



RULES FOR
CLASSIFICATION OF
SHIPS

NEWBUILDINGS

SPECIAL EQUIPMENT AND SYSTEMS
ADDITIONAL CLASS

PART 6 CHAPTER 13

GAS FUELLED ENGINE INSTALLATIONS

JANUARY 2003

*This booklet includes the relevant amendments and corrections
shown in the January 2004 version of Pt.0 Ch.1 Sec.3.*

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CHANGES IN THE RULES

General

This booklet is a reprint of the previous edition and apart from clarifications of text and the inclusion of amendments and corrections, published in the July 2002 edition of Pt.0 Ch.1 Sec.3, no other changes have been made.

This chapter is valid until superseded by a revised chapter. Supplements will not be issued except for an updated list of minor amendments and corrections presented in Pt.0 Ch.1 Sec.3. Pt.0 Ch.1 is normally revised in January and July each year.

Revised chapters will be forwarded to all subscribers to the rules. Buyers of reprints are advised to check the updated list of rule chapters printed in Pt.0 Ch.1 Sec.1 to ensure that the chapter is current.

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SECTION 1 GENERAL REQUIREMENTS

A. Classification

A 100 Application

101 The rules in this chapter apply to internal combustion engine installations in ships other than LNG carriers using gas as fuel. However, the requirements for machinery arrangements under the "inherently safe" concept can also be applied to LNG carriers, while application of the ESD concept requires acceptance by the Flag Administration under the equivalency clause in the IGC Code. The engines may be either single fuel engines or dual fuel engines, and the gas may be in gaseous or liquid state.

Guidance note:

The use of gas as fuel in ships other than LNG carriers is not covered by international conventions and such installations will need additional acceptance by flag authorities.

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A 200 Class notation

201 Ships built with machinery satisfying the requirements in this chapter will be given class notation:

GAS FUELLED.

A 300 Survey extent

301 Survey requirements for ships with the class notation **GAS FUELLED** are given in Pt.7 Ch.2 Sec.4 O.

B. Definitions

B 100 Terms

101 *Accommodation spaces:* See Pt.3 Ch.3 Sec.10 C.

102 *Control stations:* See Pt.3 Ch.3 Sec.10 C.

Guidance note:

This does not include special fire control equipment that can be most practically located in the cargo area (if the vessel is a cargo ship).

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

103 *Double block and bleed valve* is a set of three automatic valves located at the fuel supply to each of the gas engines. Two of these valves are to be in series in the gas fuel pipe to the consuming equipment. The third valve is to 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.

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

104 *Dual fuel engines* are in this context engines that can burn gaseous and liquid fuel simultaneously and in a wide variety of proportions.

105 *ESD* means emergency shutdown.

106 *Enclosed spaces* are spaces bounded by bulkheads and decks that may have doors, windows or other similar openings.

107 *Engine room* is in this chapter used for machinery spaces containing gas fuelled engines.

108 *Gas* is defined as a fluid having a vapour pressure exceeding 2.8 bar absolute at a temperature of 37.8°C.

109 *Gas dangerous spaces* are:

- enclosed or semi-enclosed spaces containing gas sources
- enclosed or semi-enclosed spaces having accesses or openings into any other gas dangerous space.

Enclosed spaces having direct access or openings to gas dangerous zones are also normally regarded as gas dangerous spaces if they are not equipped with approved arrangements to ensure that their atmosphere is at all times maintained in a safe condition.

110 *Gas dangerous zones* are zones on open deck or semi-enclosed spaces on open decks within:

- 3 m of the gas tank pressure relief valve exhaust outlets
- 3 m of gas tank openings, gas pipe flanges, openings to gas dangerous spaces containing gas sources
- 3 m of ventilation exhaust openings from rooms where gas compressors, pumps or similar equipment are present and of ventilation exhaust openings from pipe ducting and engine rooms
- 2.4 m of the outer surface of a gas containment system where such surface is exposed to the weather.

111 *Gas safe areas* are spaces or zones not being gas dangerous.

112 *Gas sources* are any valves or detachable pipe joints in the fuel gas system. Also compressors and seals of pumps in the fuel gas system are regarded as gas sources.

113 *High-pressure piping* is in this context piping with maximum working pressure above 10 bar.

114 *LEL* is lower explosion limit.

115 *Main tank valve* is a remote operated valve on the gas outlet from a gas storage tank, located as close to the tank outlet point as possible.

116 *Master gas fuel valve* is an automatic valve in the gas supply line to each engine located outside the engine room and as close to the gas heater (if fitted) as possible.

117 *Passenger areas* are those spaces that are provided for the accommodation and use of passengers, excluding baggage, store, provision and mail rooms.

118 *Semi-enclosed spaces* are locations where natural conditions of ventilation are notably different from those on open decks due to the presence of structures such as roofs, wind breakers and bulkheads and which are so arranged that dispersion of gas may not occur.

119 *Service spaces* are spaces outside the cargo area used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store rooms, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces.

120 *Single gas fuel system* is a power generating system consisting of gas-only engines, not able to switch over to fuel oil running.

C. Documentation

C 100 Plans and particulars

101 Arrangement plans are to be submitted for approval giving location of:

- machinery and boiler spaces, accommodation, service and control station spaces

- gas tanks and gas containment systems
- gas pump and compressor rooms
- gas piping with shore connections
- tank hatches, ventilation pipes and any other openings to the gas tanks
- ventilating pipes, doors and openings to gas pump rooms, compressor rooms and other gas-dangerous spaces
- entrances, air inlets and openings to accommodation, service and control station spaces
- gas dangerous spaces and zones.

102 Plans of the gas containment system with the following particulars are to be submitted for approval:

- drawing of gas tanks including information on non-destructive testing of welds and strength and tightness testing of tanks
- drawings of support and staying of independent tanks
- specification of materials in gas tanks and gas piping systems
- specifications of welding procedures for gas tanks
- specification of stress relieving procedures for independent tanks type C (thermal or mechanical)
- specification of design loads and structural analysis of gas tanks
- a complete stress analysis is to be submitted for independent tanks type C
- specification of cooling-down procedure for gas tanks
- arrangement and specifications of secondary barriers
- drawings and specifications of tank insulation
- drawing of marking plate for independent tanks.

103 Plans of the following piping systems are to be submitted for approval:

- drawings and specifications of gas piping including ventilation lines of safety relief valves or similar piping
- drawings and specifications of offsets, loops, bends and mechanical expansion joints, such as bellows, slip joints (only inside tank) or similar means in the gas piping
- drawings and specifications of flanges, valves and other fittings in the gas piping system. For valves intended for piping systems with a design temperature below minus 55°C, documentation for leak test and functional test at design temperature (type test) is required
- complete stress analysis of piping system when design temperature is below minus 110°C
- documentation of type tests for expansion components in the gas piping system
- specification of materials, welding, post-weld heat treatment and non-destructive testing of gas piping
- specification of pressure tests (structural and tightness tests) of gas piping
- program for functional tests of all piping systems including valves, fittings and associated equipment for handling gas (liquid or vapour)
- drawings and specifications of insulation for low temperature piping where such insulation is installed
- specification of electrical bonding of piping
- specification of means for removal of liquid contents from bunkering pipes prior to disconnecting the shore connection, see E100
- cooling or heating water system in connection with gas fuel system, if fitted.

104 The following plans and particulars for the safety relief valves are to be submitted for approval:

- drawings and specifications for safety relief valves and pressure/vacuum relief valves and associated ventilation piping

- calculation of required gas tank relief valve capacity, including back pressure
- specification of procedures for changing of set pressures of cargo tank safety relief valves if such arrangements are contemplated
- calculations for safety valves ventilation mast: location, height, details.

105 Plans of the following equipment and systems with particulars are to be submitted:

- drawings showing location and construction of air locks with alarm equipment, if fitted
- drawings of gastight bulkhead penetrations, if fitted
- arrangements and specifications of mechanical ventilation systems in spaces covering gas fuel system, giving capacity and location of fans and their motors. Drawings and material specifications of rotating parts and casings for fans and portable ventilators
- drawings and specifications of protection of hull steel beneath liquid piping where liquid leakage may be anticipated, such as at shore connections and at pump seals
- arrangement and specifications of piping systems for gas freeing and purging of gas tanks
- for fixed gas detection and alarm systems: specification and location of detectors, alarm devices and call points, and cable routing layout drawing
- bilge and drainage arrangements in gas pump rooms, compressor rooms, tank rooms
- exhaust gas system.

106 Plans of the following equipment and systems regarding fire protection are to be submitted for approval:

- arrangement and specification of water spray system, including pipes, valves, nozzles and fittings
- arrangement of ventilation duct required for gas pipes lead through enclosed spaces
- arrangement of ventilation duct for storage tank fitted below deck, if applicable
- arrangement of fire detection system for storage tank and ventilation trunk
- arrangement of fire insulation for storage tank and pipes, ventilation trunks for storage tank room
- arrangement and specification of dry chemical powder installation.

Plans of electrical installations giving the following particulars are to be submitted for approval:

- drawing(s) showing location of all electrical equipment in gas dangerous area
- single line diagram for intrinsically safe circuits
- list of explosion protected equipment with reference to drawings together with certificates.

107 The following control and monitoring systems shall be approved by the Society:

- gas detection system
- gas tank monitoring system
- gas compressors control and monitoring system
- gas engines control and monitoring system.

For requirements to documentation, see Pt.4 Ch.9.

108 A failure mode and effect analysis (FMEA) examining all possible faults affecting the combustion process in the gas engines is to be submitted for approval.

109 An operation manual is to be submitted for approval, to include information as outlined in E100.

D. Certification

D 100 Gas engines

101 Gas engines are in addition to the requirements in this chapter are to be certified in accordance with Pt.4 Ch.3.

D 200 Pressure vessels

201 Pressure vessels, which under normal operations will contain gas in the liquid and/or gaseous state, are to be certified as class I pressure vessels in accordance with Pt.4 Ch.7.

D 300 Valves

301 For valves a DNV product certificate is required, as given in Pt.4 Ch.7.

D 400 Pumps and compressors

401 Pumps and compressors in gas systems are to be delivered with a DNV product certificate.

402 For general requirements and in regard to testing of pumps: See Pt.4 Ch.6.

403 For general requirements and with regard to testing of compressors: See Pt.4 Ch.5.

- bunkering procedure
- gas freeing and inerting procedures
- normal operation procedures of the gas system
- emergency operation procedures of the gas system.

102 A plan for systematic maintenance and function testing is to be kept onboard showing in detail how components and systems are to be tested and what is to be observed during the tests. Columns showing test dates and verification of tests carried out are to be included. The plan is to include:

- all instrumentation, automation and control systems affecting the gas supply system
- test intervals to reflect the consequences of failure involving a particular system. Functional testing of critical alarms should not exceed 3 months intervals. Normally the longest intervals are not to surpass 12 months.

The plan should be included in the plan required for the class notation **E0**.

Guidance note:

Critical alarms are defined as low lubricating oil pressure alarms for rotating machinery.

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E. Operation and Maintenance Manuals

E 100 Contents

101 An operation manual is to include:

SECTION 2 MATERIALS

A. General

A 100 Material requirements

101 Materials are in general to be in accordance with the requirements in Pt.2.

102 Materials used in gas tanks, gas piping, process pressure vessels and other components in contact with gas are to be in

accordance with Pt.5 Ch.5 Sec.2 D. For piping see Pt.5 Ch.5 Sec.6 C200.

103 The materials used in gas piping systems are to be furnished with documentation in accordance with Pt.5 Ch.5 Sec.2 Table E1. For the definition of material documentation see Pt.1 Ch.1 Sec.3.

SECTION 3 ARRANGEMENT AND SYSTEM DESIGN

A. Location and Separation of Spaces

A 100 Gas compressor room

101 Compressor rooms, if arranged, are to be located above weather deck level, unless especially approved by DNV.

102 Electric drive motors are to be located in an adjacent gas safe space. The bulkhead penetration is to be of gas tight type.

A 200 Engine rooms

201 When more than one engine room is required and these rooms are separated by a single bulkhead, the bulkhead is to have sufficient strength to withstand a local gas explosion. A strength standard of the bulkhead corresponding to that of a watertight bulkhead is considered adequate.

202 Engine rooms are to have as simple geometrical shape as possible.

A 300 Tank rooms

301 Tank rooms boundaries are to be gas tight.

302 The tank room is not to be located adjacent to machinery spaces of category A. If the separation is by means of a cofferdam then additional insulation to class A-60 standard is to be fitted.

B. Arrangement of Entrances and Other Openings

B 100 General

101 If the compressor room is approved located below deck the room is to have a separate access from deck, not shared with any other spaces.

102 The tank room entrance is to be arranged with a sill height of at least 300 mm.

103 Access to the tank room is to be through a separate access from the deck, not shared with any other spaces. The access trunk is to be fitted with separate ventilation.

104 An engine room containing gas engines is to have at least two completely independent exits. However, if the engine room is very small, this requirement can be waived after special consideration by DNV.

105 If the access to the engine room is from another enclosed space in the ship, the entrances are to be arranged with self-closing doors. An alarm is to sound if the door is open continuously for more than 1 minute. As an alternative an arrangement with two self-closing doors in series can be approved.

C. General Gas Pipe Design

C 100 General

101 Gas pipes are in general to comply with the applicable parts of Pt.5 Ch.5 Sec.6.

102 Gas pipes are not to be located less than 760 mm from the ship's side.

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

104 The gas piping system is to be installed with sufficient flexibility. Bellows will not be accepted in enclosed spaces.

105 A system for colour marking of all gas pipes should be used, e.g. yellow painted pipes.

106 If the fuel gas contains heavier components that may condense in the system, knock out drums or equivalent means for collecting the liquid are to be fitted.

D. System Configuration

D 100 General

101 Two alternative system configurations may be accepted:

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

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

D 200 Inherently gas safe machinery spaces

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

202 In case of leakage in a gas supply pipe making shutdown of the gas supply necessary, a secondary independent fuel supply must be available. Alternatively, in the case of multi-engine installations, independent and separate gas supply systems for each engine or group of engines may be accepted.

203 For single fuel installations (gas only) the fuel storage is to be divided between two or more tanks of approximately equal size. The tanks shall be located in separate compartments.

D 300 ESD protected machinery spaces

301 Gas supply piping within machinery spaces may be accepted without a gas tight external enclosure on the following conditions:

- Engines for generating propulsion power and electric power are to be located in two or more engine rooms not having any common boundaries unless it can be documented that the common boundary can withstand an explosion in one of the rooms. Distribution of engines between the different engine rooms is to be such that in the case of shutdown of fuel supply to any one engine room it must be possible to maintain at least 40% of the propulsion power plus normal electrical power supply for sea going services. Incinerators, inert gas generators or other oil fired boilers are not to be located within an ESD protected machinery space.
- Pressure in gas supply lines within machinery spaces to be less than 10 bar.
- A gas detection system arranged to automatically shut-down the gas supply (also oil fuel supply if dual fuel) and

disconnect all non-explosion protected equipment or installations is to be fitted.

302 For single fuel installations (gas only) the fuel storage is to be divided between two or more tanks of approximately equal size. The tanks shall be located in separate compartments.

E. Gas Supply System in Machinery Spaces

E 100 Gas supply system for inherently gas safe machinery spaces

101 Gas supply lines passing through enclosed spaces are to be completely enclosed by a double pipe or duct. This double pipe or duct is to fulfil one of the following:

- The gas piping is to be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes is to be pressurised with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms are to be provided to indicate a loss of inert gas pressure between the pipes.
- The gas fuel piping is to be installed within a ventilated pipe or duct. The air space between the gas fuel piping and the wall of the outer pipe or duct is to be equipped with mechanical underpressure ventilation having a capacity of at least 30 air changes per hour. This ventilation capacity can be reduced to 10 air changes per hour provided automatic filling of the duct with nitrogen upon detection of gas is arranged for. The fan motors are to be placed outside the ventilated pipe or duct. The ventilation outlet is to be covered by a protection screen and placed in a position where no flammable gas-air mixture may be ignited.

102 The connecting of gas piping and ducting to the gas injection valves must be so as to provide complete coverage by the ducting. The arrangement must facilitate replacement and or overhaul of injection valves and cylinder covers.

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

- the maximum built up pressure: static pressure in way of the rupture resulting from the gas flowing in the annular space
- local instantaneous peak pressure in way of the rupture*: this pressure is to be taken as the critical pressure and is given by the following expression:

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

- p_0 = maximum working pressure of the inner pipe
- $k = C_p/C_v$ constant pressure specific heat divided by the specific volume specific heat
- $k = 1.31$ for CH_4

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

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

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

105 The arrangement and installation of the high-pressure

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

E 200 Gas supply system for ESD protected machinery spaces

201 The pressure in the gas supply system shall not exceed 10 bar.

202 The gas supply lines are to have a design pressure not less than 10 bar.

F. Gas Fuel Storage

F 100 Liquefied gas storage tanks

101 The storage tank used for liquefied gas is to be an independent tank type C designed in accordance with Pt.5 Ch.5 Sec.5, in particular Sec.5 I.

102 Pipe connections to the tank are to be in accordance with Pt.5 Ch.5 Sec.6 C303 to C307. However, connections below the lowest liquid level may be accepted after special consideration by DNV.

103 Pressure relief valves as required in Pt.5 Ch.5 Sec.9 B200 are to be fitted.

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

- air intake, air outlet or opening to accommodation, service and control spaces, or other gas safe spaces
- exhaust outlet from machinery or from furnace installation.

105 Storage tanks for liquid gas with vapour pressure above the design pressure at 45°C are to be fitted with efficient insulation.

106 Storage tanks for liquid gas shall not be filled to more than 98% full at the reference temperature, where the reference temperature is as defined in Pt.5 Ch.5 Sec.17 A105. A filling limit curve for actual filling temperatures is to be prepared from the formula given in Pt.5 Ch.5 Sec.17 A102. However, when the tank insulation and tank location makes the probability very small for the tank contents to be heated up due to external fire, special considerations can be made to allow a higher filling limit than calculated using the reference temperature, but never above 95%.

F 200 Compressed gas storage tanks

201 The storage tanks to be used for compressed gas are to be in accordance with Pt.4 Ch.7 and are to be certified by DNV.

202 Tanks for compressed gas are to be fitted with pressure relief valves with a set point below the design pressure of the tank and with outlet located as required in C104.

F 300 Storage above deck

301 Both gases of the compressed and the liquefied type will be accepted stored above deck level.

302 The storage tanks or tank batteries are to be located at least B/5 from the ship's side.

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

304 Tanks for liquid gas with a connection below the highest liquid level, see 102, are to be fitted with drip trays below the tank and be of sufficient size to hold the full content of the tank. The material of the drip tray should be stainless steel, and there should be efficient separation or isolation so that the hull or deck structures are not exposed to unacceptable cooling, in case of leakage of liquid gas.

F 400 Storage below deck

401 Only gas in a liquid state can be stored below deck level.

402 The maximum acceptable working pressure of a storage tank located below deck level is 10 bar.

403 The storage tank is to be located:

- minimum, the lesser of B/5 and 11.5 m from the ship side
- minimum, the lesser of B/15 and 2 m from the bottom plating
- not less than 760 mm from the shell plating.

404 The storage tank and associated valves and piping are to be located in a space designed to act as a secondary barrier, in case of liquid gas leakage. This implies that the material is to be in accordance with Pt.5 Ch.5 Sec.2 D, for secondary barriers, and that the space is to be designed to withstand the maximum pressure build up. Alternatively, pressure relief venting to a safe location (mast) can be provided. The space is to be capable of containing leakage, and is to be isolated thermally so that the surrounding hull is not exposed to unacceptable cooling, in case of leakage of the liquid gas. This secondary barrier space is in other parts of this chapter called "tank room".

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

G. Fuel Bunkering System and Distribution System outside Machinery Spaces

G 100 Fuel bunkering station

101 The bunkering station is to be so located that sufficient natural ventilation is provided. Closed or semi-enclosed bunkering stations will be subject to special consideration.

102 Drip trays are to be fitted below the bunkering connections and where leakage may occur. The drip trays are to be made of stainless steel, and should be drained over the ship's side by a pipe that preferably leads down into the sea. This pipe could be temporarily fitted for bunkering operations. The surrounding hull or deck structures are not to be exposed to unacceptable cooling, in case of leakage of liquid gas.

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

G 200 Bunkering system

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

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

203 If the ventilation in the ducting around the gas bunkering lines stop, an alarm is to sound at the bunkering control location.

204 If gas is detected in the ducting around the bunkering lines an alarm is to sound at the bunkering control location.

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

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

G 300 Distribution outside of machinery spaces

301 Gas fuel piping is not to be lead through accommodation spaces, service spaces or control stations.

302 Where gas pipes pass through enclosed spaces in the ship, they are to be enclosed in a duct. This duct is to be mechanically underpressure ventilated with 30 air changes per hour, and gas detection as required in Sec.6 is to be provided.

303 The duct is to be dimensioned according to E103 to E105.

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

305 High-pressure gas lines outside the engine room spaces should be installed and protected so as to minimise the risk of injury to personnel in case of rupture.

H. Ventilation Systems

H 100 General

101 The ventilation systems serving spaces containing gas sources shall be independent from other ventilation systems in the ship. Electric fan motors are not to be located within the ventilation ducts.

102 For design of ventilation fans serving spaces containing gas sources see requirements in Pt.5 Ch.5 Sec.10 A100.

103 Means should be provided to indicate in the engine control station any loss of the required ventilating capacity.

104 Ventilation inlets for spaces containing gas sources are to be located outside gas dangerous zones at places where there is the least possible risk of gas, gas-air mixtures or sparks being drawn into the system.

H 200 Gas tank room

201 The tank room for gas storage tank located below deck is to be provided with an effective mechanical ventilation system of the underpressure type, providing a ventilation capacity of at least 30 air changes per hour.

202 Approved automatic fail-safe fire dampers are to be fitted in the ventilation trunk for tank room.

H 300 Engine room

301 The ventilation system for the engine room is to be independent of all other ventilation.

302 ESD protected engine rooms are to have ventilation with a capacity of at least 30 air changes per hour. The ventilation system is to ensure a good air circulation in all spaces, and in particular ensure that there is no possibility of formation of gas pockets in the room.

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

H 400 Pump and compressor rooms

401 Pump and compressor rooms are to be fitted with effective mechanical ventilation system of the underpressure type,

providing a ventilation capacity of at least 30 air changes per hour.

402 Ventilation systems for pump and compressor rooms are to be in operation when pumps or compressors are working. Pumps and compressors are not to be started before the ventilation system in the electric motor room has been in operation for 15 minutes. Warning notices to this effect are to be placed in an easily visible position near the control stand.

SECTION 4 FIRE SAFETY

A. General

A 100 General

101 The requirements in this chapter are additional to those given in SOLAS Ch.II-2.

102 For the purpose of fire protection gas compressor rooms are to be treated as cargo compressor rooms in accordance with Pt.5 Ch.5 Sec.11.

B. Fire Protection

B 100 Construction

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

102 The tank room and ventilation trunks to such spaces below the bulkhead deck are to be fire insulated to class A-60 standard. However, where the room is adjacent to tanks, voids, auxiliary machinery spaces of no fire risk, sanitary and similar spaces, the insulation may be reduced to class A-0.

103 Gas pipes lead through ro-ro spaces on open deck will be subject to special considerations by DNV and might need class A-60 fire insulation.

104 The bunkering station is to be shielded with class A-60 insulation towards other spaces, except for spaces such as tanks, voids, auxiliary machinery spaces of no fire risk, sanitary and similar spaces where the insulation may be reduced to A-0 class.

105 When more than one engine room is required and these rooms are separated by a single bulkhead, the bulkhead is to be fire insulated to class A-60 standard.

C. Fire Extinction

C 100 Fire main

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

102 When the storage tank is located above the bulkhead deck, isolating valves are to be fitted in the fire main in order to isolate damage sections of the main.

C 200 Water spray systems

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

202 The system is to be designed to cover all areas as specified above with an application rate of 10 l/min/m² for horizontal projected surfaces and 4 l/min/m² for vertical surfaces.

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

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

205 A connection to the ships fire main through a stop valve is to be provided.

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

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

C 300 Dry chemical powder fire extinguishing system

301 In the bunkering station area a permanently installed dry chemical powder extinguishing system is to cover all possible leak points. The capacity is to be at least 50 kg with a rate of discharge of not less than 1 kg/s. The system is to be arranged for easy manual release from a safe location.

302 One portable dry powder extinguisher is to be located near the bunkering station.

303 Main engine rooms where the gas fuel is heavier than air are to be provided with at least one dry powder extinguisher located at the entrance to the room.

D. Fire Detection and Alarm Systems

D 100 Detection

101 An approved fixed fire detection system is to be provided for the tank room and the ventilation trunk for tank room below deck.

102 Smoke detectors alone are not considered sufficient for rapid fire detection.

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

D 200 Alarms and safety actions

201 Required safety actions at fire detection in the engine room and tank room are given in Sec.6 Table D1. In addition the ventilation is to stop automatically and fire dampers are to close.

SECTION 5 ELECTRICAL SYSTEMS

A. General

A 100 General

101 The requirements in this chapter are additional to those given in Pt.4 Ch.8.

102 Electrical equipment fitted within gas dangerous zones on the open deck is to be in accordance with Pt.5 Ch.5 Sec.12 B700.

103 The bunkering station is to be regarded as a gas dangerous area, and any electrical equipment is to be in accordance with Pt.5 Ch.5 Sec.12 B700. If the bunkering station is deficient of natural boundaries in all directions, then the zone is defined as 3 m from any gas pipe flange connections.

104 Tank rooms and compressor rooms are to be free from ignition sources of any type. Electrical equipment is to be of intrinsically safe type. Lighting is to be certified safe-type of

pressurised and flameproof type, arranged in accordance with Pt.4 Ch.8 Sec.9 D100. Gas detectors of the certified safe type are accepted.

105 Any electrical equipment inside the gas piping duct is to be of intrinsically safe type, except gas detectors, where certified safe type are accepted.

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

- In addition to fire and hydrocarbon detectors and fire and gas alarms, lighting and ventilation fans are to be certified safe for a hydrocarbon gas atmosphere (ex(e) lighting and ex(d) or ex(e) ventilation fans).
- all electrical equipment in the engine room of not certified safe type for a hydrocarbon gas atmosphere are to be automatically disconnected if gas concentrations above 20% LEL is detected on two detectors in the engine room.

SECTION 6 CONTROL, MONITORING AND SAFETY SYSTEMS

A. General

A 100 Introduction

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

102 Pressure gauges are to be fitted to gas pump discharge lines and to the bunkering lines.

103 A bilge well in each tank room surrounding an independent cargo tank is to be provided with both a level indicator and a temperature sensor. Alarm is to be given at high level in bilge well. Temperature sensor low temperature indication is to lead to automatic closing of main tank valve.

B. Monitoring

B 100 Gas tank monitoring

101 Gas tanks are to be monitored and protected against overfilling as required in Pt.5 Ch.5 Sec.13 B100 and B200.

102 The temperature of the gas tank is to be monitored by a remote reading instrument.

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

B 200 Gas compressor monitoring

201 The monitoring system shall include items given in Table B1.

Table B1 Monitoring system requirements		
	Alarm	Automatic stop
Gas heater outlet, temperature, high	X	
Gas compressor outlet, temperature, high	X	X
Gas compressor inlet, pressure, low	X	
Gas compressor outlet, pressure, high	X	
Gas compressor outlet, pressure, low	X	
Control system failure	X	
Sealing gas pressure, low	X	
Lubrication oil pressure, low	X	X
Lubrication oil temperature, high	X	
Master gas valve close	X	
In addition high-pressure gas compressors are to stop automatically in the event of:		
— control air pressure loss		
— high gas concentration in the compressor room (Table D1)		
— automatic stop or emergency stop of gas supply to diesel engine.		

B 300 Gas engine monitoring

301 In addition to the requirements given in Pt.4 Ch.3 Sec.1 E, monitoring as given in Table B2 is required for gas turbines. Additionally a failure mode and effect analysis (FMEA) examining all possible faults affecting the combustion process shall be submitted. Based on the outcome of the analysis deviations in monitoring details compared to Table B2 may be accepted or required.

Table B2 Monitoring of dual fuel diesel or gas-only engines				
Item		Alarm and safety action (stated by an x)		Comments
		Alarm	Automatic start of standby pump with alarm ¹⁾	
Exhaust gas, outlet each cylinder	Temperature, high	x		Automatic stop of gas supply
	Temperature deviation from average, large	x		Automatic stop of gas supply
Ignition failure each cylinder ²⁾		x		Automatic stop of gas supply
Gas injection valve sealing oil pressure, low		x		High-pressure injection only
Lubricating oil inlet to engine ³⁾	Temperature, high	x		
	Pressure, low	x		Independent of safety system
	Pressure, low		x	
	Pressure, low	x		Engine shutdown
	Filter differential pressure, high	x		
Cylinder lubrication ⁴⁾		Flow, low	x	
Cylinder cooling medium	Pressure, low	x		
	Pressure, low, temperature, high	x	x	Not required if main pump is engine driven Outlet each cylinder if individual stop valves are fitted for the cylinder jackets
Piston cooling medium ⁵⁾	Flow from each piston, low	x		
	Pressure, low	x		
	Pressure, low		x	Not required if main pump is engine driven
	Temperature, high	x		

Table B2 Monitoring of dual fuel diesel or gas-only engines (Continued)

Item		Alarm and safety action (stated by an x)		
Fuel injection valve cooling medium ⁶⁾	Pressure, low	x		
	Pressure, low		x	Not required if main pump is engine driven
	Temperature, high	x		
Fuel oil inlet to engine ⁶⁾	Temperature or viscosity of heavy oil, high	x		
	Temperature or viscosity of heavy oil, low	x		
	Pressure, low	x		Inlet high-pressure pump
	Pressure, low		x	Not required if main pump is engine driven
Scavenge air belt, each cylinder ⁷⁾	Temperature, high	x		
Crankcase protection ⁸⁾	Bearing temperature or oil mist concentration	x		Engine shutdown
Gas fuel knock-out drums, if fitted	Liquid level, high	x		
1) Only for propulsion engines 2) Exhaust temperature deviation may be accepted as means of detecting ignition failure 3) All separate systems 4) At least one measuring point for each lubricator unit 5) If separate system 6) Dual fuel engines only 7) For detection of fire (2-stroke engines) 8) For cross head engines slow down can be accepted				

C. Gas Detection

C 100 Locations

101 Permanently installed gas detectors are to be fitted in the locations given in 102 to 105. The number of detectors in each space must be considered taking size, layout and ventilation of the space into account, but shall not be less than the minimum requirement given in Table C1.

Table C1 Location of permanently installed gas detectors	
Location	Minimum number of independent detectors to be installed in each separate space
Tank room	2
Ventilated ducts around gas pipes	2
Engine room, ESD protected type	3
Compressor room	2
Other enclosed spaces containing gas piping or equipment	2

102 The detection equipment is to be located where gas may accumulate and or in the ventilation outlets.

103 An audible and visible alarm is to be activated before the vapour concentration reaches 20% of the lower flammable limit (LEL). For ventilated ducts around gas pipes in the engine room the alarm limit can be set to 30% LEL.

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

105 Continuous detection is required for gas pipe ducts and engine rooms.

D. Safety Functions of Gas Supply Systems

D 100 General

101 The main supply lines for gas to each engine are to be equipped with a manually operated stop valve and an automatically operated "master gas fuel valve" coupled in series or a combined manually and automatically operated stop valve. The valves are to be situated in the part of the piping that is outside engine room, and placed as near as possible to the installation for heating the gas. The master gas fuel valve is automatically to cut off the gas supply as given in Table D1.

The automatic master gas fuel valve is to be operable from a reasonable number of places in the engine room, from a room outside the engine room and from the bridge.

102 Each gas utilisation unit is to be provided with a set of "double block and bleed" valves. These valves are to be arranged so that when automatic shutdown is initiated as given in Table D1, this will cause the two gas fuel valves that are in series to close automatically and the ventilation valve to open automatically.

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

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

103 In cases where the master gas fuel valve is automatically shutdown, a ventilation valve, that will ventilate the pipe piece between the master gas valve and the double block and bleed valve, is to open. For high-pressure systems the pipe pieces between the double block and bleed valve and the gas injection valves, are to be automatically vented. See Fig.1 and Fig.2. For high-pressure systems the ventilation valves are to open at normal stop of engine.

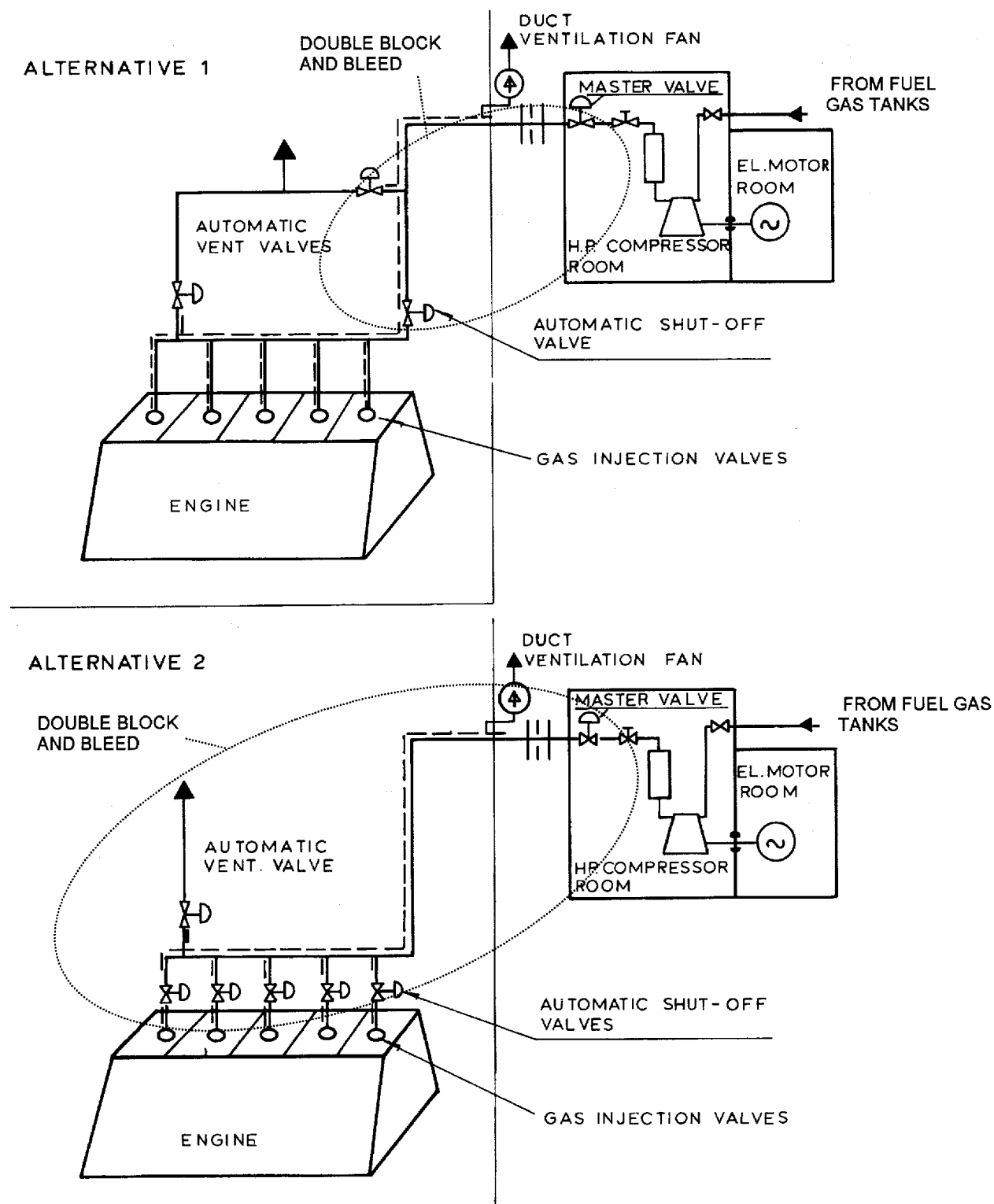


Fig. 1
Alternative supply valve arrangements for high-pressure installations (single engine or separate master valve arrangement)

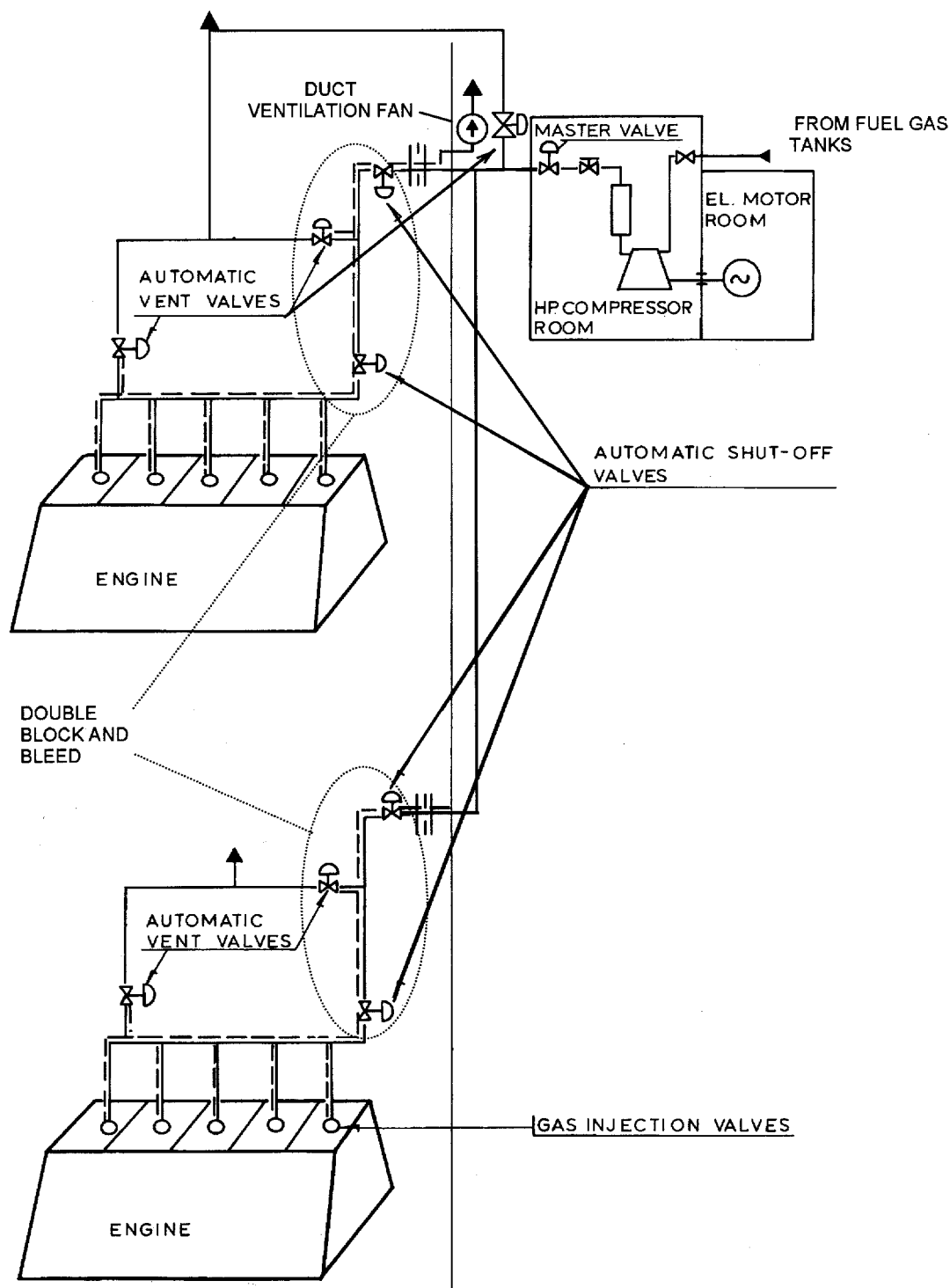


Fig. 2
Alternative supply valve arrangements for high-pressure installations (multi engine installation)

104 There is to be one manually operated shutdown valve in the gas supply line to each engine to assure safe isolation during maintenance on the engine.

105 For one-engine installations and multi-engine installations where a separate master valve is provided for each branch the master gas fuel valve and the double block and bleed valve functions can be combined as shown in Fig.1 and Fig.2, for high-pressure installations.

106 In the main supply gas line to each engine an automatic excess flow shut off valve shall be fitted. The valve shall be adjusted to shut off gas supply in the event of rupture of the gas line. The valve shall be located as close as possible to the point of entry of the gas supply line into the engine room. For ESD protected machinery spaces excess flow shut-down is also to lead to disconnection of all non-explosion protected equipment or installations in the engine room.

Guidance note:

The shutdown should be time delayed to prevent shutdown due to transient load variations.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

107 Full stop of ventilation in an engine room for a single fuelled gas system shall, additionally to what is given in Table D1, lead to one of the following actions:

- For a gas electric propulsion system with more than one engine room:* Another engine is to start. When the second engine is connected to bus-bar the first engine is to be shut-down automatically.
- For a direct propulsion system with more than one engine room:* The engine in the room with defect ventilation is to be manually shutdown if at least 40% propulsion power is still available after such a shutdown.

If only one engine room is fitted and ventilation in one of the enclosed ducts around the gas pipes is lost the master gas fuel

and double block and bleed valves in that supply line are to close automatically provided the other gas supply unit is ready to deliver.

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

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

110 A signboard shall be permanently fitted in the engine room stating that heavy lifting, implying danger of damage to the gas pipes, is not to be done when the engine(s) is running on gas.

Table D1 Monitoring of gas supply system to engines				
<i>Parameter</i>	<i>Alarm</i>	<i>Automatic shut-down of main tank valve</i>	<i>Automatic shut-down of gas supply to engine room ¹⁾</i>	<i>Comment</i>
Gas detection in tank room above 20% LEL	X			
Gas detection on second detector in tank room above 20% LEL	X	X		
Fire detection in tank room	X	X		
Bilge well high level tank room	X			
Bilge well low temperature in tank room	X	X		
Gas detection in duct between tank and engine room above 20% LEL	X			
Gas detection on second detector in duct between tank and engine room above 20% LEL	X	X ²⁾		
Gas detection in compressor room above 20% LEL	X			
Gas detection on second detector in compressor room above 20% LEL	X	X ²⁾		
Gas detection in duct inside engine room above 30% LEL	X			If double pipe fitted in engine room
Gas detection on detector in duct inside engine room above 60% LEL	X		X	If double pipe fitted in engine room
Gas detection in engine room above 20% LEL	X			Gas detection only required for ESD protected engine rooms
Gas detection on second detector in engine room above 20% LEL	X		X	Gas detection only required for ESD protected engine rooms. Is also to lead to disconnection of not certified safe electrical equipment in engine room
Loss of ventilation in duct between tank and engine room ⁵⁾	X		X ³⁾	
Loss of ventilation in duct inside engine room ⁵⁾	X		X ³⁾	If double pipe fitted in engine room
Loss of ventilation in engine room	X		X	ESD protected engine rooms only
Fire detection in engine room	X		X	
Abnormal gas pressure in gas supply pipe	X		X ³⁾	
Failure of valve control actuating medium	X		X ⁴⁾	Time delayed as found necessary
Automatic shutdown of engine (engine failure)	X		X ⁴⁾	
Emergency shutdown of engine manually released	X		X	
Excess flow in gas supply piping to ESD protected engine room	X		X	
<ol style="list-style-type: none"> Automatic shutdown of gas supply to engine room has different requirements for high and low pressure gas with regard to valve action. See D101 to D103. If the tank is supplying gas to more than one engine and the different supply pipes are completely separated and fitted in separate ducts and with the master valves fitted outside of the duct, only the master valve on the supply pipe leading into the duct where gas is detected is to close. This parameter is not to lead to shutdown of gas supply for single fuel gas engines, only for dual fuel engines. Only double block and bleed valves to close. If the duct is protected by inert gas (see Sec.3 E101) then loss of inert gas overpressure is to lead to the same actions as given in this table. 				

SECTION 7 COMPRESSORS AND GAS ENGINES

A. Gas Compressors

A 100 General

101 The fuel gas compressor is to be fitted with accessories and instrumentation necessary for efficient and reliable function.

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

- the cargo control room (relevant for cargo ships only)
- navigation bridge
- engine control room
- fire control station.

A 200 Vibrations

201 The possibility for fatigue problem of the high-pressure gas piping due to vibration caused by the high-pressure gas compressor must be considered. Such vibrations may be caused by unbalanced forces in the compressor itself, by resonant vibrations in the piping system or by resonance in the gas column of the gas discharge lines. Calculations may be required to verify that resonance problems will not occur.

B. Gas Engine Design

B 100 General

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

102 The explosion venting is to be led outside the machinery space.

103 As an alternative to explosion venting, documentation showing that the exhaust system has sufficient strength to contain the worst case explosion can be accepted.

B 200 Functional requirements dual fuel engines

201 Start, normal stop and low power operation is to be on oil fuel only. Gas injection is not to be possible without a corresponding pilot oil injection.

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

202 Changeover to and from gas fuel operation is only to be possible at a power level where it can be done with acceptable reliability as demonstrated through testing. On completion of preparations for changeover to gas operation including checks of all essential conditions for changeover, the changeover process itself is to be automatic. On power reduction the changeover to oil fuel is to be automatic (compressor and auxiliaries may continue to run unloaded).

203 On normal shutdown as well as emergency shutdown, gas fuel supply is to be shut off not later than simultaneously with the oil fuel. Shut off of the gas fuel is not to be dependent on the shut off of the oil fuel.

204 Firing of the gas-air mixture in the cylinders is to be initiated by injection of pilot fuel. The amount of pilot fuel fed to each cylinder is to be sufficient to ensure a positive ignition of the gas mixture. It is not to be possible to shut off the supply pilot fuel without first or simultaneously closing the gas supply to each cylinder or to the complete engine.

B 300 Functional requirements gas-only engines

301 The starting sequence must be such that fuel gas is not admitted to the cylinders until ignition is activated and the engine has reached a minimum rotational speed.

302 If ignition has not been detected by the engine monitoring system within 10 s after opening of gas injection valve the gas supply is to be automatically shut off and the starting sequence terminated.

303 When restarting after a failed start attempt admission of fuel gas to the cylinders is not to be possible before the exhaust gas system has been purged with a volume of air at least equal to 3 times the volume of the exhaust gas system before the turbocharger(s). Purging may be carried out through for example running the engine on starting air for a predetermined number of revolutions.

B 400 Design of on-engines piping on gas-only engines

401 The gas is to be fed to each cylinder via a special gas valve. For small engines gas feed to a common manifold may be considered.

402 For gas-only engines where gas is supplied in a mixture with air via a common inlet manifold, explosion relief venting is to be arranged; alternatively the manifold must be of sufficient strength to withstand an explosion.

SECTION 8

MANUFACTURE, WORKMANSHIP AND TESTING

A. Gas Tanks

A 100 Manufacture and testing

101 Tests related to welding and tank testing are to be in accordance with Pt.5 Ch.5 Sec.5 K, L, M, and N.

B. Gas Piping Systems

B 100 Gas pipes

101 The gas pipes are to be tested as given in Pt.5 Ch.5 Sec.6 C600 and C700. Butt welded joints of high-pressure gas pipes and gas supply pipes in ESD protected engine rooms are to be

subjected to 100% radiographic testing.

B 200 Ducting

201 If the gas piping duct contains high-pressure pipes the ducting is to be pressure tested to at least 10 bar.

B 300 Valves

301 Each type of valve to be used at working temperatures below minus 55°C is to be prototype tested as given in Pt.5 Ch.5 Sec.6 C801.

B 400 Expansion bellows

401 Expansion bellows intended for use in gas systems are to be prototype tested as given in Pt.5 Ch.5 Sec.6 C802.