RUSSIAN MARITIME REGISTER OF SHIPPING

RULES

FOR THE CLASSIFICATION AND CONSTRUCTION OF SHIPS CARRYING LIQUEFIED GASES IN BULK

PART VI

SYSTEMS AND PIPING

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RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SHIPS CARRYING LIQUEFIED GASES IN BULK

Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk of Russian Maritime Register of Shipping (RS, the Register) have been approved in accordance with the established approval procedure and come into force on 1 January 2022.

The present edition of the Rules is based on the 2021 edition taking into account the amendments developed immediately before publication.

The Rules establish requirements, which are specific for ships carrying liquefied gases in bulk, and supplement the Rules for the Classification and Construction of Sea-Going Ships and Rules for the Equipment of Sea-Going Ships of Russian Maritime Register of Shipping.

The Rules are published in the following parts:

Part I "Classification";

Part II "Ship Arrangement";

Part III "Stability. Subdivision. Freeboard";

Part IV "Cargo Containment";

Part V "Fire Protection";

Part VI "Systems and Piping";

Part VII "Electrical Equipment";

Part VIII "Instrumentation and Automation Systems";

Part IX "Materials and Welding";

Part X "Special Requirements".

REVISION HISTORY
(purely editorial amendments are not included in the Revision History)

For this version, there are no amendments to be included in the Revision History.

1 GENERAL

1.1 This Part of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk[1] supplements Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships[2] and sets forth the requirements for the special systems and piping of ships carrying liquefied gases in bulk[3].

1.2 Pumps, piping, valves and other fittings of the systems arranged in way of cargo tanks shall have identification markings.

1.3 Any pressure vessels shall meet the requirements in Part X "Boilers, Heat Exchangers and Pressure Vessels" of the Rules for the Classification. The requirements for type C independent tanks provided in Part IV "Cargo Containment" may also apply to the process pressure vessels, including surge tanks, heat exchangers and accumulators that store or treat liquid or vapour cargo. The term "pressure vessels" as used in Part IV "Cargo Containment", covers both type C independent tanks and process pressure vessels.

[1] Hereinafter referred to as "the LG Rules".
[2] Hereinafter referred to as "the Rules for the Classification".
[3] Hereinafter referred to as "the LG carriers".

2 PIPING

2.1 Materials.

2.1.1 The piping and valves used at a working temperature from 0 to –165 °C shall be made of the materials mentioned in Table 2.1-4, Part IX "Materials and Welding". The choice and testing of materials used in piping systems shall comply with the requirements of Section 2, Part IX "Materials and Welding" taking into account the minimum design temperature. However, some relaxation may be permitted in the quality of material of open-ended vent piping, provided that the temperature of the cargo at the pressure relief valve (PRV) setting is not lower than –55 °C, and that no liquid discharge to the vent piping can occur. Similar relaxations may be permitted under the same temperature conditions to open-ended piping inside cargo tanks, excluding discharge piping and all piping inside membrane and semi-membrane tanks.

2.1.2 Materials having a melting point below 925 °C shall not be used for piping outside the cargo tanks except for short lengths of pipes attached to the cargo tanks, in which case fire-resisting insulation shall be provided.

2.1.3 Cargo piping insulation system.

2.1.3.1 Cargo piping systems shall be provided with a thermal insulation system as required to minimize heat leak into the cargo during transfer operations and to protect personnel from direct contact with cold surfaces.

Properties of the thermal insulation of cargo piping systems shall be taken into consideration when calculating the heat balance of the containment system and capacity of the pressure/temperature control system. Surfaces of cargo piping systems with which personnel is likely to contact under normal conditions shall be protected by a thermal insulation, with the exception of the following examples:

surfaces of cargo piping systems which are protected by physical screening measures to prevent such direct contact;

surfaces of manual valves having extended spindles that protect the operator from the cargo temperature;

surfaces of cargo piping systems whose design temperature (to be determined from inner fluid temperature) is –10 °C.

2.1.3.2 Where applicable, due to location or environmental conditions, insulation materials shall have suitable properties of resistance to fire and flame spread and shall be adequately protected against penetration of water vapour and mechanical damage.

2.1.4 Where the cargo piping system is of a material susceptible to stress corrosion cracking in the presence of a salt-laden atmosphere, adequate measures to avoid this occurring shall be taken by considering material selection, protection of exposure to salty water and/or readiness for inspection.

2.1.5 For an outer pipe or duct equipped with mechanical exhaust ventilation having a capacity of at least 30 air changes per hour, the effects of both pressure and possible low temperature in the event of a high pressure line failure shall be taken into account.

2.2 Pipe wall thickness.

2.2.1 The wall thickness of pipes operating under the internal pressure shall be not less than that determined by Formula (2.3.1), Part VIII "Systems and Piping" of the Rules for the Classification with due regard for the following values involved in the formula.

2.2.1.1 p (design pressure) is the maximum pressure, to which the system may be subjected in service.

The greater of the following design conditions shall be used for piping, piping systems and components, based on the cargoes being carried:

for vapour piping systems or components that may be separated from their relief valves and which may contain some liquid, the saturated vapour pressure at a design temperature of 45 ºC. Higher or lower values may be used (refer to 13.2, Part IV "Cargo Containment"); or for systems or components that may be separated from their relief valves and which contain only vapour at all times, the superheated vapour pressure at 45 ºC. Higher or lower values may be used (refer to 13.2, Part IV "Cargo Containment"), assuming an initial condition of saturated vapour in the system at the system operating pressure and temperature; or

the MARVS of the cargo tanks and cargo processing systems; or

the pressure setting of the associated pump or compressor discharge relief valve; or

the maximum total discharge or loading head of the cargo piping system; or

the relief valve setting on a pipeline system.

In any case, the design pressure *p* shall not be less than 1 MPa except for open-ended lines where it shall be not less than 0,5 MPa or 10 times that of the relief valve setting.

Those parts of the liquid piping systems that may be subjected to surge pressures shall be designed to withstand this pressure.

The design pressure of the outer pipe or duct of gas fuel systems shall not be less than the maximum working pressure of the inner gas pipe. Alternatively, for gas fuel piping systems with a working pressure greater than 1 MPa, the design pressure of the outer duct shall not be less than the maximum built-up pressure arising in the annular space considering the local instantaneous peak pressure in way of any rupture and the ventilation arrangements.

The expression "design pressure of the outer pipe or duct" is either of the following:

.1 the maximum pressure that can act on the outer pipe or equipment enclosure after the inner pipe rupture as documented by suitable calculations taking into account the venting arrangements; or

.2 for gas fuel systems with inner pipe working pressure greater than 1 MPa, the "maximum built-up pressure arising in the annular space", after the inner pipe rupture, which shall be calculated in accordance with 9.5.7.2, Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" of the Rules for the Classification.

2.2.1.2 c is the corrosion allowance; it may be increased over the required in 2.3.1, Part VIII "Systems and Piping" of the Rules for the Classification if enhanced corrosion or piping erosion is expected. This allowance shall be consistent with the expected life of the piping.

2.2.1.3 The remaining values involved in the formula shall meet the requirements of 2.3.1, Part VIII "Systems and Piping" of the Rules for the Classification; no reduction of the safety factors is allowed.

2.2.1.4 The minimum material ultimate strength and yield stress safety factors accepted for the cargo pipeline shall be specified in the Certificate.

2.2.2 The minimum pipe wall thickness shall be taken in accordance with Table 2.3.8, Part VIII "Systems and Piping" of the Rules for the Classification or standards agreed with the Register.

Where necessary for mechanical strength to prevent damage of pipes resulted from excessive sag due to superimposed loads from supports, ship deflection or other causes, the wall thickness shall be increased over that required by 2.2.1. If this is impracticable or would cause excessive local stresses, these loads shall be reduced or eliminated completely by other design methods.

Such superimposed loads may be due to: supporting structures, ship deflections, liquid pressure surge during transfer operations, the weight of suspended valves, reaction to loading arm connections, or otherwise.

2.2.3 When the design temperature of the medium is –110 °C or lower, a complete stress analysis, taking into account all the stresses due to weight of pipes, including acceleration loads if significant, internal pressure, thermal contraction and loads induced by hog and sag of the ship for each branch of the piping system shall be submitted to the Register.

For temperatures of above –110 °C, a stress analysis may be required by the Register in relation to such matters as the design or stiffness of the piping system and the choice of materials.

Such analysis shall be carried out according to methods approved by the Register.

In any case, consideration shall be given to thermal stresses, even though calculations are not submitted.

2.2.4 High-pressure gas fuel outer pipes or ducting scantlings.

2.2.4.1 In fuel gas piping systems of design pressure greater than the critical pressure, the tangential membrane stress of a straight section of pipe or ducting shall not exceed the tensile strength divided by 1,5 (R_m/1,5) when subjected to the design pressure specified in 2.2.1. The pressure ratings of all other piping components shall reflect the same level of strength as straight pipes.

2.3 Pipe joints.

2.3.1 The present requirements apply to piping inside and outside the cargo tanks. On agreement with the Register, relaxations from these requirements may be accepted for piping inside cargo tanks and open- ended piping.

2.3.2 Butt-welded joints with complete penetration may be used in all applications. For design temperatures below –10 °C, butt welds shall be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a backing ring, consumable insert or inert gas back-up on the first pass.

For design pressures in excess of 1 MPa and design temperatures of –10 °C or lower, backing rings shall be removed after welding. The scope of non-destructive testing shall be not less than that required in 3.3.3, Part XIV "Welding" of the Rules for the Classification, for Class I piping.

2.3.3 Flange connections of piping, valves and other fittings shall meet the requirements of 2.4.3, Part VIII "Systems and Piping" of the Rules for the Classification.

The type B flange connections shall not be used for the design temperatures lower than –10 °C and in nominal sizes above 100 mm.

The strength dimensions of the flanges shall be determined in accordance with standards approved by the Register for the design pressure accepted in compliance with 2.2.1.1.

2.3.4 Sleep-on welded joints with sleeves and related welding are only to be used for open-ended lines with external diameter of 50 mm or less and design temperature not lower than –55 °C.

2.3.5 On agreement with the Register, screwed couplings may only be used for accessory lines with external diameter of 25 mm or less.

2.3.6 Where bellows and expansion joints are uses in the piping, they shall be held to a minimum but their number shall be sufficient to protect the pipelines and individual assemblies of the system against excessive stresses due to thermal expansion of the cargo tanks, pipelines and ship's hull deformations.

Bellows may be only installed outside the cargo tanks. Expansion joints of other types may be installed inside the cargo tanks.

If necessary, bellows shall be protected against icing.

The design and installation of expansion bellows shall be in accordance with recognized standard, and they shall be fitted with means to prevent damage due to over-extension or compression.

2.4 Heat treatment of pipes.

2.4.1 Post-weld heat treatment shall be required for all butt welds of liquefied gas pipes made with carbon, carbon-manganese and low alloy steels.

2.4.2 The Register 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 Insulation of piping.

Pipelines intended for media with low temperature shall be thermally isolated from the adjacent hull structures, where necessary, in order to prevent the temperature of these structures from falling below the design temperature.

Where liquid piping is dismantled regularly, or where liquid leakage may be anticipated (such as at shore connections or at the pump seals), protection for the hull beneath shall be provided.

2.6 Piping arrangement.

2.6.1 Any piping system that may contain cargo liquid or vapour shall:

.1 be segregated from other piping systems, except where interconnections are required for cargo-related operations such as purging, gas-freeing or inerting. The requirements of 6.1.4 shall be taken into account with regard to preventing back-flow of cargo. In such cases, precautions shall be taken to ensure that cargo or cargo vapour cannot enter other piping systems through the interconnections;

.2 except as provided in Section 11, not pass through any accommodation space, service space or control station or through a machinery space other than a cargo machinery space;

.3 be connected to the cargo containment system directly from the weather decks except where pipes installed in a vertical trunkway or equivalent are used to traverse void spaces above a cargo containment system and except where pipes for drainage, venting or purging traverse cofferdams;

.4 be located in the cargo area above the weather deck except for bow or stern loading and unloading arrangements, emergency cargo jettisoning piping systems, turret compartment systems and except in accordance with Section 11. The emergency cargo jettisoning piping system в may be led aft, external to accommodation spaces, service spaces or control stations or machinery spaces, but shall not pass through them; and

.5 be located inboard of the transverse tank location requirements of Section 2, Part II "Ship Arrangement", except for athwartship shore connection piping not subject to internal pressure at sea or emergency cargo jettisoning piping systems.

2.7 Side overboard discharges below freeboard deck.

2.7.1 Provision and control of valves fitted at the side overboard discharges of piping from spaces situated below the freeboard deck, or from enclosed superstructures and deckhouses on the freeboard deck shall comply with the requirements of 4.3.2, Part VIII "Systems and Piping" of the Rules for the Classification.

2.7.2 The choice of the valves shall be based on the following.

2.7.2.1 The overboard discharges are generally to be provided with one automatically operated non-return valve with a positive means of closing positioned above the freeboard deck.

2.7.2.2 Where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0,01 of the ship's length, the discharge opening may have two automatically operated non-return valves without positive means of closing provided that the inboard valve is readily accessible for inspection under service conditions.

3 CARGO SYSTEM

3.1 System and arrangement requirements.

3.1.1 The cargo handling and cargo control systems shall be designed taking into account the following:

.1 prevention of an abnormal condition escalating to a release of liquid or vapour cargo;

.2 the safe collection and disposal of cargo fluids released;

.3 prevention of the formation of flammable mixtures;

.4 prevention of ignition of flammable liquids or gases and vapours released; and;

.5 limiting the exposure of personnel to fire and other hazards.

3.1.2 Suitable means shall be provided to relieve the pressure and remove liquid cargo from loading and discharging crossover headers; likewise, any piping between the outermost manifold valves and loading arms or cargo hoses to the cargo tanks.

3.1.3 Piping systems carrying fluids for direct heating or cooling of cargo shall not be led outside the cargo area unless a suitable means is provided to prevent or detect the migration of cargo vapour outside the cargo area.

3.1.4 Relief valves discharging liquid cargo from the piping system shall discharge into the cargo tanks. Alternatively, they may discharge to the cargo vent mast, if means are provided to detect and dispose of any liquid cargo that may flow into the vent system. Where required to prevent overpressure in downstream piping, relief valves on cargo pumps shall discharge to the pump suction.

3.2 Cargo system valve requirements.

3.2.1 Every cargo tank and piping system shall be fitted with manually operated valves for isolation purposes as specified in this Section.

3.2.2 In addition, remotely operated valves shall also be fitted, as appropriate, as part of the emergency shutdown (ESD) system the purpose of which shall stop cargo flow or leakage in the event of an emergency when cargo liquid or vapour transfer is in progress. The ESD system is intended to return the cargo system to a safe static condition so that any remedial action can be taken. Due regard shall be given in the design of the ESD system to avoid the generation of surge pressures within the cargo transfer pipework. The equipment to be shut down on ESD activation includes manifold valves during loading or discharge, any pump or compressor, etc., transferring cargo internally or externally (e.g. to shore or another ship/barge) and cargo tank valves, if the MARVS exceeds 0,07 MPa.

3.3 Cargo tank connections.

3.3.1 All liquid and vapour connections, except for safety relief valves and liquid level gauging devices, shall have shutoff valves located as close to the tank as practicable. These valves shall provide full closure and shall be capable of local manual operation. They may also be capable of remote operation.

3.3.2 For cargo tanks with a MARVS exceeding 0,07 MPa gauge, the above connections shall also be equipped with remotely controlled ESD valves. These valves shall be located as close to the tank as practicable. A single valve may be substituted for the two separate valves, provided the valve complies with the requirements of 3.21.6 and provides full closure of the line.

3.4 Cargo manifold connections.

3.4.1 One remotely controlled ESD valve shall be provided at each cargo transfer connection in use to stop liquid and vapour transfer to or from the ship. Transfer connections not in use shall be isolated with suitable blank flanges.

3.4.2 If the cargo tank MARVS exceeds 0,07 MPa, an additional manual valve shall be provided for each transfer connection in use, and may be inboard or outboard of the ESD valve to suit the ship's design.

3.4.3 Excess flow valves may be used in lieu of ESD valves, if the diameter of the protected pipe does not exceed 50 mm. Excess flow valves shall close automatically at the rated closing flow of vapour or liquid as specified by the manufacturer. The piping including fittings, valves and appurtenances protected by an excess flow valve shall have a capacity greater than the rated closing flow of the excess flow valve. Excess flow valves may be designed with a bypass not exceeding the area of a 1 mm diameter circular opening to allow equalization of pressure after a shutdown activation.

3.4.4 Cargo tank connections for gauging or measuring devices need not be equipped with excess flow valves or ESD valves, provided that the devices are constructed so that the outward flow of tank contents cannot exceed that passed by a 1,5 mm diameter circular hole.

3.4.5 All pipelines or components which may be isolated in a liquid full condition shall be protected with relief valves for thermal expansion and evaporation.

3.4.6 All pipelines or components which may be isolated automatically due to a fire with a liquid volume of more than 0,05 m^3, entrapped shall be provided with PRVs sized for a fire condition according to 3.19.1.

3.5 Cargo transfer arrangements.

3.5.1 Where cargo transfer is by means of cargo pumps that are not accessible for repair with the tanks in service, at least two separate means shall be provided to transfer cargo from each cargo tank, and the design shall be such that failure of one cargo pump or means of transfer will not prevent the cargo transfer by another pump or pumps, or other cargo transfer means.

3.5.2 The procedure for transfer of cargo by gas pressurization shall preclude lifting of the relief valves during such transfer. Gas pressurization may be accepted as a means of transfer of cargo for those tanks where the design factor of safety is not reduced under the conditions prevailing during the cargo transfer operation. If the cargo tank relief valves or set pressure are changed for this purpose, as it is permitted in accordance with IGC Code, the new set pressure shall not exceed P_h as is defined in Section 1, Part IV "Cargo Containment".

3.6 Vapour return connections.

3.6.1 Connections for vapour return to the shore installations shall be provided.

3.7 Cargo tank vent piping systems.

3.7.1 The pressure relief system shall be connected to a vent piping system designed to minimize the possibility of cargo vapour accumulating on the decks, or entering accommodation spaces, service spaces, control stations and machinery spaces, or other spaces where it may create a dangerous condition.

3.8 Cargo sampling connections.

3.8.1 Connections to cargo piping systems for taking cargo liquid samples shall be clearly marked and shall be designed to minimize the release of cargo vapours. For vessels permitted to carry toxic products, the sampling system shall be of a closed loop design to ensure that cargo liquid and vapour are not vented to atmosphere.

The present requirements are only applicable if such a sampling system is fitted on board. Connections used for control of atmosphere in cargo tanks during inerting or gassing up are not considered as cargo sampling connections.

3.8.2 Liquid sampling systems shall be provided with two valves on the sample inlet. One of these valves shall be of the multi-turn type to avoid accidental opening, and shall be spaced far enough apart to ensure that they can isolate the line if there is blockage, by ice or hydrates for example.

3.8.3 On closed loop systems, the valves on the return pipe shall also comply with 3.8.2.

3.8.4 The connection to the sample container shall comply with recognized standards and be supported so as to be able to support the weight of a sample container. Threaded connections shall be tack-welded, or otherwise locked, to prevent them being unscrewed during the normal connection and disconnection of sample containers. The sample connection shall be fitted with a closure plug or flange to prevent any leakage when the connection is not in use.

3.8.5 Sample connections used only for vapour samples may be fitted with a single valve in accordance with 2.3, 3.2 and Section 11 and shall also be fitted with a closure plug or flange.

3.9 Cargo filters.

3.9.1 The cargo liquid and vapour systems shall be capable of being fitted with filters to protect against damage by extraneous objects. Such filters may be permanent or temporary, and the standards of filtration shall be appropriate to the risk of debris, etc., entering the cargo system. Means shall be provided to indicate that filters are becoming blocked, and to isolate, depressurize and clean the filters safely.

Means to indicate that filters are becoming blocked and filter maintenance is required shall be provided for fixed in-line filter arrangement and portable filter installations where dedicated filter housing piping is provided. Where portable filters for fitting to manifold presentation flanges are used without dedicated filter housing, and these can be visually inspected after each loading and discharging operation, no additional arrangements for indicating blockage or facilitating drainage are required.

3.10 Piping installation requirements.

3.10.1 Provision shall be made to protect the piping, piping system and components and cargo tanks from excessive stresses due to thermal movement and from movements of the tank and hull structure. The preferred method outside the cargo tanks is by means of offsets, bends or loops, but multi-layer bellows may be used if offsets, bends or loops are not practicable.

3.10.2 Low temperature piping shall be thermally isolated from the adjacent hull structure, where necessary, to prevent the temperature of the hull from falling below the design temperature of the hull material. Where liquid piping is dismantled regularly, or where liquid leakage may be anticipated, such as at shore connections and at pump seals, protection for the hull beneath shall be provided.

3.10.3 For cargo temperatures below – 110 °C, a water distribution system shall be fitted in way of the hull under the shore connections to provide a low-pressure water curtain for additional protection of the hull steel and the ship's side structure. This system is in addition to the requirements of 3.3, Part V "Fire Protection" and shall be operated when cargo transfer is in progress.

3.10.4 Where tanks or cargo piping and piping equipment are separated from the ship's structure by thermal isolation, provision shall be made for electrically bonding both the piping and the tanks. All gasketed pipe joints and hose connections shall be electrically bonded. Except where bonding straps are used, it shall be demonstrated that the electrical resistance of each joint or connection is less than 1 MOhm.

3.11 Arrangements for cargo piping outside the cargo area.

3.11.1 Emergency cargo jettisoning.

3.11.1.1 If fitted, an emergency cargo jettisoning piping system may be led aft, external to accommodation spaces, service spaces or control stations or machinery spaces, but shall not pass through them. If an emergency cargo jettisoning piping system is permanently installed, a suitable means of isolating the piping system from the cargo piping shall be provided within the cargo area.

3.12 Bow and stern loading arrangements.

3.12.1 Subject to the requirements of this Section, cargo piping may be arranged to permit bow or stern loading and unloading.

3.12.2 Arrangements shall be made to allow such piping to be purged and gas-freed after use. When not in use, the spool pieces shall be removed and the pipe ends blank-flanged. The vent pipes connected with the purge shall be located in the cargo area.

3.12.3 Cargo piping and related piping equipment outside the cargo area shall have only welded connections. The piping outside the cargo area shall run on the weather decks and shall be at least 0,8 m inboard, except for athwartships shore connection piping. Such piping shall be clearly identified and fitted with a shutoff valve at its connection to the cargo piping system within the cargo area. At this location, it shall also be capable of being separated by means of a removable spool piece and blank flanges, when not in use.

3.12.4 The piping shall be full penetration butt-welded and subjected to full radiographic or ultrasonic inspection, regardless of pipe diameter and design temperature. Flange connections in the piping shall only be permitted within the cargo area and at the shore connection.

3.13 Turret compartment transfer systems.

3.13.1 For the transfer of liquid or vapour cargo through an internal turret arrangement located outside the cargo area, the piping serving this purpose shall comply with the following:

.1 piping shall be located above the weather deck, except for the connection to the turret;

.2 portable arrangements shall not be permitted; and

.3 arrangements shall be made to allow such piping to be purged and gas-freed after use. When not in use, the spool pieces for isolation from the cargo piping shall be removed and the pipe ends blank-flanged. The vent pipes connected with the purge shall be located in the cargo area;

.4 cargo piping and related piping equipment outside the cargo area shall have only welded connections; and

.5 the piping shall be full penetration butt-welded, and subjected to full radiographic or ultrasonic inspection, regardless of pipe diameter and design temperature. Flange connections in the piping shall only be permitted within the cargo area and at connections to cargo hoses and the turret connection.

3.14 Pumps and compressors.

3.14.1 To transfer the liquefied gases, centrifugal, peripheral and steam-driven direct acting pumps of special design may be used.

The construction of the pumps shall include special sealing components to keep the suction pressure above the liquid phase saturated vapour pressure at the maximum temperature.

3.14.2 Single-stage and double-stage compressors may be used to transfer liquefied gases cargo vapours.

3.14.3 Where cargo transfer is by means of cargo pumps not accessible for repair with the tanks in service, at least two separate means shall be provided to transfer cargo from each tank and the design shall be such that failure of one cargo pump, or means of transfer, will not prevent the cargo transfer by another cargo pump or pumps, or other cargo transfer means.

3.14.4 Relief valves shall be provided for pumps and compressors the delivery pressure of which may exceed the design pressure in the system.

3.14.5 The procedure for transfer of cargo by gas pressurization shall preclude lifting of the relief valves during such transfer.

3.14.6 The cargo pumps and compressors shall be arranged to shutdown automatically if:

emergency shutdown valves in pressure pipelines required by 3.15.1 are closed by the emergency shutdown system required by 3.15.4;

prescribed cargo level in cargo tank is reached;

pressure in the cargo tank drops to the minimum allowable value.

3.14.7 Cargo hoses shall have Type Approval Certificates and meet the requirements of Section 6, Part VIII "Systems and Piping" of the Rules for the Classification.

3.15 Piping and valves.

3.15.1 Every cargo piping system and cargo tank shall be provided with the emergency shutdown valves.

3.15.1.1 For cargo tanks with MARVS not exceeding 0,07 MPa, all liquid and vapour connections, except safety relief valves and closed liquid level gauging devices which penetrate the cargo tank, shall have shutoff valves located as close to the tank as practicable. These valves may be remotely controlled but shall be capable of local manual operation and provide full closure.

Remotely controlled emergency shutdown valves shall be provided on the ship for shutting down liquid and vapour cargo transfer between ship and shore and shall meet the requirements of 3.15.3 and 3.15.4.

3.15.1.2 For cargo tanks with MARVS exceeding 0,07 MPa, all liquid and vapour connections, except safety relief valves and closed liquid level gauging devices which penetrate the cargo tank, shall be equipped with a manually operated stop valve and a remotely controlled emergency shutdown valve. These valves shall be located as close to the tank as practicable.

Where the pipe size does not exceed 50 mm in diameter, excess flow valves specified in 3.15.5 may be used in lieu of the emergency shutdown valve.

A single valve may be substituted for the two separate valves provided the valve complies with the requirements of 3.15.4, is capable of local manual operation and provides full closure.

3.15.2 Cargo tank connections for gauging or measuring devices need not be equipped with excess flow or emergency shutdown valves provided that the internal diameter of a connection does not exceed 1,5 mm.

3.15.3 One remotely operated emergency shutdown valve shall be provided at each cargo hose connection. Connections not used in transfer operations may be blinded with blank flanges.

3.15.4 All required emergency shutdown valves shall be controlled from at least two remote locations on the ship. One of these locations shall be the cargo control room.

The control system shall be also provided with fusible elements designed to melt at temperatures 98 to 104 °C which will cause the emergency shutdown valves to close in the event of fire. Locations for such fusible elements shall include the tank domes and loading stations.

Emergency shutdown valves shall be of the fail-closed (closed on loss of power) type and be capable of local manual closing operation.

It is recommended that the valve closing operation is performed without use of a remote power supply but by physical mechanical over-ride forcing the valve onto its seat. Along with that, a clear indication of the valve opening and closing position shall be provided. The operating instruction of the valve Manufacturer shall be kept on board the ship and provide technical information on installation, maintenance, including disassembly and assembly, periodic inspections, including external and inner examinations and testing by pressure equal to the working pressure.

Emergency shutdown valves in liquid piping shall fully close under all service conditions with 30 s of actuation.

Valves connected with the high liquid level alarm and the sensor for automatic closure thereof, in accordance with Part VIII "Instrumentation and Automation System" shall comply with the following requirements to control overpressure in the cargo main and prevent the cargo tank from becoming liquid full.

3.15.4.1 The total valve closure time (i.e. the time from shutdown signal initiation to complete valve closure), in s, shall not exceed $3600u/LR$ (where u is ullage volume at operating signal level, in m^3; LR is the maximum loading rate agreed between ship and shore facility, in m^3/h) and shall be such as to avoid surge pressures.

3.15.4.2 The total valve closure time shall be such as to prevent pressure increase during closure of the valve above the acceptable level.

Information on the closing time of the valves and their operating characteristics shall be available on board and the valve closure time shall be verifiable and reproducible. Such valves shall close in such a manner as to cut off the flow smoothly.

3.15.5 Excess flow valve shall close automatically at the rated closing flow of vapour or liquid as specified by the manufacturer.

The piping including fittings, valves and appurtenances protected by an excess flow valve, shall have greater capacity than the rated closing flow of the excess flow valve.

Excess flow valves may be designed with a bypass not exceeding an area of 1,0 mm diameter circular opening to allow equalization of pressure, after an operating shutdown.

3.15.6 All pipelines or components which may be isolated in a liquid-full condition from the cargo piping systems and tanks shall be provided with relief valves.

Relief valves discharging liquid cargo from the cargo piping system shall discharge to the cargo vent mast if means are provided to detect and dispose of any liquid cargo which may flow into the vent system.

Relief valves on cargo pumps shall discharge to the pump suction.

3.15.7 Suitable means shall be provided to relief the pressure and remove liquid contents from cargo loading and discharging crossover headers and cargo hoses to the cargo tanks or other suitable location, prior to disconnecting the cargo hoses (refer to 3.15.10).

3.15.8 On agreement with the Register, for the purpose of carrying out cargo handling operations from bow and stern, cargo piping may be laid aft or forward outside the cargo area in accordance with 3.15.9 and 3.15.10, but it shall not be used for transfer of toxic goods.

Connections for the cargo hoses shall be arranged as follows.

3.15.8.1 Entrances, air intakes and opening leading to the accommodation, service and machinery spaces as well as control stations shall not face the shore connections of bow or stern loading and discharging arrangements. They shall be situated at the superstructure or deckhouse side at a distance equal to at least 4 % of ship length or 3 m from the deckhouse end facing the shore connection of the bow or stern loading and discharging arrangements. This distance need not, however, to exceed 5 m. Sidelights facing the side where the shore connections are fitted and situated on the superstructure or deckhouse side within the above distance shall be of dead (non-opening) type. Also, when the bow or stern loading and discharging arrangements are used, all doors, cargo ports and other openings situated on the relevant side of the superstructure or deckhouse shall be kept closed at all times.

3.15.8.2 Deck opening and air intakes located at a distance of 10 m from the position of the shore connection of the bow or stern loading and discharging arrangements shall be kept closed over the whole period when these arrangements are used.

3.15.8.3 Electrical equipment located within the 3 m zone from the position of the shore connection of the above arrangements shall meet the requirements of Part VII "Electrical Equipment".

3.15.8.4 Fire fighting equipment intended for use in the area where the bow or stern loading and discharging arrangements are located shall meet the requirements of 3.3, Part V "Fire Protection".

3.15.8.5 Communication shall be maintained between the cargo control room and the position of shore connection of the cargo hoses.

3.15.9 Cargo piping for bow or stern loading shall be permanently installed and meet the following requirements.

3.15.9.1 Cargo piping arranged forward or aft of the cargo area shall be laid on open parts of the deck, be clearly marked and be at least 760 mm away from the ship side.

3.15.9.2 Only butt-welded joints with complete penetration and 100 % radiographic inspection of the welds shall be used in cargo piping outside the cargo area, irrespective of the diameter, temperature and pressure for which the piping has been designed. Flange connections may be only used within the cargo area and at cargo hose connection.

3.15.9.3 The bow and stern loading and discharging piping shall be isolated from the cargo main by shut-off valves, spool pieces and blank flanges located in the cargo area.

3.15.10 To remove the cargo residues after using the piping referred to in 3.15.8 special means for their purging and gas-freeing shall be provided.

Vent piping system connected with the means for re-moving the cargo residues shall be located in the cargo area.

3.15.11 Where a part of the cargo which cannot be pumped out by cargo pump remains in the cargo tank, special means shall be provided to remove the cargo residues.

3.16 Pressure relief system.

3.16.1 All cargo tanks shall be provided with a pressure relief system arranged to send the surplus of the evaporated cargo into the vent piping system. The relieving system shall be appropriate to the design of the cargo containment system and the cargo being carried.

Hold spaces, interbarrier spaces and cargo piping which may be subject to pressures beyond their design capabilities shall be also provided with a suitable system to carry off the evaporated cargo. These systems shall be connected to a vent piping system so designed as to minimize the possibility of cargo vapour accumulating on the decks, or entering accommodation spaces, service spaces, machinery and other spaces and control stations where it may create a dangerous condition.

Pressure relief systems shall be independent of other systems including the pressure control systems specified in Section 4.

3.16.2 Each cargo tank including deck tanks shall be fitted with at least two pressure relief valves of equal capacity within the tolerances specified by the manufacturer and each shall be designed and constructed for the prescribed service.

3.16.3 Interbarrier spaces shall be provided with pressure relief devices approved by the Register.

The required relieving capacity of pressure relief devices of interbarrier spaces surrounding cargo tanks of various designs shall be determined as follows:

.1 the relieving capacity of pressure relief devices of interbarrier spaces surrounding independent type A cargo tanks shall be determined in accordance with 3.19.3;

.2 the relieving capacity of pressure relief devices of interbarrier spaces surrounding independent type B cargo tanks may be determined in accordance with 3.19.3, however, the leakage rate shall be determined in accordance with 7.2, Part IV "Cargo Containment";

.3 the relieving capacity of pressure relief devices for interbarrier spaces of membrane and semi-membrane tanks shall be evaluated on the basis of specific membrane/semi-membrane tank design;

.4 the relieving capacity of pressure relief devices for interbarrier spaces adjacent to integral tanks may, if applicable, be determined in accordance with 3.19.3.

3.16.4 The setting of the pressure relief valves shall not be higher than the vapour pressure which has been used in the design of the tank.

3.16.5 Pressure relief valves shall be connected to the highest part of the cargo tank above deck level. Pressure relief valves shall be arranged to prevent their becoming inoperative due to ice formation when they are closed.

Due consideration shall be given to the construction and arrangement of pressure relief valves on cargo tanks subject to low ambient temperatures.

3.16.6 In case of cargo tanks permitted to have more than one relief valve setting this may be accomplished by:

installing two or more properly set and sealed valves and providing means as necessary for isolating the valves not in use from the cargo tank; or

installing relief valves whose settings may be changed by the insertion of previously approved spacer pieces or alternative springs or by other similar means not requiring pressure testing to verify the new set pressure.

All valve adjustments shall be sealed.

The requirements for testing and adjusting the relief valves are set out in 12.1.3.

The procedure for changing of relief valve setting shall be included in the cargo system operation manual (refer to 4.1.27 of Part I "Classification").

3.16.7 Stop valves or other means of blanking off pipes between tanks and pressure relief valves to facilitate maintenance shall not be fitted unless all the following arrangements are provided:

.1 suitable arrangements to prevent more than one pressure relief valve being out of service;

.2 a device which automatically and in a clearly visible way indicates which one of the pressure relief valves is out of service;

.3 pressure relief capacities such that if one valve is out of service the remaining valves have the combined relieving capacity required by 3.6. However, this capacity may be provided by the combined capacity of all valves, if a suitably maintained spare valve is carried on board.

3.16.8 Each pressure relief valve installed on a cargo tank shall be connected to a venting system.

3.16.9 If cargoes which react in a hazardous manner with each other are carried simultaneously, a separate pressure relief system shall be fitted for each cargo carried.

3.16.10 Pressure relief valves and piping shall be so arranged that liquid can under no circumstances accumulate in or near the pressure relief valves.

3.16.11 Pressure relief valves shall be positioned on the cargo tank so that they will remain in the vapour phase under conditions of 15° list and 0,015*L* trim (for *L*, refer to the definition in Part II "Hull" of the Rules for the Classification).

The provisions of IACS Recommendation No. 150 published in the Supplement to Rules and Guidelines of Russian Maritime Register of Shipping "IACS Procedural Requirements, Unified Requirements, Unified Interpretations and Recommendations" shall be taken into consideration.

3.17 Additional pressure relieving system for liquid level control.

3.17.1 Where required by 3.20.4.2, an additional pressure relieving system to prevent the tank from becoming liquid full at any time during relief under the fire exposure conditions referred to in 3.6 shall be fitted to each tank. This pressure relieving system shall consist of:

.1 one or more relief valves set at a pressure corresponding to the gauge vapour pressure of the cargo at the reference temperature defined in 3.20.4.2;

.2 an override arrangement, whenever necessary, to prevent its normal operation. This arrangement shall include fusible elements designed to melt at temperatures between 98 °C and 104 °C and to cause relief valves specified in 3.17.1.1 to become operable. The fusible elements shall be located in the vicinity of relief valves.

The said overriding arrangement shall not be dependent on any source of ship's power.

The additional pressure relieving system shall become operable upon loss of system power, if provided.

3.17.2 The total relieving capacity of the additional pressure relieving system at the pressure mentioned in 3.17.1.1 shall be not less than

$$Q = FG'A^{0,82} \qquad (3.17.2\text{-}1)$$

where Q = minimum required rate of discharge of air, in m^3/s, at standard conditions of 0 °C and 0,1013 MPa;
G' = gas factor determined by the formula

$$G' = \frac{12,4}{(L+\rho_R \cdot m)D}\sqrt{ZT'/M} \qquad (3.17.2\text{-}2)$$

where ρ_R = relative density of liquid phase of product at relieving conditions (ρ_R=1,0 for fresh water);
$m = -di/d\rho_R$ = gradient of decrease of liquid phase enthalpy against increase of liquid phase density, in kJ/kg, at relieving conditions.
For set pressures not higher than 0,206 MPa the values of m given in Table 3.17.2 may be used. For products not listed in Table 3.17.2 and for higher set pressures the value of m shall be calculated on the basis of the thermodynamic data of the product itself;
i = enthalpy of liquid, in kJ/kg;
T' = temperature in kelvins (°K) at relieving conditions, i.e. the pressure, at which the additional pressure relieving system is set;
F, A, L, D, Z and M are given in 3.19.1.2.

Table 3.17.2

Product	m
Nitrogen	400
Ammonia, anhydrous	3400
Butadiene	1800
Butane	2000
Butylene	1900
Methane	2300
Propylene oxide	1550
Propane	2000
Propylene	1600
Vinyl chloride	900
Methyl chloride	816
Ethane	2100
Ethylene	1500
Note. The values of m are given for set pressures not higher than 0,206 MPa.	

3.17.3 If compliance with 3.17.1.1 requires changing of the setting of the relief valves, this shall be accomplished in accordance with the requirements of 3.16.6.

3.17.4 Relief valves mentioned under 3.17.1.1 above may be the same as the pressure relief valves mentioned in 3.16, provided the setting pressure and the relieving capacity are in compliance with the requirements of 3.17.

3.17.5 The exhaust of such pressure relief valves may be led to the venting system (refer also to 3.16.8, 5.2 and 5.3).

3.18 Vacuum protection systems.

3.18.1 Cargo tanks designed to withstand a maximum external pressure differential exceeding 0,025 MPa and capable of withstanding the maximum external pressure differential which can be attained at maximum discharge rates with no vapour return into cargo tanks, or by operation of a cargo refrigeration system, need no vacuum relief protection.

3.18.2 Cargo tanks for which, in accordance with 3.18.1, a vacuum relief protection is required, shall be fitted with:

two independent pressure switches for sequentially alarm and subsequently stop all suction of cargo liquid or vapour from the cargo tank, and refrigeration equipment, if fitted, at a pressure sufficiently below the maximum external pressure differential of the cargo tank; or

vacuum relief valves with a gas flow capacity at least equal to the maximum cargo discharge rate per cargo tank, set to open at a pressure sufficiently below the external differential pressure of the cargo tank; or

other vacuum relief systems approved by the Register.

3.18.3 The vacuum relief valves shall admit an inert gas, cargo vapour or air to the cargo tank and shall be arranged to minimize the possibility of the entrance of water or snow.

If cargo vapour is admitted during operation of vacuum relief valves, it shall be from a source other than the cargo vapour lines.

3.18.4 The vacuum protection system shall be capable of being tested to ensure that it operates at the prescribed pressure.

3.19 Size of valves.

3.19.1 Pressure relief valves shall have a combined relieving capacity for each tank to discharge the greater of the following with not more than a 20 % rise in cargo tank pressure above MARVS:

.1 the maximum capacity of the cargo tank inerting system if the maximum attainable working pressure of the cargo tank inerting system exceeds MARVS of the cargo tanks; or

.2 vapours generated under fire exposure calculated by the formula

$$Q = FGA^{0,82} \qquad (3.19.1.2\text{-}1)$$

where Q = minimum required rate of discharge of air, in m^3/s, at standard conditions (0 °C and 0,1013 MPa);

F = fire exposure factor for different cargo tank types:
1 — for tanks without insulation located on deck;
0,5 — for tanks above the deck when insulation is approved by the Register. Approval shall be based on the use of an approved fireproofing material, the thermal conductance of insulation, and its stability under fire exposure;
0,5 — for uninsulated independent tanks installed in holds;
0,2 — for insulated independent tanks in holds (or uninsulated independent tanks in insulated holds);
0,1 — for insulated independent tanks in inerted holds or uninsulated independent tanks in inerted, insulated holds;
0,1 — for membrane and semi-membrane tanks.
For independent tanks partly protruding through the open deck, the fire exposure factor shall be determined on the basis of the surface areas above and below deck.

G — gas factor to be determined by the formula

$$G = \frac{12,4}{LD}\sqrt{ZT/M} \qquad (3.19.1.2\text{-}2)$$

where T — temperature in degrees Kelvin at relieving conditions, i.e. 120 % of the pressure at which the pressure relief valve is set; L — latent heat of the material being vapourized at relieving conditions, in kJ/kg;

D = a constant shown in Table 3.19.1.2 depending on K; K — the ratio of gas specific heat at the constant pressure to the specific gas heat at the constant volume. If K is not known, D = 0,606 shall be used;

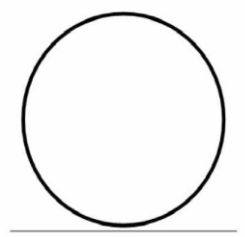
Z = compressibility factor of the gas at relieving conditions. If not known, Z = 1 shall be used;

M = molecular mass of the product;

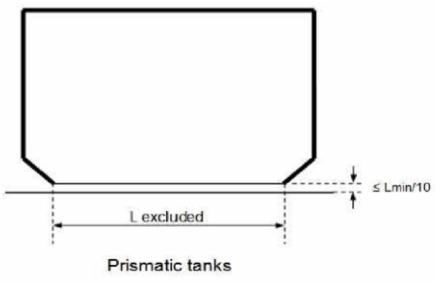
A = external surface area of the tank, in m^2, for different tank types, as shown in Fig. 3.19.1.2.

Table 3.19.1.2

K	D	K	D	K	D
1,00	0,606	1,36	0,677	1,72	0,734
1,02	0,611	1,38	0,681	1,74	0,736
1,04	0,615	1,40	0,685	1,76	0,739
1,06	0,620	1,42	0,688	1,78	0,742
1,08	0,624	1,44	0,691	1,80	0,745
1,10	0,628	1,46	0,695	1,82	0,747
1,12	0,633	1,48	0,698	1,84	0,750
1,14	0,637	1,50	0,701	1,86	0,752
1,16	0,641	1,52	0,704	1,88	0,755
1,18	0,645	1,54	0,707	1,90	0,758
1,20	0,649	1,56	0,710	1,92	0,760
1,22	0,652	1,58	0,713	1,94	0,763
1,24	0,656	1,60	0,716	1,96	0,765
1,26	0,660	1,62	0,719	1,98	0,767
1,28	0,664	1,64	0,722	2,00	0,770
1,30	0,667	1,66	0,725	2,02	0,772
1,32	0,671	1,68	0,728	2,20	0,792
1,34	0,674	1,70	0,731	—	—

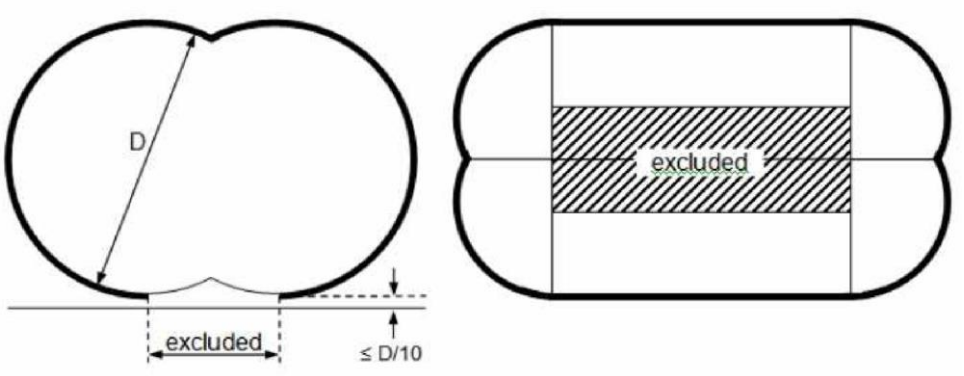


Spherical or cylindrical tanks with spherical dished ends, hemispherical or semi-ellipsoidal heads.
External surface area A is assumed equal to the total area of the outer surface of the tank.

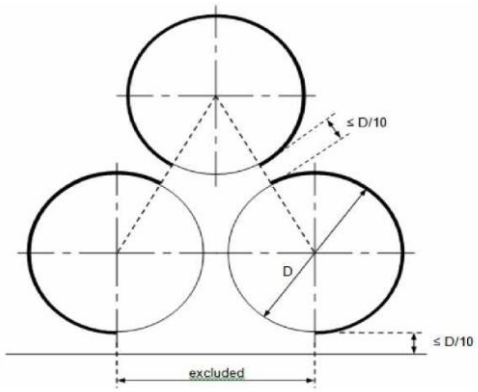


Prismatic tanks

Prismatic tanks
For prismatic tanks whose distance between the flat bottom of the tank and bottom of the hold space is equal to or less than $L_{\min}$/10:
A — external surface area minus flat bottom surface area.
For prismatic tanks whose distance between the flat bottom of the tank and bottom of the hold space is greater than $L_{\min}$/10:
A shall be equal to the external surface area.
$L_{\min}$, for non-tapered tanks, is the smaller of the horizontal dimensions of the flat bottom of the tank. For tapered tanks, which may be used for the forward tank, $L_{\min}$ is the smaller of the length and the average width.



Bilobe tanks
For bilobe tanks whose distance between the flat bottom of the tank and bottom of the hold space is greater than D/10. A shall be equal to the external surface area.



For horizontal cylindrical tanks arrangement part of the surface is excluded if the distance between the tanks and between the tanks and the support deck is less than D/10.

Fig. 3.19.1.2
Area of the calculated surface

The required air capacity of the protective arrangement shall be determined as per the formula

$$M_{air} = Q\rho_{air}, \text{kg/s}, \qquad (3.19.1.2\text{-}3)$$

where ρ_{air} = air density at 273,15 K and 0,1013 MPa is assumed equal to 1,293 kg/m^3.

3.19.2 The back pressure in the vent lines from the pressure relief valves shall be taken into account in determining the flow capacity required in 3.19.1. The pressure drop in the vent line from the tank to the pressure relief valve inlet shall not exceed 3 % of the valve set pressure. For unbalanced pressure relief valves, the back pressure in the discharge line shall not exceed 10 % of the gauge pressure at the relief valve inlet with the vent lines under fire exposure as referred to in 3.19.1.2.

3.19.3 The combined relieving capacity of the pressure relief devices for interbarrier spaces surrounding type A independent cargo tanks is determined by the following formula:

$$Q_{sa} = 3{,}4A_c\frac{\rho}{\rho_v}\sqrt{h} \qquad (3.19.3)$$

where Q_{sa} = minimum required discharge rate of air, in m^3/s, at standard conditions (0 °C and 0,1013 MPa);
A_c = design crack opening area, in m^2;
$A_c = \frac{\pi}{4}\delta L$;
δ = max, crack opening width, m;
$\delta = 0{,}2t$;
t = thickness of tank bottom plating, in m;
L = design crack length, in m, equal to the diagonal of the largest plate panel of the tank bottom, as shown in Fig. 3.19.3;
h = max liquid height above tank bottom plus 100·MARVS, in m;
ρ = density of product liquid phase, in kg/m^3, at the set pressure of the interbarrier space relief device;
ρ_v = density of product vapour phase, in kg/m^3, at the set pressure of the interbarrier space relief device and a temperature of 0 °C;
MARVS = max allowable relief valve setting of the cargo tank, MPa.

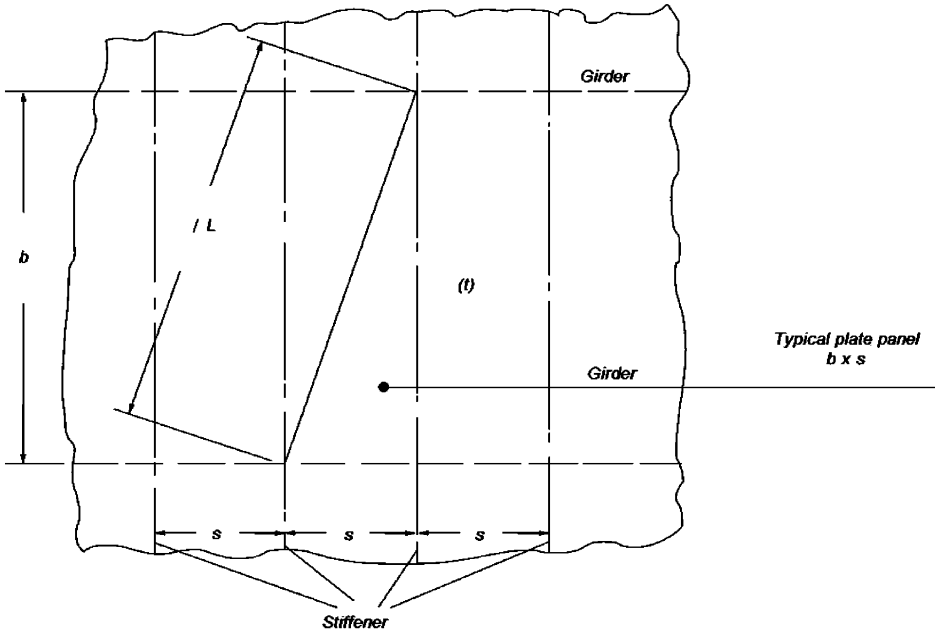


Fig. 3.19.3

3.20 The maximum filling limit of cargo tanks.

3.20.1 The maximum filling limit of cargo tanks shall be so determined that the vapour space has a minimum volume at reference temperature allowing for:

.1 tolerance of instrumentation such as level and temperature gauges;

.2 volumetric expansion of the cargo between the set pressure of pressure relief valves (PRV) and the maximum allowable rise stated in 3.16.1;

.3 an operational margin to account for liquid drained back to cargo tanks after completion of loading, operator reaction time and closing time of valves, refer to 3.15.4.1.

The default value for the filling limit (FL) of cargo tanks is 98 % at the reference temperature specified in 3.20.4. Exceptions to this value shall meet the requirements of 3.20.2.

3.20.2 A filling limit greater than the limit of 98 % may be permitted under the trim and list conditions specified in 3.16.11 and taking into account the provisions of IACS Recommendation No. 149, published in the Supplement to Rules and Guidelines of Russian Maritime Register of Shipping "IACS Procedural Requirements, Unified Requirements, Unified Interpretations and Recommendations", provided that:

.1 no isolated vapour pockets are created within the cargo tank;

.2 the PRV inlet arrangement shall remain in the vapour space;

.3 allowances are made for volumetric expansion of the liquid cargo due to the pressure increase from the maximum allowable relief pressure setting (MARVS) to full flow relieving pressure in accordance with 3.17.2;

.4 an operational margin shall be of minimum 0,1 % of tank volume;

.5 tolerances of instrumentation such as level and temperature gauges are considered;

.6 despite the compliance with 3.20.2.1 — 3.20.2.5, in no case shall a filling limit exceeding 99,5 % at reference temperature be permitted.

3.20.3 The maximum loading limit (LL) to which a cargo tank may be loaded shall be determined by the following formula

$$LL = FL\frac{\rho_R}{\rho_L} \qquad (3.20.3)$$

where LL — loading limit expressed in percent, which means the maximum allowable liquid volume relative to the tank volume to which the tank may be loaded;

FL — filling limit expressed in percent equal to the maximum liquid volume in a cargo tank relative to the total tank volume when the liquid cargo has reached the reference temperature specified in 3.20.4;

ρ_R — relative density of cargo at the reference temperature;

ρ_L — relative density of cargo at the loading temperature and pressure.

3.20.4 For the purposes of this Chapter only, the reference temperature means:

.1 when no cargo vapour pressure/temperature control, as referred to in Section 4, is provided, the temperature corresponding to the vapour pressure of the cargo at the set pressure of the PRVs;

.2 when a cargo vapour pressure/temperature control, as referred to in Section 4, is provided, the temperature of the cargo upon termination of loading, during transportation or at unloading, whichever is the greatest. When such temperature is obtained in the cargo tank at its complete loading prior to the cargo reaching the temperature corresponding to the vapour pressure of the cargo at the set pressure of the PRVs, as specified in 3.16, an additional pressure relief system shall be installed in compliance with the requirements of 3.17.

3.20.5 The Register may allow type C tanks to be loaded according to the formula in 3.20.3, with ρ_R relative density of cargo at the highest temperature that the cargo may reach upon termination of loading, during transportation, or at unloading, under the ambient design temperature conditions described in 4.1.3. This paragraph does not apply to products requiring a type **1G** ship for transportation.

3.20.6 A document shall be provided onboard the ship, specifying the maximum allowable loading limits for each cargo tank and product, at each applicable loading temperature and maximum reference temperature. Pressures at which the PRVs have been set shall also be stated in the list, including those required by 3.17. The list shall be approved by the Register and shall be permanently kept on board.

3.21 Cargo emergency shutdown (ESD) system.

3.21.1 A cargo emergency shutdown system shall be fitted to stop cargo flow in the event of an emergency, either internally within the ship, or during cargo transfer to ship or shore. The design of the ESD system shall avoid the potential generation of surge pressures within cargo transfer pipe work (refer to 3.21.6).

3.21.2 Auxiliary systems for conditioning the cargo that use toxic or flammable liquids or vapours shall be treated as cargo systems for the purposes of ESD. Indirect refrigeration systems using an inert medium, such as nitrogen, need not be included in the ESD function.

3.21.3 The ESD system shall be activated by the manual and automatic initiations listed in Table 3.21.7.3. Any additional initiations shall only be included in the ESD system if it can be shown that their inclusion does not reduce the integrity and reliability of the system overall.

3.21.4 Ship's ESD systems shall incorporate a ship-shore link in accordance with recognized standard.

3.21.5 A functional flow chart of the ESD system and related systems shall be provided in the cargo control station and on the navigation bridge.

3.21.6 ESD valve requirements.

3.21.6.1 The term "ESD valve" means any valve operated by the ESD system.

3.21.6.2 ESD valves shall be remotely operated, be of the fail-closed type (closed on loss of actuating power), be capable of local manual closure and have positive indication of the actual valve position. As an alternative to the local manual closing of the ESD valve, a manually operated shut-off valve in series with the ESD valve may be used. The manual valve shall be located adjacent to the ESD valve. Provisions shall be made to handle trapped liquid should the ESD valve close while the manual valve is also closed.

3.21.6.3 ESD valves in liquid piping systems shall close fully and smoothly within 30 s of actuation. Information about the closure time of the valves and their operating characteristics shall be available on board, and the closing time shall be verifiable and repeatable.

3.21.6.4 The closing time of the valve referred to in 3.1 and 3.2, Part VIII "Instrumentation and Automation Systems" ((i.e. time from shutdown signal initiation to complete valve closure) shall not be greater than

$$3600U/LR, s,$$

where U = ullage volume at operating signal level, in m^3;
LR = maximum loading rate agreed between ship and shore facility, in m^3/h.

The loading rate shall be adjusted to limit surge pressure on valve closure to an acceptable level, taking into account the loading hose or arm, the ship and the shore piping systems, where relevant.

3.21.6.6 One ESD valve shall be provided at each manifold connection. Cargo manifold connections not being used for transfer operations shall be blanked with blank flanges rated for the design pressure of the pipeline system.

3.21.6.7 If cargo system valves are also ESD valves, then the requirements of this Chapter shall apply.

3.21.7 ESD system controls.

3.21.7.1 As a minimum, the ESD system shall be capable of manual operation by a single control on the bridge and either in the control position required by 1.3, Part VIII "Instrumentation and Automation Systems", or the cargo control room, if installed, and no less than two locations in the cargo area.

3.21.7.2 The ESD system shall be automatically activated on detection of a fire on the weather decks of the cargo area and/or cargo machinery spaces. As a minimum, the method of detection used on the weather decks shall cover the liquid and vapour domes of the cargo tanks, the cargo manifolds and areas where liquid piping is dismantled regularly. Detection may be by means of fusible elements designed to melt at temperatures between 98 °C and 104 °C, or by area fire detection methods.

3.21.7.3 Cargo machinery that is running shall be stopped by activation of the ESD system in accordance with the cause and effect matrix in Table 3.21.7.3.

Table 3.21.7.3

ESD functional arrangements

Shutdown action → / Initiation ↓	Pumps		Compressor systems				Valves	Link
	Cargo pumps/cargo booster pumps	Spray/stripping pumps	Vapour return compressors	Fuel gas compressors	Reliquefaction plant*, including condensate return pumps, if fitted	Gas combustion unit	ESD valves	Signal to ship/ shore link**
Emergency push buttons (refer to 3.21.7.1)	√	√	√	[1]	√	√	√	√
Fire detection on deck or in compressor house*** (refer to 3.21.7.2)	√	√	√	√	√	√	√	√
High level in cargo tank (refer to 3.1 and 3.2, Part VIII "Instrumentation and Automation Systems")	√	√	√	[1, 2]	[2, 3]	[2]	[4]	√
Signal from ship/shore link (refer to 3.21.4)	√	√	√	[1]	[3]	N/A	√	N/A
Loss of motive power to ESD valves****	√	√	√	[1]	[3]	N/A	√	√
Main electric power failure ("blackout")	[5]	[5]	[5]	[5]	[5]	[5]	√	√
Level alarm override (refer to 3.1, Part VIII "Instrumentation and Automation Systems")	[6]	[6, 7]	√	[2]	[2]	[2]	√	√

[1] If the fuel gas compressor is used to return cargo vapour to shore, it shall be included in the ESD system when operating in this mode.

[2] These items of equipment can be omitted from these specific automatic shutdown initiators, provided the equipment inlets are protected against cargo liquid ingress.

[3] If the reliquefaction plant compressors are used for vapour return/shore line clearing, they shall be included in the ESD system when operating in that mode.

[4] The sensors referred to in 3.1, Part VIII "Instrumentation and Automation Systems" may be used to close automatically the tank filling valve for the individual tank where the sensors are installed, as an alternative to

Shutdown action → / Initiation ↓	Pumps		Compressor systems				Valves	Link
	Cargo pumps/cargo booster pumps	Spray/stripping pumps	Vapour return compressors	Fuel gas compressors	Reliquefaction plant*, including condensate return pumps, if fitted	Gas combustion unit	ESD valves	Signal to ship/ shore link**
closing the ESD valve referred to in 3.21.6.6. If this option is adopted, activation of the full ESD system shall be initiated when the high-level sensors in all the tanks to be loaded have been activated. [5] These items of equipment shall be designed not to restart upon recovery of main electric power and without confirmation of safe conditions. [6] The override system permitted by 3.1, Part VIII "Instrumentation and Automation Systems" may be used at sea to prevent false alarms or shutdowns. When level alarms are overridden, operation of cargo pumps and the opening of manifold ESD valves shall be inhibited except when high-level alarm testing is carried out in accordance with 12.2.2 (refer to 3.21.7.4). For this purpose, an electric or mechanical interlocking device shall be provided to prevent inadvertent operation of cargo pumps and inadvertent opening of manifold ESD valves. [7] Cargo spray or stripping pumps used to supply forcing vaporizer may be excluded from the ESD system only when operating in that mode. * Indirect refrigeration systems which form part of the reliquefaction plant do not need to be included in the ESD function if they employ an inert medium such as nitrogen in the refrigeration cycle. ** Signal need not indicate the event initiating ESD. *** Fusible plugs, electronic point temperature monitoring or area fire detection may be used for this purpose on deck. **** Failure of hydraulic, electric or pneumatic power for remotely operated ESD valve actuators. √ — Functional requirement. N/A — Not applicable.								

3.21.7.4 The ESD control system shall be configured so as to enable the high-level testing required in 12.2.2, to be carried out in a safe and controlled manner. For the purpose of the testing, cargo pumps may be operated while the overflow control system is overridden. Procedures for level alarm testing and re-setting of the ESD system after completion of the high-level alarm testing shall be included in the operation manual.

3.21.8 Additional shutdowns.

3.21.8.1 The requirements of 3.5.2 to protect the cargo tank from external differential pressure may be fulfilled by using an independent low pressure trip to activate the ESD system, or, as minimum, to stop any cargo pumps or compressors.

3.21.8.2 An input to the ESD system from the overflow control system required by 3.2, Part VIII "Instrumentation and Automation Systems" may be provided to stop any cargo pumps or compressors' running at the time a high level is detected, as this alarm may be due to inadvertent internal transfer of cargo from tank to tank.

3.21.9 Pre-operations testing.

3.21.9.1 Cargo emergency shutdown and alarm systems involved in cargo transfer shall be checked and tested before cargo handling operations begin.

3.21.10 Hot work on or near cargo containment systems.

3.21.10.1 Special fire precautions shall be taken in the vicinity of cargo tanks and, particularly, insulation systems that may be flammable or contaminated with hydrocarbons or that may give off toxic fumes as a product of combustion.

3.21.11 Additional operating requirements.

3.21.11.1 Additional operating requirements will be found in the following sections and paragraphs of the Code: 2.2.2, 2.2.5, 2.2.8, 3.8.4, 3.8.5, 5.3.2, 5.3.3.3, 5.7.3, 7.1, 8.2.7, 8.2.8, 8.2.9, 9.2, 9.3, 9.4.4, 12.1.1, 13.1.3, 13.3.6, 13.6.18, 14.3.3, 15.3, 15.6, 16.6.3, 17.4.2, 17.6, 17.7, 17.9, 17.10, 17.11, 17.12, 17.13, 17.14, 17.16, 17.18, 17.19, 17.21, 17.22.

3.22 Regasification plant.

3.22.1 The regasification plant shall be designed so that a single accidental event shall not result in a critical situation. The safety system shall provide two levels of protection to prevent or minimise the effects of an equipment failure within the regasification plant. These means of protection shall be independent of each other and in addition to the control devices used in normal operation.

3.22.2 Heating and evaporation of cargo may be arranged as direct heating or indirect heating. Means shall be provided to detect gas in heating medium and to prevent overpressure in the heating system.

Where heating medium used for LNG evaporating or heating returns outside the cargo area, the system shall provide a degasification tank in the cargo area for the heating medium input. The degasification tank shall be fitted with the gas detectors and alarm devices. The vent outlet of the degasification tank air piping shall be located in the safe position and be fitted with a flame arrestor.

3.22.3 Means shall be provided to protect the vaporizers against freezing of heating medium.

3.22.4 A process shut-down system (PSD) for the regasification plant shall be arranged. Initiation of PSD shall be from the monitoring system, from manual call points and remote controls. The minimum requirements to monitoring and control of the regasification plant are given in Table 3.22.4.

Table 3.22.4

Minimum required monitoring and control of regasification plant

Parameter	Alarm	Shut-down	Comments
Suction drum pressure	H/L		
Suction drum level	L	LL	PSD
Vaporizer, heating medium inlet temperature	L	LL	PSD
Vaporizer, heating medium inlet pressure	L	LL	PSD
Vaporizer, heating medium outlet temperature	L	LL	PSD
Vaporizer, LNG inlet pressure	H/L		
Vaporizer, NG outlet temperature	L	LL	PSD
Vaporizer, NG outlet pressure	H/L		
Heat exchanger, steam supply pressure	L		If steam is not direct heating medium
Heat exchanger, steam condensate return temperature	H/L		If steam is not direct heating medium
Overflow/Expansion tank in glycol loop	H	HH	If a glycol heating circuit is arranged
Liquid collector	H/L		If propan heating circuit is arranged
Gas metering for export, monitor NG flow	X	X	
Loss of power supply to control and monitoring system	X	X	
Natural gas to shore, pressure	H/L	LL	PSD
Natural gas to shore, pressure	L	LL	PSD
Vapour leakage into heating system detected	X		Gas detection in ca-se of steam or glycol heating, pressure in case of propane heating
Activation of ship's ESD		X	PSD
Before disconnection; ensure depressurize and purge cycle completed		X	No disconnection before depressurize/ purge
Gas detection in regasification units	X		
Confirmed fire in regasification area (Based on voting, i.e. two sensors confirming fire)	X	X	ESD and blow dawn and LNG outlet

Activation of the PSD shall:
stop the high pressure booster pump;
close isolation valves for the relevant regasification unit.

Separate transmitters shall be provided for control and shutdown functions. The control and safety system shall be designed to ensure that no single failure leads to a dangerous situation.

If an input signal of any parameter indicated in Table 3.22.4 is lost, the corresponding process shutdown shall be activated immediately to stop the regasification system. However, if instrument redundancy is provided, it is acceptable to continue with one healthy transmitter.

3.22.5 Emergency shut down (ESD).

3.22.5.1 The requirements to emergency shutdown system given in 3.15.4 and 3.21 shall be extended to cover to the regasification plant. The ESD system shall be activated by manual call points and by fusible elements/fire detectors located in way of the regasification units in addition to 3.15.4 and 3.21.

Activation of the ESD shall:
stop in-tank transfer pumps;
close gas export valves;
close manifold load valves.

3.22.6 Depressurising system.

3.22.6.1 The depressurising system shall be arranged to vent all parts of the regasification unit containing more than 400 kg of hydrocarbon inventory to the vent system. The depressurising system shall ensure safe collection and disposal of hydrocarbons during normal operations and during emergency conditions. Process systems that contain significant energy shall be depressurised during an emergency situation. The rate of depressurising shall be sufficient to ensure that rupture will not occur in case of external heat input from a fire. This normally implies that blow down valves are spring return, and fail to open position. It shall be possible to activate the depressurising system manually from the control station, in addition to automatic actions initiated through the fire detection system based on voting.

3.22.7 Pressure relief valves of regasification system.

3.22.7.1 If a suction drum is arranged to supply the high pressure booster pumps it shall be provided with a relief valve sized for relevant cases i.e. fire exposure when discharge pipe of buster pump is closed.

3.22.7.2 Pressure relief valves shall be fitted in sections of the piping system where LNG may be kept in the closed volume.

3.22.7.3 In case of relief to cargo tanks, the effect of routing high pressure LNG/NG to the cargo tank shall be documented.

3.22.8 Vent system.

3.22.8.1 Special consideration shall be given with respect to release rate and the potential for liquid flow through the vent mast. In general, the fitting of a knock-out drum to be considered between the relief valves and the vent mast. The knock out drum shall be provided with high level alarm.

As an alternative, a calculation showing sufficient capacity of the vent mast to avoid any liquid release through the mast shall be carried out. Part of the regasification unit will contain high pressure LNG and part will contain high pressure gas.

Relief arrangements for both phases need to be considered.

3.22.8.2 For permanently moored ships it may be considered disposing of gas via a flare rather than a vent. In such cases the capacity should be assessed per API RP 521 and it shall be ensured that radiation levels are within acceptable limits.

4 CARGO PRESSURE/TEMPERATURE CONTROL

4.1 General.

4.1.1 Unless the ship's cargo tanks are designed to withstand the full gauge vapour pressure of the cargo under conditions of the upper ambient design temperatures, the pressure and temperature of a cargo tank shall be constantly maintained in the design value range by using one of the following methods or a combination thereof:

.1 re-liqueficaliton of gas vapours;

.2 thermal oxidizing of vapours;

.3 pressure accumulation; and

.4 liquid cargo refrigerating.

For some highly dangerous cargoes specified in Part X "Special Requirements", the cargo containment system shall withstand full pressure of cargo vapours at the upper ambient design temperature independently of the type of the system provided for handling the vapourizing gas.

Cargo vapours venting into the atmosphere is not permitted except in emergencies

4.1.2 Use of at least two units for control of cargo pressure and temperature, capable of operating in every ship's mode, shall be provided onboard the ship. The capacity of each system for control of cargo pressure and temperature shall correspond to the maximum possible intensity of cargo vaporization from all LNG tanks during the normal ship's operation at the maximum design ambient temperature stated in 4.1.3, and the pressure in cargo tank not exceeding MARVS.

4.1.3 The systems required by 4.1.1 shall be constructed, fitted and tested upon approval of the Register. Materials used in their construction shall be suitable for use with the cargoes to be carried. For normal service, the upper ambient design temperature shall be 32 °C for sea and 45 °C for air. For service in particularly hot or cold zones, these design temperatures may be increased or decreased, upon agreement with the Register.

4.1.4 For certain highly hazardous cargoes specified in Part X "Special Requirements", the cargo tanks shall be capable of withstanding the full vapour pressure of the cargo under conditions of the upper ambient design temperatures, irrespective of any system provided for dealing with boil-off gas.

4.2 Refrigeration and reliquefaction systems.

4.2.1 A refrigeration system shall consist of one or more units capable of maintaining the required cargo pressure/temperature under conditions of the upper ambient design temperatures.

In addition to the main unit, a stand-by unit (or units) affording space capacity at least equal to the largest required unit shall be provided.

A stand-by unit shall consist of a compressor with its driving motor, control system and any necessary fittings to permit operation independently of the normal service units.

A stand-by heat exchanger shall be provided unless the normal heat exchanger for the unit has an excess capacity of at least 25 % of the largest required capacity. Separate piping systems are not required for the stand-by heat exchanger.

4.2.2 The refrigeration system may be arranged in one of the following ways:

.1 a direct system where evaporated cargo is compressed, condensed and returned to the cargo tanks. For certain cargoes specified in Part X "Special Requirements" this system shall not be used;

.2 an indirect system where cargo or evaporated cargo is cooled or condensed by refrigerant without being compressed;

.3 a combined system where evaporated cargo is compressed and condensed in a heat exchanger by refrigeration and returned to the cargo tanks. For certain cargoes specified in Part X "Special Requirements" this system shall not be used.

4.2.3 For the carriage of two or more refrigerated cargoes which may react chemically in a dangerous manner, separate refrigeration systems shall be provided for each cargo, as specified in 4.2.1. However, where cooling is provided by an indirect or combined system and leakage in the heat exchanger cannot cause mixing of the cargoes, separate refrigeration units are not required.

4.2.4 Where two or more refrigerated cargoes are not mutually soluble under the condition of carriage, but their vapour pressures would be additive on mixing, measures on preventing the possibility of mixing the cargoes shall be provided in the refrigeration system.

4.2.5 Where sea cooling water is required in the refrigeration system, a separate sea water pump used exclusively for supply of water to this system shall be provided. This pump shall have two sea suction lines, leading from sea chests, one port and one starboard.

A spare pump of adequate capacity shall be provided. This pump is also to have suction from two sea chests.

The said spare pump may be a pump of adequate capacity and pressure head, used for other services so long as its use for cooling would no interfere with any other essential service.

4.2.6 All primary and secondary refrigerants must be compatible with each other and with the cargo with which they come into contact.

The heat exchange may take place outside either remotely from the cargo tank or by cooling coils fitted inside or outside the cargo tank.

4.2.7 The relevant requirements of the Rules for the Classification shall also apply to mechanisms, arrangements and equipment of reliquefaction unit for cargo vapours unless otherwise specified in the LG Rules.

4.3 Systems for disposing the evaporated cargo.

4.3.1 Where no other means of pressure reduction are provided onboard the ship, mandatory 100 % redundancy of gas flaring units shall be provided, each of them shall be designed for the maximum cargo evaporating intensity during the normal operation. Availability of three gas flaring units on the ship is permitted, each of them is designed for at least 50 % of the maximum cargo evaporating intensity during the normal operation.

4.3.2 Alternatively to the redundancy of the gas flaring unit, the redundancy of all the main components in one gas flaring unit may be permitted:

combustion air fan;
dilution and cooling air fan;
ignition spark;
electrical sparking ignition arrangement;
continuous burning control system;
control and monitoring systems.

4.3.3 It is not allowed to arrange the gas flaring unit in common machinery space. Where gas flaring unit is located in the enclosed space, such space:

.1 shall be considered as machinery space of category A;

.2 shall be equipped with the mechanical ventilation system having a capacity of not less than 30 air changes per hour based upon the total volume of the space and using at least two fans drawing in air from the gas-safe spaces;

.3 ventilation intakes shall be fitted with the devices preventing ingress of moisture and foreign objects;

.4 shall be fitted with gas detection system as stated in 11.10.

4.3.4 Gas to the gas flaring unit shall be supplied through the ship open parts or in compliance with the requirements of Section 11 (through a double-wall piping system or the pipes in special ventilation ducts).

4.3.5 Ahead of the piping pass-through into the space where the gas flaring unit is located, the gas supply system shall be provided with the master gas fuel valve in compliance with 11.7, and the system shall be provided with the valves in compliance with 11.6.

4.3.6 Exhaust gas temperature after disposing in the gas flaring unit shall be at least 50 degrees lower the self-ignition temperature of the transported cargo. For this way of disposing LNG vapours, the exhaust gas temperature shall not exceed 535 °C.

4.3.7 Combustion chamber of the gas flaring unit shall be so designed that in any operating mode the ignition spark size does not run beyond its dimensions. Temperature of the outer surfaces of the gas flaring unit case shall not exceed 220 °C even with the dilution air fan is shut down.

4.3.8 Gas supplied to the gas flaring unit shall be at the temperature and under pressure permitted for operation of the gas burning installation. Gas pressure in the piping shall not exceed 1 MPa. Compressors, pressure vessels and heat exchangers used in the gas conditioning devices, shall meet the requirements of the relevant parts of the Rules for the Classification.

4.3.9 The electric motors of fans for combustion, dilution and cooling, as well as the ventilating systems shall be located in a gas-safe space.

4.3.10 The firing control system of the gas flaring unit shall be operated automatically and allow for the manual operation from the local control station.

4.3.11 The burning installation of the gas flaring unit shall be fitted with two flare monitoring devices, and the gas supply shall be automatically stopped and they are activated. The burning installation of the gas flaring unit shall prevent the repeated supply of burning gas till the completion of the combustion chamber blowing-off.

4.3.12 The burning installation of the gas flaring unit shall be fitted with the ignition spark or electrical spark ignition arrangement. For the ignition spark to provide continuous ignition, liquid fuel shall be used in compliance with 1.1.2, Part VII "Machinery Installations" of the Rules for the Classification. Liquid fuel supply piping for the ignition spark shall comply with the requirements of 13.2, Part VIII "Systems and Piping" of the Rules for the Classification. The ignition spark shall be fitted with a fire control device; in case of its activating the fuel supply to the ignition spark shall be automatically cut off.

4.3.13 The firing control system of the gas firing unit shall automatically shut down supply of combustion gas in the following cases:

shutdown of combustion air supply (fan switching off or combustion air pressure drop);

loss of flame;

loss of power;

actuation of gas detection system in the space of gas flaring unit;

actuation of gas detection system in the ventilation duct of gas fuel supply;

loss of nitrogen pressure in the tube space of gas supply piping or loss of air pressure in the ventilation duct of gas supply piping;

increase of exhaust gas temperature above the value stated in 4.3.7;

reduction of gas temperature below the value permissible for normal operation of the burning installation;

fire in the space of gas flaring unit.

4.3.14 The firing control system of the gas flaring unit shall prevent supply of burning gas in the following cases:

absence of signal of the ignition spark or electrical spark unit operation;

completion of combustion chamber blowing-off.

5 VENT PIPING SYSTEM

5.1 A vent piping system shall be provided to remove surplus gas from the cargo tank pressure relief valves.

5.2 The vent piping system shall be so constructed that the discharge of gas will be directed upwards and so arranged as to minimize the possibility of water or snow entering the system.

5.3 The height of the vent exits shall be not less than $B/3$ or 6 m, whichever is the greater, above the weather deck and 6 m above the working area and fore and aft gangway.

5.4 Cargo tank pressure relief vent exits shall be arranged at a distance at least equal to ship breadth or 25 m, whichever is less, from the nearest air intake or opening to accommodation spaces, service spaces, or other gas-safe spaces.

For ships less than 90 m in length, smaller distances may be permitted by the Register. All other vent exits connected to the cargo containment system shall be arranged at a distance of at least 10 m from the nearest air intake or opening to accommodation spaces, service spaces and control stations, or other gas-safe spaces.

5.5 All other cargo vent exits associated with cargo and not dealt with in other parts shall meet the requirements of 5.2 — 5.4.

5.6 If cargoes which react in a hazardous manner with each other are carried simultaneously, a separate pressure relief system shall be fitted for each cargo carried.

5.7 In the vent piping system, means for draining liquid from places where it may accumulate shall be provided.

5.8 Suitable protection screens shall be fitted on vent outlets to prevent the ingress of foreign objects.

5.9 All vent piping shall be so designed and arranged that it will not be damaged by temperature variations to which it may be exposed, or by the ship's motions.

6 INERT GAS SYSTEM

6.1 General.

6.1.1 The inerting shall provide a non-combustible environment, through the use of inert gases. The inert gas used shall be compatible chemically, under operating conditions, with the materials of construction and with the cargo carried at all temperatures likely to occur within the spaces in service.

6.1.2 If the inert gas is stored at temperatures below 0 °C, the system shall prevent the temperature of the ship's structures from dropping below the limiting values imposed.

6.1.3 The inert gas system shall provide iterting of interbarrier and hold spaces of the ship as well as safe gas-freeing of these spaces and areas, cargo tanks and cargo pipelines.

The inert gas system shall be also capable of delivering gas to the dead zones of the spaces protected.

6.1.4 Arrangements shall be provided to prevent the backflow of cargo vapour into the inert gas system.

6.1.5 The inert gas system shall be such that each space being inerted can be isolated and the pressure therein can be controlled by appropriate controls and relief valves.

6.1.6 Inert gas which is used for the fire fighting purposes shall be stored separately and shall not be used for cargo services.

6.2 Inerting of hull spaces.

6.2.1 If the ship is intended for the carriage of flammable products, the interbarrier and hull spaces adjacent to cargo containment systems requiring a complete or partial secondary barrier, shall be inerted by dried inert gas. The inert environment shall be maintained by the shipboard gas generation plant or inert gas storage the capacity of which shall be sufficient for normal consumption of gas for at least 30 days.

6.2.2 The interbarrier and hull spaces adjacent to cargo containment systems requiring a complete or partial secondary barrier, except as listed in Part X "Special Requirements", may be filled by dry air, if the ship is provided with an inert gas generation plant or inert gas storage the capacity of which is sufficient to inert the largest such space provided that their configuration and the capacity of the inert gas generation system ensure rapid detection of leakage from cargo tanks and the inerting thereof before a hazardous environment can develop.

Equipment shall be provided to produce a sufficient amount of dry air to satisfy the expected consumers.

6.2.3 Spaces adjacent to the refrigerated type C independent cargo tanks shall be inerted by dry inert gas or filled with dry air. Such condition shall be maintained by the shipboard devices specified in 6.2.1, or by equipment ensuring dry air supply.

6.2.4 In the internal insulation tanks, the interbarrier spaces as well as spaces between the secondary barrier and inner hull or the independent tank structure fully filled by the insulation complying with the requirements of 19.3 and 19.4, Part IV "Cargo Containment" need not be inerted.

6.3 Inerting of cargo tanks and systems.

6.3.1 The inert gas system shall minimize the possibility of flammable mixture formation in cargo tanks at any gas-freeing stage.

6.3.2 The cargo piping systems shall be capable of becoming free of inert gas and of being purged as indicated in 6.3.1.

6.3.3 To monitor the purging and gas-freeing process, each cargo tank shall be fitted with gas sampling arrangements.

Gas sampling connections shall be valved and fitted above the upper deck.

The gas sampling connection shall be fitted with at least two isolating valves. Use of threaded and union couplings shall be reduced to the minimum in the gas sampling pipeline and be avoided in the pipelines with an outside diameter more than 25 mm.

The open method of sampling shall be only allowed for the cargoes, which sample remains may be discharged to the atmosphere. For other cargoes an arrangement for the sample safe return into a cargo tank shall be provided.

6.3.4 The inert gas may be supplied from both the shipboard and shore-based facility.

6.4 Inert gas generation plant.

6.4.1 The plant shall produce inert gas with an oxygen content at no time greater than 5 % by volume subject to the requirements of Part X "Special Requirements".

A continuous-reading oxygen content meter with an alarm set at a maximum of 5 % oxygen content by volume subject to the requirements of Part X "Special Requirements" shall be fitted to the inert gas supply from the plant.

Liquefied nitrogen used as inert gas and produced by an onboard process of fractional distillation of the air, before entering the shipboard storage vessel, shall be monitored for traces of oxygen to avoid possible oxygen enrichment of the gas when released for inerting purposes.

6.4.2 The inert gas system shall be fitted with pressure controls and monitoring arrangements appropriate to the cargo containment system.

An arrangement shall be provided to prevent ingress of cargo into the inert gas system.

6.4.3 Spaces containing inert gas generation plants shall not have direct access to accommodation, service spaces and control stations. The plants may be located in the machinery spaces. Where the plants are arranged outside the cargo area, two non-return valves or equivalent devices required by 6.4.2 shall be fitted in the inert gas supply main within the cargo area.

The inert gas main shall not pass through accommodation, service spaces and control stations.

6.4.4 Flame burning equipment for generating inert gas shall not be located within the cargo area.

Special consideration shall be given to the location of inert gas generating equipment using the catalytic combustion process.

7 BILGE AND BALLAST SYSTEMS

7.1 Where cargo is carried in cargo tanks not requiring a secondary barrier, hold spaces shall be provided with suitable drainage arrangements. These arrangements shall be independent and not connected with the machinery space.

Means of detecting any leakage shall be provided for such spaces.

7.2 Where there is a secondary barrier, suitable drainage arrangements for dealing with any leakage into the hold or insulation spaces through adjacent ship structure shall be provided.

The suction shall not be led to pumps inside the machinery space.

Means of detecting such leakage shall be provided.

7.3 The interbarrier space shall be provided with drainage system suitable for handling liquid cargo in the event of cargo tank leakage or rupture. Such arrangements shall provide for the return of any cargo leakage to cargo tanks.

7.4 Suitable independent arrangements shall be provided for drainage of pump and compressor rooms.

7.5 In case of internal insulation tanks, means of detecting leakage and drainage arrangements are not required for interbarrier spaces and spaces between the secondary barrier and the inner hull or independent tank structure which are completely filled by insulation material complying with the requirements of 19.3 and 19.4, Part IV "Cargo Containment".

7.6 Ballast tanks, fuel oil tanks and gas-safe spaces may be connected to pumps in the machinery space.

Bottom pipe tunnels may be connected to pumps in the machinery space, provided the connections are led directly to the pumps and the discharge from pumps led directly overboard with no valves or manifolds in either line which could connect the line from the bottom tunnel to lines serving gas-safe spaces.

Pump vents serving dry bottom ballast pipe tunnels shall not be open to the machinery space.

8 VENTILATION SYSTEM

8.1 Spaces required to be entered during normal cargo handling operations.

8.1.1 Electric motor rooms, cargo compressor and pump-rooms, other enclosed spaces which contain cargo handling equipment and similar spaces in which cargo handling operations are performed shall be fitted with mechanical ventilation systems independent of other ventilation systems and capable of being controlled outside such spaces.

Provision shall be made to ventilate such spaces prior to entering the compartment and operating the equipment and a warning notice requiring the use of such ventilation shall be placed outside the compartment.

8.1.2 Mechanical ventilation inlets and outlets shall be arranged to ensure sufficient air movement through the space to avoid the accumulation of flammable or toxic vapours and to ensure a safe working environment.

The ventilation system shall have a capacity of not less than 30 air changes per hour based upon the total volume of the space. As an exception, gas-safe cargo control rooms may have 8 changes of air per hour.

8.1.3 Ventilation systems of spaces shall be fixed and, if of the negative pressure type, permit extraction from both the upper and lower parts of the spaces, depending on the density of the vapours of the products carried.

8.1.4 In rooms housing electric motors driving cargo compressors or pumps, spaces containing inert gas generators, cargo control rooms if considered as gas-safe spaces and other gas-safe spaces within the cargo area the ventilation shall be of positive pressure type and shall ensure positive pressure in these spaces.

8.1.5 In cargo compressor and pump-rooms and in cargo control rooms if considered gas-dangerous, the ventilation shall be of the negative pressure type.

8.1.6 Ventilation exhaust ducts from gas-dangerous spaces shall discharge upwards. The outlets shall 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 and they shall be located at least 10 m in the horizontal direction from ventilation intakes and openings to accommodation spaces, service spaces, control stations and other gas-safe spaces.

8.1.7 Ventilation intakes shall be so arranged as to minimize the possibility of re-cycling hazardous vapours from any ventilation discharge opening.

8.1.8 Ventilation ducts from gas-dangerous spaces shall not be led through machinery, accommodation and service spaces or control stations, except as specified in Section 10.

8.1.9 Electric motors driving fans shall be placed outside the ventilation ducts if the carriage of flammable products is intended.

Ventilation fans shall 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, for gas-dangerous spaces shall be of non-sparking construction complying with the requirements of 5.3.3, Part IX "Machinery" of the Rules for the Classification.

8.1.10 Spare impellers together with shaft, bearings and electric motors, one of each type, shall be carried for each type of fan used in cargo areas.

8.1.11 Protection screens of not more than 13 mm square mesh shall be fitted in outside openings of ventilation ducts.

8.2 Spaces not normally entered.

8.2.1 Hold spaces, interbarrier spaces, void spaces, cofferdams, spaces containing cargo piping and other spaces where cargo vapours may accumulate, shall be capable of being ventilated to ensure a safe environment when entry into the spaces is necessary. Where a permanent ventilation system is not provided for such spaces, approved means of portable mechanical ventilation shall be provided.

Where necessary, essential ventilation ducting in hold spaces and interbarrier spaces shall be permanently installed.

Fans or blowers shall be clear of personnel access openings, and shall comply with the requirements of 8.1.9.

8.3 Ventilation of other spaces.

8.3.1 The ventilation inlets shall not face the cargo area. They shall be located on the end bulkhead not facing the cargo area, bow or stern loading and discharging arrangements and/or on the side of the superstructure at a distance equal to $L/25$, but not less than 3 m, from the bulkhead facing the cargo area. This distance may not to exceed 5 m.

Consideration shall be given to the arrangement of ventilation inlets in relation to cargo piping, vent piping and exhaust piping of arrangements operating on liquefied gas.

The Register may allow relaxation from the said requirements for ships intended for the carriage of cargoes which are not toxic or ignition hazardous as well as for small ships where these requirements cannot be fulfilled.

8.3.2 All air intakes, outlets and other openings into the accommodation spaces, service spaces and control stations shall be fitted with closing devices ensuring gastightness.

When carrying toxic products, they shall be capable of being operated from inside the space. However, in this case:

.1 the requirement for fitting air intakes and openings with closing devices operated from inside the space for toxic products need not apply to spaces not normally manned, such as deck stores, forecastle stores, workshops. In addition, the requirement does not apply to cargo control rooms located within the cargo area;

.2 the closing devices need not be operable from within the single spaces if centralized control is provided from a centralized control station;

.3 engine room casings, cargo machinery spaces, electric motor rooms and steering gear compartments are considered as spaces not normally manned and not covered by this paragraph and therefore the requirement for closing devices need not be applied to these spaces;

.4 the closing devices shall give a reasonable degree of gas tightness. Steel fire-flaps without gaskets/ seals shall not be considered satisfactory;

.5 regardless of these requirements, closing devices for all air intakes and outlets operable from outside the space shall be provided in accordance with 12.1.7, Part VIII "Systems and Piping" of the Rules for the Classification.

8.3.3 The air lock space shall be provided with mechanical ventilation of positive pressure type from the gas-safe space to maintain positive pressure in relation to the gasdangerous zone on the weather deck.

The ventilation shall have a capacity to give at least 30 air changes per hour.

8.3.4 For ships with regasification unit the ventilation openings mentioned in 8.3.2 shall be provided with closing arrangements to be remotely activated from the bridge and CCR.

8.4 In machinery spaces of category A where gas is used as fuel, an independent mechanical ventilation shall be provided to ensure freedom from dead zones.

9 CARGO PUMP ROOMS AND CARGO COMPRESSOR ROOMS

9.1 Cargo pump-rooms and cargo compressor rooms shall be situated above the weather deck and located within the cargo area. The fire integrity of bulkheads and decks of these spaces shall comply with the requirements of 2.4.2, Part VI "Fire Protection" of the Rules for the Classification imposed on pump rooms.

9.2 Where pumps and compressors are driven by shafting passing through a bulkhead or deck, gastight seals with efficient lubrication or other means of ensuring the permanence of gas seal shall be fitted in way of the bulkhead or deck. Cargo pumps and compressors shall be fitted with temperature sensors of the seals of shafts passing through the bulkhead or deck, of the bearings and pump casings.

9.3 Arrangements of cargo pump rooms and cargo compressor rooms shall be such as to ensure safe unrestricted access for personnel wearing protective clothing and breathing apparatus, and in the event of injure, to allow unconscious personnel to be removed. All valves necessary for cargo handling shall be readily accessible to personnel wearing protective clothing.

10 CARGO CONTROL ROOMS

10.1 Any cargo control room shall be above the weather deck and may be located in the cargo area. The cargo control room may be located within the accommodation spaces, service spaces or control stations, provided the following conditions are complied with:

.1 the cargo control room is considered a gas-safe space;

.2 if the entrance complies with the requirements of 1.5.2, Part II "Ship Arrangement" and 8.3.1 of this Part, the control room may have access to the spaces described above; and

.3 if the entrance does not comply with 1.5.2, Part II "Ship Arrangement", the cargo control room shall have no access to the spaces described above, air inlets and openings shall comply with 1.5.7 and 1.12, Part II "Ship Arrangement" and 8.3.1 of this Part, the boundaries for such spaces shall be insulated to "A-60" class.

10.2 If the cargo control room is considered as gas-safe space, instrumentation shall be, as far as possible, by indirect reading system and shall be in any case designed to prevent any escape of gas into the atmosphere of that space.

Location of gas detectors within the cargo control room will not violate the gas-safe space if installed in accordance with Section 6, Part VIII "Instrumentation and Automation Systems".

10.3 If the cargo control room for ships carrying flammable cargoes is considered as gas-dangerous space, sources of ignition shall be excluded.

Consideration shall be given to the safety characteristics of any electrical installations in the cargo control rooms.

11 USE OF CARGO AS FUEL

11.1 Liquefied methane is the only cargo whose vapour or boil-off gas may be utilized as a fuel in boilers, inert gas generators, combustion engines and gas turbines.

Machinery spaces of category A in which gas fuel is utilized shall be fitted with gas detectors complying with the requirements of Section 6, Part VIII "Instrumentation and Automatic System".

11.2 Gas fuel piping shall not pass through accommodation spaces, service spaces and control stations. Gas fuel piping may pass through or extend into other spaces provided they fulfil the following:

.1 the gas fuel piping shall be a double-wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes shall be pressurized with inert gas at a pressure greater than the gas fuel pressure.

Suitable alarms and automatic shutdown of gas fuel shall be provided in the event of loss of inert gas pressure between the pipes;

.2 the gas fuel piping shall be installed within a ventilated pipe or duct.

The air space between the gas fuel piping and inner wall of this pipe or duct shall be equipped with mechanical exhaust ventilation having a capacity of at least 30 air changes per hour.

Suitable alarms and automatic shutdown of gas fuel shall be provided if the required air flow is not established by the ventilation system.

The ventilation system shall be arranged to maintain a pressure less than the atmospheric pressure.

The fan motors shall be placed outside the ventilated pipe or duct.

The ventilation outlet shall be placed in a position where no explosive gas-air mixture may be ignited.

The ventilation inlets shall be so arranged that no gas or gas-air mixture can be taken into the ventilation system.

The ventilation shall be always in operation when there is gas fuel in the piping.

Continuous gas detection shall be provided to indicate leaks and to shut down the gas fuel supply to the machinery space in accordance with 11.10.

The exhaust ventilation fan for such duct shall be so arranged as to shut down the gas fuel supply to the machinery space if the required air flow is not established and maintained.

The electrical equipment arranged inside double-wall piping shall be of intrinsically safe type.

11.3 If a gas leak occurs, the gas fuel supply shall not be restored until the leak has been found and repaired. Instructions to this effect shall be placed in a prominent position in the machinery spaces.

11.4 The double-wall piping systems or the ventilated pipe or duct provided for the gas fuel piping shall terminate at the ventilation hood or casing required by 11.5.

11.5 A ventilation hood or casing shall be provided for the areas occupied by flanges, valves, etc., and for the gas fuel piping, at the gas fuel utilization units.

If this ventilation hood or casing is not served by the exhaust ventilation fan as specified in 11.2.2, then it shall be equipped with an exhaust ventilation system and continuous gas detection shall be provided to indicate leaks and to shut down the gas fuel supply to the machinery space in accordance with 11.10.

The exhaust ventilation fan shall be so arranged as to shut down the gas fuel supply to the machinery space if the exhaust ventilation does not ensure the required air flow.

The ventilation hood or casing shall be installed or mounted to permit the ventilating air to sweep across the gas utilization unit and be exhausted at the top of the ventilation hood or casing.

11.6 Each gas utilization unit shall be provided with a set of three automatic valves. Two of these valves shall be in series in the gas fuel pipe to the consuming equipment. The third valve shall be in a pipe that vents, to a safe location in the open air, that portion of the gas fuel piping that is between the two valves in series. The shut-off valves shall be arranged for manual reset.

These valves shall be arranged so that failure of the necessary forced draught, loss of flame on boiler burners, abnormal pressure in the gas fuel supply line, or failure of the hydraulic valve control actuator will cause the two gas fuel valves which are in series to close automatically and the vent valve to open automatically.

One of the valves in series and the vent valve can be incorporated into one valve body so arranged that, when one of the above conditions occurs, flow to the gas utilization unit will be blocked and the vent opened.

11.7 A master gas fuel valve shall be installed outside the machinery space. The valve shall be arranged so as to close automatically if:

leakage of gas fuel is detected;

conditions stated in 11.2.1 are fringed;

engine crankcase oil mist concentration or engine bearing monitoring sensor is actuated;

It is recommended that the master gas fuel valve will be closed automatically when the gas valves referred to in 11.6 are actuated.

11.8 Provision shall be made for inerting and gas-freeing that portion of the gas fuel piping system located in the machinery space.

11.9 The ventilation inlet and discharge for the required ventilation systems shall be respectively from and to a safe location.

11.10 Gas detection systems referred to in 11.2 and 11.5 shall activate the alarm at 30 % of the lower flammable limit and shut down the gas fuel supply to the machinery space before the gas concentration reaches 60 % of the lower flammable limit.

11.11 All items of the gas fuel system shall be approved by the Register.

11.12 Gas fuel piping in machinery spaces shall comply with the requirements of 13.12, Part VIII "Systems and Piping" of the Rules for the Classification and Sections 2 and 12 of this Part as far as applicable. The piping shall have welded joints. Those parts of the gas fuel piping which are not enclosed in ventilated pipe or duct according to 11.2 and are on the open deck outside the cargo area shall have full penetration butt-welded joints and shall be fully radiographed.

11.13 If the cargo carried is utilized as fuel, a gas make-up plant and related storage tanks shall be provided on board the ship.

11.13.1 All equipment (heaters, compressors, filters, etc.) for making up the gas for its use as fuel and related storage tanks shall be located in the cargo area. If the equipment is in an enclosed space, the requirements of 3.1, Part V "Fire Protection", 8.1 of this Part and Section 6, Part VIII "Instrumentation and Automation Systems" shall be complied with.

11.13.2 The compressors shall be capable of being automatically stopped before the vacuum relief valves of the tanks are actuated.

The compressors shall be capable of being remotely stopped from a position which is readily accessible, and also from the engine room.

The compressors shall be provided with a device for automatic shut down when the automatic shut-off valves referred to in 11.6 and 11.7 are actuated. These valves shall be arranged for manual reset.

Volumetric compressors shall be fitted with pressure relief valves discharging into the suction line of the compressor. The size of the pressure relief valves shall be determined in such a way that under any circumstances the maximum pressure does not exceed by more than 10 % the maximum working pressure.

11.13.3 If the heating medium for the gas fuel evaporator or heater is returned to spaces outside the cargo area it is first to go through a degassing tank. The degassing tank shall be located in the cargo area. Provisions shall be made to detect and alarm the presence of gas in the tank. The vent outlet of the tank shall be in a safe position and fitted with a flame screen.

11.14 Boilers which use the cargo as fuel shall comply with the following requirements.

11.14.1 Each boiler shall have a separate uptake.

11.14.2 Combustion chambers of boilers shall be of suitable form such as not to present pockets where gas may accumulate.

11.14.3 The burning installations shall be suitable to burn either oil fuel or methane alone or oil and methane simultaneously.

Transfer from gas to oil burning shall not cause change of the boiler operating mode.

The gas burning installation shall be provided with a pilot burner operating on oil fuel.

The burning installations shall be interlocked and equipped with non-disconnectable protective devices as specified in 5.3.2 to 5.3.4, Part X "Boilers, Heat Exchangers and Pressure Vessels" of the Rules for the Classification.

11.14.4 On the pipe of each gas burner a manually operated shut-off valve shall be fitted.

An installation shall be provided for purging the gas supply piping to the burners by means of inert gas or steam, after the extinguishing of these burners.

11.14.5 The controls, regulators, interlocking, protective devices and alarms of the automated burning installations shall comply with the requirements of 4.3, Part XV "Automation" of the Rules for the Classification.

11.15 Special requirements for gas-fired internal combustion engines.

Dual fuel engines are those that employ gas fuel (with pilot oil) and oil fuel. Oil fuels may include distillate and residual fuels. Gas only engines are those that employ gas fuel only.

11.15.1 Arrangement.

11.15.1.1 When gas is supplied in a mixture with air through a common manifold, flame arrestors shall be installed before each cylinder head.

11.15.1.2 Each engine shall have its own separate exhaust.

11.15.1.3 The exhausts shall be configured to prevent any accumulation of unburnt gaseous fuel.

11.15.1.4 Unless designed with the strength to withstand the worst case overpressure due to ignited gas leaks, air inlet manifolds, scavenge spaces, exhaust system and crank cases shall be fitted with suitable pressure relief systems. Pressure relief systems shall lead to a safe location, away from personnel.

Suitable pressure relief system for air inlet manifolds, scavenge spaces and exhaust system shall be provided unless designed to accommodate the worst-case overpressure due to ignited gas leaks or justified by the safety concept of the engine. A detailed evaluation regarding the hazard potential of overpressure in air inlet manifolds, scavenge spaces and exhaust system shall be carried out and reflected in the safety concept of the engine. In the case of crankcases, the explosion relief valves, as required by regulation 27.4, SOLAS Chapter II-1 as amended by IMO resolutions up to MSC.436(99), shall be considered suitable for the gas operation of the engine. For engines not covered by said regulation, a detailed evaluation regarding the hazard potential of fuel gas accumulation in the crankcase shall be carried out.

11.15.1.5 Each engine shall be fitted with vent systems independent of other engines for crankcases, sumps and cooling systems.

11.15.2 Combustion equipment.

11.15.2.1 Prior to admission of gas fuel, correct operation of the pilot oil injection system on each unit shall be verified.

11.15.2.2 For a spark ignition engine, if ignition has not been detected by the engine monitoring system within an engine specific time after opening of the gas supply valve, this shall be automatically shut off and the starting sequence terminated. It shall be ensured that any unburnt gas mixture is purged from the exhaust system.

11.15.2.3 For dual-fuel engines fitted with a pilot oil injection system, an automatic system shall be fitted to change over from gas fuel operation to oil fuel operation with minimum fluctuation of the engine power.

11.15.2.4 In the case of unstable operation on engines with the arrangement in 11.15.2.3 when gas firing, the engine shall automatically change to oil fuel mode.

11.15.3 Safety.

11.15.3.1 During stopping of the engine, the gas fuel shall be automatically shut off before the ignition source.

11.15.3.2 Arrangements shall be provided to ensure that there is no unburnt gas fuel in the exhaust gas system prior to ignition.

11.15.3.3 Crankcases, sumps, scavenge spaces and cooling system vents shall be provided with gas detection (refer to Section 6, Part VIII "Instrumentation and Automation Systems").

11.15.3.4 Provision shall be made within the design of the engine to permit continuous monitoring of possible sources of ignition within the crank case. Instrumentation fitted inside the crankcase shall be in accordance with the requirements of Section 2, Part VII "Electrical Equipment".

11.15.3.5 A means shall be provided to monitor and detect poor combustion or misfiring that may lead to unburnt gas fuel in the exhaust system during operation. In the event that it is detected, the gas fuel supply shall be shut down. Instrumentation fitted inside the exhaust system shall be in accordance with the requirements of Section 2, Part VII "Electrical Equipment".

12 TESTING

12.1 Tests of piping components and pumps prior to installation on board.

12.1.1 Valves.

12.1.1.1 Tests of piping valves shall comply with the requirements of 21.1, Part VIII "Systems and Piping" of the Rules for the Classification. Moreover, valves of cargo system and piping containing cargo or its vapours shall be subjected to the prototype and unit production testing, as stipulated in 12.1.1.1.1 and 12.1.1.1.2.

12.1.1.1.1 Type testing of piping components.

12.1.1.1.1.1 Each size and type of valve intended to be used at a working temperature below –55 °C shall be approved through design assessment and prototype testing. Prototype testing for all valves to the minimum design temperature or lower and to a pressure not lower than the maximum design pressure foreseen for the valves shall be witnessed in the presence of the RS surveyor. Flow and capacity of pressure relief valves covered by 3.16 shall be certified by the Administration or the Register acting on its behalf. For other types of valves, the manufacturer shall certify the flow properties of the valves based on tests carried out according to recognized standards. Prototype testing shall include hydrostatic test of the valve body at a pressure equal to 1,5 times the design pressure, and cryogenic testing consisting of valve operation or safety valve set pressure. In addition, for all valves other than safety valves, a seat and stem leakage test at a pressure equal to 1,1 times the design pressure shall be conducted.

The following type tests shall be conducted:

.1 each size and type of valve shall be subjected to seat tightness testing over the full range of operating pressures for bi-directional flow and temperatures, at intervals, up to the rated design pressure of the valve. During the testing, satisfactory operation of the valve shall be verified;

.2 the flow or capacity shall be certified to a recognized standard for each size and type of valve;

.3 pressurized components shall be pressure tested to at least 1,5 times the rated pressure; and

.4 for emergency shutdown valves, with materials having melting temperatures lower than 925 °C, the type testing shall include a fire test. ESD valves, with materials having melting temperatures lower than 925 °C, do not include emergency shutdown valves which use such materials only in components such as rubber handle covers where failure would not cause deterioration of shell or seat tightness intrinsically.

12.1.1.1.2 Unit production testing.

12.1.1.1.2.1 All valves shall be tested at the plant of manufacturer in the presence of the surveyor to the Register. For valves used for isolation of instrumentation in piping not greater than 25 mm, unit production testing need not be witnessed by the surveyor. Records of testing shall be available for review. Testing shall include hydrostatic test of the valve body at a pressure equal to 1,5 times the design pressure for all valves, seat and stem leakage test at a pressure equal to 1,1 times the design pressure for all valves other than safety valves. In addition, cryogenic testing consisting of valve operation and leakage verification for a minimum of 10 % of each type and size of valve for all valves other than safety valves intended to be used at a working temperature below –55 °C. The set pressure of safety valves shall be tested at ambient temperature. Opening pressure of the pressure relief valve shall be tested at temperature + 25 °C ±10 ºC.

As an alternative to the above, if so requested by the relevant manufacturer, the certification of a valve may be issued subject to the following:

.1 the valve has been approved as required by 12.1.1.1.1 for valves intended to be used at a working temperature below –55 °C;

.2 the manufacturer has a recognized quality system that has been assessed and certified by the Register subject to periodic audits;

.3 the quality control plan contains a provision to subject each valve to a hydrostatic test of the valve body at a pressure equal to 1,5 times the design pressure and seat and stem leakage test at a pressure equal to 1,1 times the design pressure for valves other than safety valves at working temperature. Opening pressure of the pressure relief valve shall be tested at temperature + 25 °C ±10 °C. The manufacturer shall maintain records of such tests;

.4 cryogenic testing consisting of valve operation and leakage verification for a minimum of 10 % of each type and size of valve for valves other than safety valves intended to be used at a working temperature below –55 °C in the presence of the surveyor to the Register.

12.1.2 Expansion bellows.

12.1.2.1 The following type tests shall be performed on each type of expansion bellows intended for use on cargo piping outside the cargo tank and on those installed within the cargo tanks:

.1 elements of the bellows, not pre-compressed, shall be pressure tested at not less than five times the design pressure without bursting. The duration of the test shall not be less than 5 min;

.2 pressure test shall be performed on a type expansion joint, complete with all the accessories such as flanges, stays and articulations, at the minimum design temperature and twice the design pressure at the extreme displacement conditions recommended by the manufacturer, without permanent deformation.

Based on the materials used, the Register may require testing at the minimum design temperature;

.3 a cyclic test (thermal movements) shall be performed on a complete expansion joint, which shall 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 ambient temperature is permitted when this testing is at least as severe as testing at the service temperature;

.4 a cyclic fatigue test (ship deformation) shall be performed on a complete expansion joint, without internal pressure, by simulating the bellows movement corresponding to a compensated pipe length, for at least 2000000 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.

12.1.3 Pressure relief valves.

12.1.3.1 The pressure relief valves installed on cargo tanks according to 3.3.2 shall be tested to verify the relieving capacity required by 3.6. Additionally each pressure relief valve shall be tested to ensure that it opens at the prescribed pressure setting, with an allowance not exceeding:

±10 % for 0 to 0,15 MPa (0 to 1,5 kgf/cm^2);

±6 % for 0,15 to 0,3 MPa (1,5 to 3,0 kgf/cm^2);

±3 % for 0,3 MPa (3 kgf/cm^2) and above.

The pressure relief valves shall be set and sealed by the surveyor to the Register. An appropriate entry shall be made in the report issued to the ship, the report shall also indicate MARVS.

12.1.4 Cargo pumps.

12.1.4.1 Prototype testing.

12.1.4.1.1 Each size and type of pump shall be approved through design assessment and prototype testing. Prototype testing shall be witnessed in the presence of the surveyor to the Register. In lieu of prototype testing, satisfactory in-service experience of an existing pump design approved by the Register submitted by the manufacturer may be considered. Prototype testing shall include a hydrostatic test of the pump body equal to 1,5 times the design pressure and a capacity test. For submerged electric motor driven pumps, the capacity test shall be carried out with the design medium or with a medium below the minimum working temperature. For shaft driven deep well pumps, the capacity test may be carried out with water. In addition, for shaft driven deep well pumps, a spin test to demonstrate satisfactory operation of bearing clearances, wear rings and sealing arrangements shall be carried out at the minimum design temperature. The full length of shafting is not required for the spin test, but shall be of sufficient length to include at least one bearing and sealing arrangement. After completion of tests, the pump shall be opened out for examination.

12.1.4.2 Unit production testing.

12.1.4.2.1 All pumps shall be tested at the plant of manufacturer in the presence of the surveyor to the Register. Testing shall include hydrostatic test of the pump body equal to 1,5 times the design pressure and a capacity test. For submerged electric motor driven pumps, the capacity test shall be carried out with the design medium or with a medium below the minimum working temperature. For shaft driven deep well pumps, the capacity test may be carried out with water.

As an alternative to the above, if so requested by the relevant manufacturer, the certification of a pump may be issued subject to the following:

.1 the pump has been approved as required by 12.1.4.1;

.2 the manufacturer has a recognized quality system that has been assessed and certified by the Register subject to periodic audits;

.3 the quality control plan contains a provision to subject each pump to a hydrostatic test of the pump body equal to 1,5 times the design pressure and a capacity test. The manufacture shall maintain records of such tests.

12.2 Testing of cargo systems and piping on board.

12.2.1 After assembly, all cargo and process piping shall 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 on board shall be hydrostatically tested to at least 1,5 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 means shall be submitted to the Register for approval. After assembly on board, each cargo and process piping system shall be subjected to a leak test (by air, halides, etc.) to a pressure depending on the leak detection method applied.

12.2.2 All piping systems including valves, fittings and associated equipment for handling cargo or vapours shall be tested under normal operating conditions not later than at the first loading operation.

12.2.3 Piping, which does not contain liquid cargo or its vapours, shall be tested in compliance with 21.2, Part VIII "Systems and Piping" of the Rules for the Classification.

Russian Maritime Register of Shipping

Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk
Part VI
Systems and Piping

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