete engine.

6.4.4 For constant speed engines the shutdown sequence should be such that the engine gas supply valve closes at idle speed and that the ignition system is kept active until the engine is down to standstill.

Section 7

Manufacture, Workmanship and Testing

7.0 Documents for approval

The following documents related to Section 7 are to be submitted electronically via GLOBE[1] or in paper form in triplicate. GLOBE submission is the preferred option.

- Specification of pressure tests (structural and tightness tests) of gas piping, pressure vessels and tanks
- Specifications of insulation for low temperature piping where such insulation is installed
- Specification of electrical bonding of piping, pressure vessels and tanks
- Specification of non-destructive testing of gas piping, pressure vessels and tanks

GL reserves the right to request additional documentation as necessary.

7.1 General

The manufacture, testing, inspection and documentation should be in accordance with recognized standards and the specific requirements given in these guidelines.

7.2 Gas tanks

Tests related to welding and tank testing should be in accordance with GL Rules, Liquefied Gas Carriers (I-1-6), Section 4, 4.10 and 4.11.

7.3 Gas piping systems

7.3.1 The requirements for testing should apply to gas piping inside and outside the gas tanks. However, relaxation from these requirements may be accepted for piping inside gas tanks and open ended piping.

7.3.2 Welding procedure tests should be required for gas piping and should be similar to those required for gas tanks in GL Rules, Liquefied Gas Carriers (I-1-6), Section 6, 6.3.3. Unless otherwise especially agreed with the Administration, the test requirements should be in accordance with 7.3.3 below.

7.3.3 Test requirements

.1 Tensile tests: Generally, tensile strength should not be less than the specified minimum tensile strength for the appropriate parent materials. The Administration may also require that the transverse weld tensile strength should not be less than the specified tensile strength for the weld metal, where the weld metal has a lower tensile strength than that of the parent metal. In every case, the position of fracture should be reported for information.

.2 Bend tests: No fracture should be acceptable after a 180° bend over a former of a diameter four times the thickness of the test piece, unless otherwise specially required or agreed with the Administration.

.3 Charpy V-notch impact tests: Charpy tests should be conducted at the temperature prescribed for the base material being joined. The results of the weld impact tests, minimum average energy (E), should be no less than 27 J. The weld metal requirements for sub size specimens and singe energy values should be in accordance with GL Rules, Liquefied Gas Carriers (I-1-6), Section 6, 6.1.4. The results of fusion line and heat affected zone impact tests should show a minimum average energy (E) in accordance with the transverse or longitudinal requirements of the base material, whichever applicable, and for sub size specimens, the minimum average energy (E) should be in accordance with GL Rules, Liquefied Gas Carriers (I-1-6), Section 6, 6.1.4. If the material thickness does not permit machining either full-sized or standard sub size specimens, the testing procedure and acceptance standards should be in accordance with recognized standards.

Impact testing is not required for piping with thickness less than 6 mm.

7.3.4 In addition to normal controls before and during the welding and to the visual inspection of the finished welds, the following tests should be required:

.1 For butt welded joints for piping systems with design temperatures lower than -10 °C and with inside diameters of more than 75 mm or wall thicknesses greater than 10 mm, 100 % radiographic testing should be required.

.2 When such butt welded joints of piping sections are made by automatic welding processes in the pipe fabrication shop, upon special approval, the extent of radiographic inspection

[1] Detailed information about GLOBE submission can be found on GL's website www.gl-group.com.

may be progressively reduced but in no case to less than 10 % of the joints. If defects are revealed the extent of examination should be increased to 100 % and shall include inspection of previously accepted welds. This special approval should only be granted if well-documented quality assurance procedures and records are available to enable the Administration to assess the ability of the manufacturer to produce satisfactory welds consistently.

.3 For other butt welded joints of pipes, spot radiographic tests or other non-destructive tests should be carried out at the discretion of the Administration depending upon service, position and materials. In general, at least 10 % of butt welded joints of pipes should be radiographed.

Butt welded joints of high-pressure gas pipes and gas supply pipes in ESD-protected machinery spaces should be subjected to 100 % radiographic testing.

The radiographs should be assessed according to a recognized standard. [2]

7.3.5 After assembly, all gas piping should be subjected to a hydrostatic test to at least 1,5 times the design pressure. However, when piping systems or parts of systems are completely manufactured and equipped with all fittings, the hydrostatic test may be conducted prior to installation aboard ship. Joints welded onboard should be hydrostatically tested to at least 1,5 times the design pressure. Where water cannot be tolerated and the piping cannot be dried prior to putting the system into service, proposals for alternative testing fluids or testing methods should be submitted for approval.

7.3.6 After assembly onboard, each gas piping system should be subjected to a leak test using air, halides or other suitable medium.

7.3.7 All gas piping systems including valves, fittings and associated equipment for handling gas should be tested under normal operating condition before set into normal operation.

7.4 Ducting

If the gas piping duct contains high-pressure pipes the ducting according to 2.7.1.3 should be pressure tested to at least 10 bar.

7.5 Valves

Each size and each type of valve intended to be used at a working temperature below -55 °C should be prototype tested as follows. It should be subjected to a tightness test at the minimum design temperature or lower and to a pressure not lower than the design pressure for the valves. During the test, the good operation of the valve should be ascertained.

7.6 Expansion bellows

7.6.1 The following prototype tests should be performed on each type of expansion bellows intended for use in gas piping, primarily on those used outside the gas tank:

.1 An overpressure test. A type element of the bellows, not precompressed, should be pressure tested to a pressure not less than 5 times the design pressure without bursting. The duration of the test should not be less than 5 min.

.2 A pressure test on a type expansion joint complete with all the accessories (flanges, stays, articulations, etc.) at twice the design pressure at the extreme displacement conditions recommended by the manufacturer. No permanent deformations should be allowed. Depending on materials the test may be required to be performed at the minimum design temperature.

.3 A cyclic test (thermal movements). The test should be performed on a complete expansion joint, which is to successfully withstand at least as many cycles, under the conditions of pressure, temperature, axial movement, rotational movement and transverse movement, as it will encounter in actual service. Testing at room temperature, when conservative, is permitted.

.4 A cyclic fatigue test (ship deformation). The test should be performed on a complete expansion joint, without internal pressure, by simulating the bellow movement corresponding to a compensated pipe length for at least 2×10^6 cycles at a frequency not higher than 5 Hz. This test is only required when, due to the piping arrangement, ship deformation loads are actually experienced.

The Administration may waive performance of the tests specified in 7.6.1, provided that complete documentation is supplied to establish the suitability of the expansion joints to withstand the expected working conditions. When the maximum internal pressure exceeds 1 bar, this documentation should include sufficient tests data to justify the design method used, with particular reference to correlation between calculation and test results.

2 Refer to ISO 5817:2003, Arc-welded joints in steel-Guidance on quality levels for imperfections, and should at least meet the requirements for quality level B.

Section 8

Operational and Training Requirements

8.1 Operational requirements

8.1.1 The whole operational crew of a gas-fuelled cargo or and a passenger ship should have necessary training in gas-related safety, operation and maintenance prior to the commencement of work on board.

8.1.2 Additionally, crew members with a direct responsibility for the operation of gas-related equipment on board should receive special training. The company should document that the personnel have acquired the necessary knowledge and that this knowledge is maintained at all times.

8.1.3 Gas-related emergency exercises should be conducted at regular intervals. Safety and response systems for the handling of defined hazards and accidents should be reviewed and tested.

8.1.4 A training manual should be developed and a training programme and exercises should be specially designed for each individual vessel and its gas installations.

8.2 Gas-related training

Note

The provisions of this subsection 8.2 relating to gas-related training are included in MSC.285(86) and are provided here for information only. They are not applicable for the purpose of Classification.

8.2.1 Training in general

The training on gas-fuelled ships is divided into the following categories:

.1 category A: Basic training for the basic safety crew;

.2 category B: Supplementary training for deck officers; and

.3 category C: Supplementary training for engineer officers.

8.2.1.1 Category A training

.1 The goal of the category A training should provide the basic safety crew with a basic understanding of the gas in question as a fuel, the technical properties of liquid and compressed gas, explosion limits, ignition sources, risk reducing and consequence reducing measures, and the rules and procedures that must be followed during normal operation and in emergency situations.

.2 The general basic training required for the basic safety crew is based on the assumption that the crew does not have any prior knowledge of gas, gas engines and gas systems. The instructors should include one or more of the suppliers of the technical gas equipment or gas systems, alternatively other specialists with in-depth knowledge of the gas in question and the technical gas systems that are installed on board.

.3 The training should consist of both theoretical and practical exercises that involve gas and the relevant systems, as well as personal protection while handling liquid and compressed gas. Practical extinguishing of gas fires should form part of the training, and should take place at an approved safety centre.

8.2.1.2 Categories B and C training

.1 Deck and engineer officers should have gas training beyond the general basic training. Category B and category C training should be divided technically between deck and engineer officers. The Company's training manager and the Master should determine what comes under deck operations and what comes under engineering.

.2 Those ordinary crew members who are to participate in the actual bunkering work, as well as gas purging, or are to perform work on gas engines or gas installations, etc., should participate in all or parts of the training for category B/C. The Company and the Master are responsible for arranging such training based on an evaluation of the concerned crew member's job instructions/area of responsibility on board.

.3 The instructors used for such supplementary training should be the same as outlined for category A.

.4 All gas-related systems on board should be reviewed. The ship's maintenance manual, gas supply system manual and manual for electrical equipment in explosion hazardous spaces and zones should be used as a basis for this part of the training.

.5 This regulation should be regularly reviewed by the Company and onboard Senior Management team as part of the SMS system. Risk analysis should be emphasized, and any risk analysis and sub analyses performed should be available to course participants during training.

.6 If the ship's own crew will be performing technical maintenance of gas equipment, the training for this type of work should be documented.

.7 The Master and the Chief engineer officer should give the basic safety crew on board their final clearance prior to the entry into service of the ship. The clearance document should only apply to gas-related training, and it should be signed by both the Master/Chief engineer officer and the course participant. The clearance document for gas-related training may be integrated in the ship's general training programme, but it should be clearly evident what is regarded as gas-related training and what is regarded as other training.

.8 The training requirements related to the gas system should be evaluated in the same manner as other training requirements on board at least once a year. The training plan should be evaluated at regular intervals.

8.3 Maintenance

8.3.1 A special maintenance manual should be prepared for the gas supply system on board.

8.3.2 The manual should include maintenance procedures for all technical gas-related installations, and shall comply with the recommendations of the suppliers of the equipment. The intervals for and the extent of the replacement/approval of gas valves should be established. The maintenance procedure should specify who is qualified to carry out maintenance.

8.3.3 A special maintenance manual should be prepared for electrical equipment that is installed in explosion hazardous spaces and areas. The inspection and maintenance of electrical installations in explosion hazardous spaces should be performed in accordance with a recognized standard. [1]

8.3.4 Any personnel that should carry out inspections and maintenance of electrical installations in explosion hazardous spaces, should be qualified (pursuant to IEC 60079-17, item 4.2).

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1 Refer to IEC 60079 17:2007 Explosive atmospheres – Part 17: Electrical installations inspection and maintenance