RULES FOR CLASSIFICATION OF

Ships / High Speed, Light Craft and Naval Surface Craft

PART 6 CHAPTER 13

NEWBUILDINGS
SPECIAL EQUIPMENT AND SYSTEMS – ADDITIONAL CLASS

Gas Fuelled Engine Installations

JANUARY 2011

This chapter has been amended since the main revision (January 2011), most recently in July 2011.
See "Changes" on page 3.

DET NORSKE VERITAS AS

FOREWORD

DET NORSKE VERITAS (DNV) is an autonomous and independent foundation with the objectives of safeguarding life, property and the environment, at sea and onshore. DNV undertakes classification, certification, and other verification and consultancy services relating to quality of ships, offshore units and installations, and onshore industries worldwide, and carries out research in relation to these functions.

The Rules lay down technical and procedural requirements related to obtaining and retaining a Class Certificate. It is used as a contractual document and includes both requirements and acceptance criteria.

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CHANGES

General

As of October 2010 all DNV service documents are primarily published electronically.

In order to ensure a practical transition from the "print" scheme to the "electronic" scheme, all rule chapters having incorporated amendments and corrections more recent than the date of the latest printed issue, have been given the date January 2011.

An overview of DNV service documents, their update status and historical "amendments and corrections" may be found through http://www.dnv.com/resources/rules_standards/.

Amendments July 2011

- **Sec.1 General Requirements**

— In Table C1 references to documentation type "Z030 – System arrangement plan" have been amended to read "Z030 – Arrangement plan".

Amendments January 2011

- **Sec.3 Arrangement and System Design**

— In item D101, references to Pt.4 Ch.1 have been corrected.

Main changes

Since the previous edition (January 2010), this chapter has been amended, most recently in January 2011. All changes previously found in Pt.0 Ch.1 Sec.3 have been incorporated and a new date (January 2011) has been given as explained under "General".

In addition, the layout has been changed to one column in order to improve electronic readability.

CONTENTS

SECTION 1
GENERAL REQUIREMENTS

A. Classification

A 100 Application

101 The rules in this chapter apply to internal combustion engine installations in ships. Application of the ESD concept for LNG carriers 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 1:
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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Guidance note 2:
Requirements not relevant for LNG carriers are shown in ***bold italic*** text.

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102 The rules are applicable for installations where natural gas is used as fuel. If other gases are used as fuel special considerations will have to be done, and additional requirements may be relevant.

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 the Rules for Classification of Ships, Pt.7 Ch.1 Sec.2 A and C, Pt.7 Ch.1 Sec.3 C and Pt.7 Ch.1 Sec.4 C.

B. Definitions

B 100 Terms

101 *Accommodation spaces*: See the Rules for Classification of Ships, Pt.4 Ch.10.

102 *Control stations:* See the Rules for Classification of Ships, Pt.4 Ch.10.

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).

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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 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.

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, or can operate successively on oil fuel and gas.

105 *ESD* means emergency shutdown.

106 *Enclosed space* means any space within which, in the absence of artificial ventilation, the ventilation will be limited and any explosive atmosphere will not be dispersed naturally.

Guidance note:
See also definition in IEC 60092-502:1999.

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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 *Hazardous area*

Area in which an explosive gas atmosphere or a flammable gas with a flash point below 60°C is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

Hazardous areas are divided into Zone 0, 1 and 2 as defined below and according to the area classification specified in Sec.5 B.

Zone 0

Area in which an explosive gas atmosphere or a flammable gas with a flash point below 60°C is present continuously or is present for long periods

Zone 1

Area in which an explosive gas atmosphere or a flammable gas with a flash point below 60°C is likely to occur in normal operation

Zone 2

Area in which an explosive gas atmosphere or a flammable gas with a flash point below 60°C is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only.

Guidance note:

The definition of hazardous area is only related to the risk of explosion. In this context, health, safety and environmental issues, i.e. toxicity, is not considered.

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110 *Non-hazardous area*

An area not considered to be hazardous, i.e. gas safe, provided certain conditions are being met.

111 *Sources of release* are valves or detachable pipe joints in the fuel gas system. Also compressors and seals of pumps in the fuel gas system are regarded as sources of release.

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

113 *LEL* is lower explosion limit.

114 ***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.***

115 *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.

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

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.

121 *Tank room* means the gastight space surrounding the bunker tank, containing all tank connections and all tank valves.

C. Documentation

C 100 Plans and particulars

101 Documentation shall be submitted as required by Table C1.

Table C1 Documentation requirements

System	*Documentation type*	*Additional description*	*For approval (AP) or information (FI)*
Propulsion system	Z050 Design Philosophy	Including information on the machinery configuration, engine room arrangements, fuel arrangements, shut down philosophy, redundancy considerations etc. Shall be submitted before other documentation, to give support for approval of these.	FI
Fuel gas system general	G130 Cause and effect diagram	Test program for safety functions.	AP
	Z030 Arrangement plan	Including: — machinery and boiler spaces, accommodation, service and control station spaces — ***gas tanks and gas containment systems*** — ***gas pump and compressor rooms*** — ***gas bunkering pipes 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 hazardous areas*** — entrances, air inlets and openings to accommodation, service and control station spaces.	AP
	Z140 Test procedure for quay and sea trial		AP
	Z160 Operational manual	***Including procedures for:*** — ***bunkering*** — ***gas freeing and inerting*** — ***normal operation*** — ***emergency operation.***	***AP***
Fuel gas tanks	***C030 Detailed drawing***	— ***tanks*** — ***supports and stays*** — ***secondary barriers*** — ***insulation*** — ***marking plates.***	***AP***
	C040 Design analysis	— ***specification of design loads and structural analysis of gas tanks*** — ***complete stress analysis for independent tanks type B and type C.***	***AP***
	C050 Non-destructive testing (NDT) plan	***Including*** — ***information about strength and tightness testing*** — ***specification of stress relieving procedures for independent tanks type C (thermal or mechanical).***	***AP***
	M060 Welding procedures		***AP***
	M010 Material specifications	***Including connected pipes.***	***FI***
	Z030 Arrangement plan		***FI***
	Z250 Procedure	***Cooling down.***	***AP***

Table C1 Documentation requirements (Continued)

System	*Documentation type*	*Additional description*	*For approval (AP) or information (FI)*
Fuel gas tanks safety relief valves and associated ventilation piping	***C030 Detailed drawing***		***AP***
	S030 Capacity analysis	***Including back pressure.***	***AP***
	Z100 Specification		***AP***
Fuel gas tanks gas freeing and purging system	***S010 Piping diagram***		***AP***
Fuel gas tanks control and monitoring system	***I200 - Control and monitoring system documentation***		***AP***
Fuel gas piping system	C030 Detailed drawing	Insulation of low temperature piping.	FI
	C050 Non-destructive testing (NDT) plan	Including: — Specification of pressure tests (structural and tightness tests) — Specification of post-weld heat treatment	AP
	M060 Welding procedures		AP
	S010 Piping diagram	Including ventilation lines for safety relief valves or similar piping, and ducts for gas pipes	AP
	S060 Pipe routing sketch		FI
	S080 Thermal stress analysis	When design temperature is below -110°C	FI
	S090 Specification of valves, flanges and fittings	Including offsets, loops, bends, expansion elements such as bellows and slip joints (only inside tanks). For valves intended for service with a design temperature below -55°C, documentation of leak test and functional test at design temperature (type test) shall be included.	FI
	Z140 Test procedure for quay and sea trial	Functional tests of all piping systems including valves, fittings and associated equipment for handling gas (liquid or vapour)	AP
	Z280 Type approval certificate	Type tests for expansion elements.	FI
	Z100 Specification	Insulation of low temperature piping.	FI
Fuel gas system drip trays	***Z030 Arrangement plan***	***Hull protection beneath liquid piping where leakages may be anticipated, such as at shore connections and at pump seals. Including specification.***	AP
Electric bonding of piping	Z100 Specification		AP
Cooling system	S010 Piping diagram	In connection with fuel gas system.	AP
Heating system	S010 Piping diagram	In connection with fuel gas system.	AP

Table C1 Documentation requirements (Continued)

System	*Documentation type*	*Additional description*	*For approval (AP) or information (FI)*
Fuel gas compressors control and monitoring system	I200 Control and monitoring system documentation		AP
Fuel gas driven engines	Z071 Failure mode and effect analysis	Examining all possible faults affecting the combustion process.	AP
Exhaust gas system	S010 Piping diagram		AP
Hazardous areas	G080 Hazardous area classification drawing		AP
Gas masts	Z030 Arrangement plan	***Location and details of outlets from gas tanks safety relief valves.***	***AP***
Air locks	Z030 Arrangement plan	Location and construction details, including alarm equipment.	AP
Gastight bulkhead penetrations	C030 Detailed drawing		AP
Ventilation of gas fuel system spaces	V010 Ducting diagram	For spaces containing gas installations, like gas pipe ducts led through enclosed spaces, ***and storage tanks below deck.*** Including capacity and location of fans and their motors.	AP
	C030 Detailed drawing	Rotating parts and casings for fans and portable ventilators.	AP
Explosion protection	***Z030 Arrangement plan***	***Electrical equipment in hazardous areas.***	FI
	E170 Electrical schematic drawing	***Single line diagrams for all intrinsically safe circuits, for each circuit including data for verification of the compatibility between the barrier and the field components.***	AP
	Z180 Maintenance manual	***Electrical equipment in hazardous areas, see Sec.5 D.***	FI
Gas detection system, fixed	I200 - Control and monitoring system documentation		AP
	Z030 Arrangement plan	Detectors, call points and alarm devices.	AP
Fire protection	***G060 Structural fire protection drawing***		AP
Fire water supply and distribution system	S010 Piping diagram		AP
	S030 Capacity analysis		AP
	Z030 Arrangement plan		AP
External surface protection water spraying system	***G200 Fixed fire extinguishing system documentation***		***FI***

Table C1 Documentation requirements (Continued)			
System	*Documentation type*	*Additional description*	*For approval (AP) or information (FI)*
Bunkering station fire fighting system	***G200 Fixed fire extinguishing system documentation***		AP
Fire detection and alarm system	***I200 - Control and monitoring system documentation***	***For storage tanks and ventilation trunks.***	***AP***
	Z030 Arrangement plan		***AP***
Mobile fire extinguishing equipment	Z030 Arrangement plan	At bunkering station and entrance to engine rooms.	AP

102 For general requirements to documentation, see Pt.0 Ch.3 Sec.1.

103 For a full definition of the documentation types, see Pt.0 Ch.3 Sec.2.

D. Certification

D 100 Gas engines

101 Gas engines are in addition to the requirements in this chapter shall 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, shall be certified as class I pressure vessels in accordance with Pt.4 Ch.7.

D 300 Valves

301 For valves used in high pressure gas systems or systems with working temperature below 0°C product certification as given in Rules for Classification of Ships, Pt.5 Ch.5 Sec.6 H is required.

For valves used in gas piping systems with low pressure and temperature above 0°C product certification is required, as given in the Rules for Classification of Ships, Pt.4 Ch.6.

D 400 Pumps and compressors

401 Pumps and compressors in gas systems shall be delivered with the Society's product certificate.

402 For general requirements and in regard to testing of pumps: See the Rules for Classification of Ships, Pt.4 Ch.6.

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

E. Onboard Documentation

E 100 Contents

101 ***An operation manual as described in Table C1 shall be kept onboard.***

102 A plan for systematic maintenance and function testing shall be kept onboard showing in detail how components and systems shall be tested and what shall be observed during the tests. Columns showing test dates and verification of tests carried out shall be included. The plan shall 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 shall not 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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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 with high pressure or a working temperature below 0°C shall be in accordance with the Rules for Classification of Ships, Pt.5 Ch.5 Sec.2 D. For piping see the Rules for Classification of Ships, Pt.5 Ch.5 Sec.6 C200.

For CNG tanks, the use of materials not covered by Rules for Classification of Ships, Pt.5 Ch.5 may be specially considered and approved by the Society.

103 The materials used in gas piping systems with high pressure or temperature below 0°C shall be furnished with documentation in accordance with the Rules for Classification of Ships, Pt.5 Ch.5 Sec.2 Table E1.

The materials used in gas piping systems with low pressure and temperature above 0°C shall be furnished with documentation in accordance with the Rules for Classification of Ships, Pt.4 Ch.6 Sec.2 Table A2. Gas piping is pertaining to the same pipe class as fuel oil piping in Pt.4 Ch.6 Sec.1 Table B1.

For the definition of material documentation see the Rules for Classification of Ships, Pt.1 Ch.1 Sec.4.

104 The outer pipe in inherently safe engine room spaces with high pressure gas in the inner pipe is as least required to fulfil the material requirements for pipe materials with design temperature down to -55 in the Rules for Classification of Ships, Pt.5 Ch.5 Sec.2 Table D4.

105 The outer pipe or duct around gas pipes with liquid gas shall be made of cold resistant steel unless it is efficiently protected from possible leakages from the inner pipe.

SECTION 3
ARRANGEMENT AND SYSTEM DESIGN

A. Location and Separation of Spaces

A 100 Gas compressor room

101 Compressor rooms, if arranged, shall be located on open deck, unless those rooms are arranged and fitted in accordance with the requirements of this Rule chapter for tank rooms.

102 Where compressors are driven by shafting passing through a bulkhead or deck, the bulkhead penetration shall 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 shall 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 of the ESD protected type shall have as simple geometrical shape as possible.

A 300 Tank rooms

301 ***Tank rooms boundaries shall be gas tight.***

302 ***The tank room shall not 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 shall be fitted.***

B. Arrangement of Entrances and Other Openings

B 100 General

101 Direct access through doors, gastight or otherwise, shall generally not be permitted from a non hazardous space to a hazardous space. Where such openings are necessary for operational reasons, an air lock which complies with the requirements of Rules for Classification of Ships, Pt.5 Ch.5 Sec.3 C300 shall be provided.

102 ***If the compressor room is approved located below open deck the room shall have an independent access direct from the open deck. Where a separate access from deck is not practicable, an air lock which complies with the requirements of Pt.5 Ch.5 Sec.3 C300 shall be provided.***

103 ***The tank room entrance shall be arranged with a sill height of at least 300 mm.***

104 ***Access to the tank room is as far as practicable to be independent and direct from open deck. If the tank room is only partially covering the tank, this requirement shall be applied to the room surrounding the tank, and where the opening to the tank room is located.***

Where a separate access from deck is not practicable, an air lock which complies with the requirements of Rules for Classification of Ships, Pt.5 Ch.5 Sec.3 C300 shall be provided.

The access trunk shall be fitted with separate ventilation.

The tank room shall not be open for entry during normal operation of the gas system.

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

106 If the access to an engine room of ESD protected type is from another enclosed space in the ship, the entrances shall be arranged with self-closing doors. Audible and visible alarm shall sound at a permanently manned location 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 shall in general comply with the applicable parts of the Rules for Classification of Ships, Pt.5 Ch.5 Sec.6.

102 Gas piping shall not 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 shall be provided.

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

105 Gas pipes shall be colour marked based on a recognized standard.

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

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

107 High pressure gas piping systems shall have sufficient constructive strength. This shall be confirmed by carrying out stress analysis and taking into account:

— stresses due to the weight of the piping system
— acceleration loads when significant
— internal pressure and loads induced by hog and sag of the ship.

[IACS UR M59]

Guidance note:
Significant acceleration loads is in this context acceleration loads that give a stress equal to more than 20% of the stress from the internal pressure in the pipe

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

[IACS UR M59]

109 All gas piping and tanks shall be electrically bonded to the ship's hull. Bonding straps across stainless steel flanges with bolts and nuts of stainless steel are not required. If carbon-manganese steel is not fitted with bonding straps across the flanges, it shall be checked for electric bonding. The electrical bonding is sufficient, when the electrical resistance between piping and the hull does not exceed 10^6 Ohm.

Gas piping sections of piping components which are not permanently connected to the hull by permanent piping connections, or where such connections are removable e.g. for removal of spool pieces, shall be electrically bonded to the hull by special bonding straps.

Guidance note:
The value of resistance 10^6 Ohm may be achieved without the use of bonding straps where gas piping systems and equipment are directly, or via their supports, either welded or bolted to the hull of the ship. It will be generally necessary initially to achieve a resistance value below 10^6 Ohm, to allow for deterioration in service.

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110 Gas piping shall be protected against mechanical damage.

D. System Configuration

D 100 General

101 The propulsion and fuel supply system shall be so designed that the remaining power for propulsion and power generation after any gas leakage with following safety actions shall be in accordance with the requirements for remaining power and main functions after single failure in Rules for Classification of Ships, Pt.4 Ch.1.

D 200 Engine room configuration options

201 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 non- hazardous under normal conditions, but under certain abnormal conditions may have the potential to become gas hazardous. In the event of abnormal conditions involving gas hazards, emergency shutdown (ESD) of non-safe equipment (ignition sources) and machinery shall be automatically executed while equipment or machinery in use or active during these conditions shall be of explosion protected design.

D 300 Inherently gas safe machinery spaces

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

302 For low pressure gas systems ventilation inlet openings for the double wall piping or duct can be accepted located in the engine room on the condition that a gas detection system is fitted in the engine room.

D 400 ESD protected machinery spaces

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

a) Engines for generating propulsion power and electric power shall 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 shall 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 shall not be located within an ESD protected machinery space.

b) Pressure in gas supply lines within machinery spaces to be less than 10 bar.

c) A gas detection system arranged to automatically shutdown the gas supply (also oil fuel supply if dual fuel) and disconnect all non-explosion protected equipment or installations shall be fitted.

E. Gas supply system arrangement

E 100 Gas supply system general

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

102 Each gas storage tank shall be provided with a tank valve capable of being remote operated. The valve shall be located as close to the tank outlet as possible.

103 The main supply lines for gas to each engine room shall 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 shall 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, if fitted. The master gas fuel valve is automatically to cut off the gas supply as given in Sec.6 Table B3.

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

104 Each gas utilisation unit shall be provided with a set of "double block and bleed" valves. These valves shall be arranged so that when automatic shutdown is initiated as given in Sec.6 Table B3, 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 shall be of the fail-to-close type, while the ventilation valve shall be fail-to-open. The double block and bleed valves are also to be used for normal stop of the engine.

105 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, shall open. For high-pressure systems the pipe pieces between the double block and bleed valve and the gas injection valves, shall be automatically vented. See Fig.1 and Fig.2. For high-pressure systems the ventilation valves shall open at normal stop of engine.

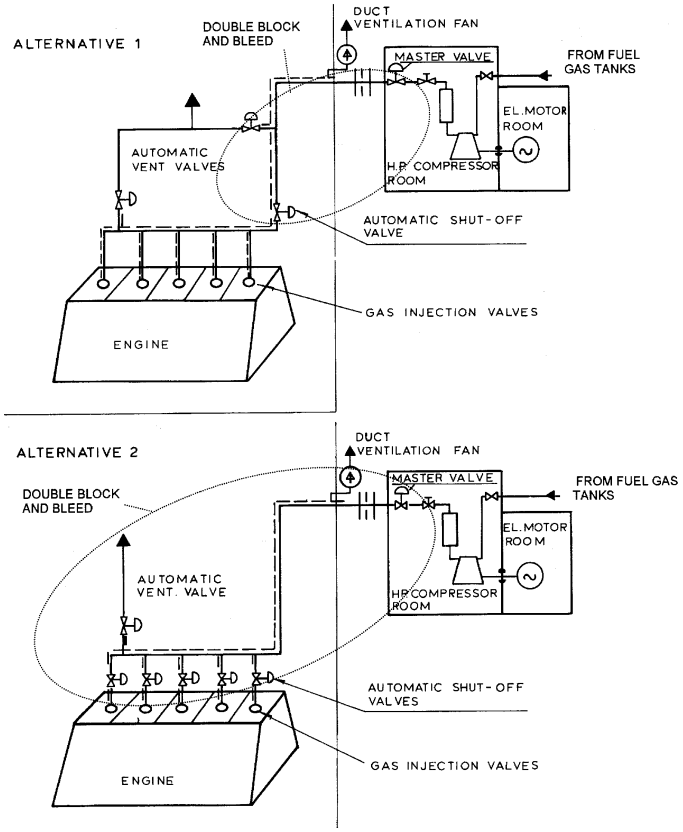

Fig. 1
Alternative supply valve arrangements for high-pressure installations (single engine or separate master valve arrangement)

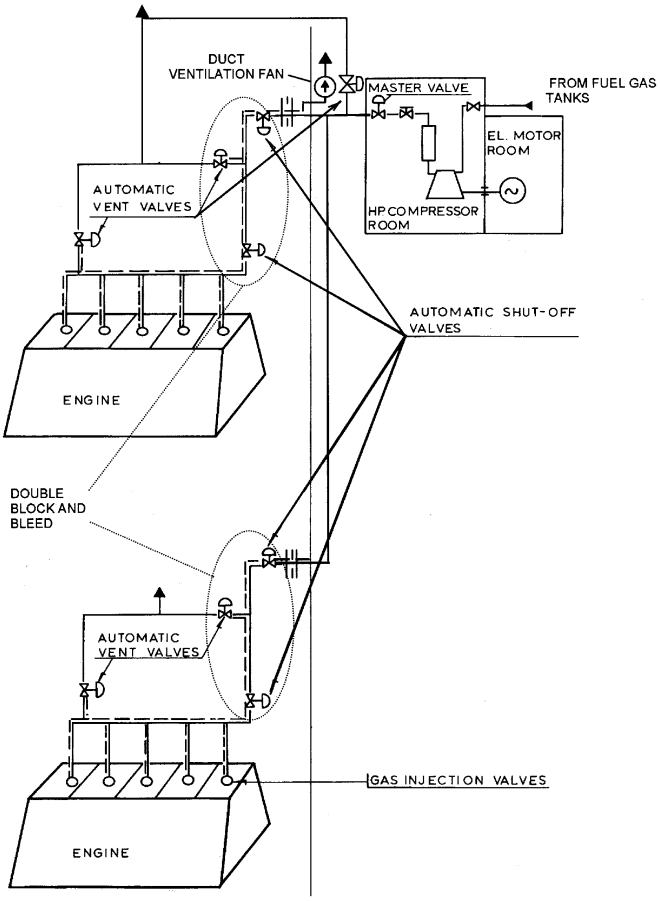

Fig. 2
Alternative supply valve arrangements for high-pressure installations (multi engine installation)

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

107 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. Examples for high-pressure installations are shown in Fig.1 and Fig.2.

108 In the main supply gas line to each engine located in an ESD protected machinery space, and in each gas supply line to high pressure installations means shall be provided for rapid detection of a rupture in the gas line in the engine room. When rupture is detected a valve shall be automatically shut off. This valve shall be located in the gas supply line before it enters the engine room or as close as possible to the point of entry inside the engine room, and it can be a separate valve or combined with other functions, e.g. the master valve.

Acceptable means of detection are e.g.:

— an orifice or flow fuse detecting excess flow located close to the point of entry to the engine room;
— a combined excess flow detector with automatic shut off valve located close to the point of entry to the engine room;
— a low pressure detector located as close as possible to the engine inlet.

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

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E 200 Distribution outside of machinery spaces

201 ***Gas fuel piping shall not be lead through accommodation spaces, service spaces or control stations.***

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

203 ***The duct shall be dimensioned according to F103 and F104.***

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

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

F. Gas Supply System in Machinery Spaces

F 100 Gas supply system for inherently gas safe machinery spaces

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

a) The gas 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 pressurised with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms shall be provided to indicate a loss of inert gas pressure between the pipes.
When the inner pipe contains high pressure gas the system shall be so arranged so that the pipe between the master gas valve and the engine is automatically purged with inert gas when the master gas valve is closed.
[IACS UR M59]

b) The gas fuel piping shall 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 shall 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 shall be placed outside the ventilated pipe or duct. The ventilation outlet shall 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.

Double ducting is also required for gas pipes on the engine and up to where the gas is supplied into the combustion chamber.

Guidance note:
If gas is supplied into the air inlet pipe on a low pressure engine, double ducting may be omitted on the air inlet pipe

on the condition that a gas detector is fitted above the engine.

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103 For high-pressure piping the design pressure of the ducting shall 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 p*: this pressure shall 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 constant volume specific heat
k = 1.31 for CH_4

The tangential membrane stress of a straight pipe shall not 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 shall 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 shall be dimensioned for a design pressure not less than the maximum working pressure of the gas pipes. As an alternative the calculated maximum built up pressure in the duct in the case of a pipe rupture when ventilation is not running may be approved used for dimensioning of the duct.

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 engine, without running the risk of fatigue problems. The length and configuration of the branch lines are important factors in this regard.

F 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 shall have a design pressure not less than 10 bar.

G. Gas Fuel Storage Tanks

G 100 *Liquefied gas storage tanks*

101 ***The storage tank used for liquefied gas shall be an independent tank designed in accordance with the Rules for Classification of Ships,*** **Pt.5 Ch.5 Sec.5 I.**

102 ***Pipe connections to the tank shall be in accordance with the Rules for Classification of Ships,*** **Pt.5 Ch.5 Sec.6 C303** ***to*** **C307.** ***However, connections below the lowest liquid level may be accepted after special consideration by the Society.***

103 ***Pressure relief valves as required in the Rules for Classification of Ships,*** **Pt.5 Ch.5 Sec.9 B200** ***shall be fitted.***

104 ***The outlet from the pressure relief valves shall 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 shall be located at least 10 m from the nearest:***

— ***air intake, air outlet or opening to accommodation, service and control spaces, or other non hazardous spaces***
— ***exhaust outlet from machinery or from furnace installation.***

For small ships and ship types where the operation limits the possible location of the outlet, smaller height and distances than given above may be accepted.

105 ***Storage tanks for liquid gas with vapour pressure above the design pressure at 45°C shall 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 the Rules for Classification of Ships,*** **Pt.5 Ch.5 Sec.17 A105.** ***A filling limit curve for actual filling temperatures shall be prepared from the formula given in the Rules for Classification of Ships,*** **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%.

107 *It shall be possible to empty, inert and purge bunker tanks and associated gas piping systems. Procedures shall be developed in accordance with Rules for Classification of Ships, Pt.5 Ch.5 Sec.9.*

G 200 *Compressed gas storage tanks*

201 *The storage tanks to be used for compressed gas shall be in accordance with* **Pt.4 Ch.7** *and shall be certified by the Society.*

202 *Tanks for compressed gas shall be fitted with pressure relief valves with a set point below the design pressure of the tank and with outlet located as required in 104.*

G 300 *Storage on open deck*

301 *Both gases of the compressed and the liquefied type will be accepted stored on open deck.*

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

303 *The gas storage tanks or tank batteries and equipment shall 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***, shall be fitted with drip trays below the tank 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 insulation so that the hull or deck structures are not exposed to unacceptable cooling, in case of leakage of liquid gas.*

G 400 *Storage in enclosed spaces*

401 *Gas in a liquid state with a maximum acceptable working pressure of 10 bar may be stored in enclosed spaces. Storage of compressed gas in enclosed spaces and location of gas tanks with a higher pressure than 10 bar in enclosed spaces is not acceptable unless the following is fulfilled in addition to 404:*

- *adequate means are provided to depressurize the tank in case of a fire which can affect the tank; and*
- *all surfaces within the tank room are provided with suitable thermal protection against any lost high-pressure gas and resulting condensation unless the bulkheads are designed for the lowest temperature that can arise from gas expansion leakage; and*
- *a fixed fire-extinguishing system is installed in the tank room.*

402 *The gas storage tank(s) shall be located as close as possible to the centreline and:*

- *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.*

For vessels other than passenger vessels a tank location closer than B/5 from the ship side may be accepted and approved by the Society, on a case by case basis.

403 *The storage tank and associated valves and piping shall be located in a space designed to act as a secondary barrier, in case of liquid gas leakage. This implies that the material shall be in accordance with the Rules for Classification of Ships,* **Pt.5 Ch.5 Sec.2 D***, for secondary barriers, and that the space shall be designed to withstand the maximum pressure build up. Alternatively, pressure relief venting to a safe location (mast) can be provided. The space shall be capable of containing leakage, and shall 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".*

When the tank is double walled and the outer tank shell is made of cold resistant material, a tank room could be arranged as a box fully welded to the outer shell of the tank, covering all tank connections and valves, but not necessarily all of the outer tank shell.

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

H. *Fuel Bunkering System*

H 100 *Fuel bunkering station*

101 *The bunkering station shall be so located that sufficient natural ventilation is provided. Closed or*

semi-enclosed bunkering stations will be subject to special consideration.

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

For compressed gas bunkering stations, low temperature steel shielding shall be provided to prevent the possible escape of cold jets impinging on surrounding hull structure.

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

H 200 ***Bunkering system***

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

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

203 ***Means shall be provided for draining the liquid from the bunkering pipes at bunkering completion.***

204 ***Bunkering lines shall be arranged for inerting and gas freeing. During operation of the vessel the bunkering pipes shall be gas free.***

I. Ventilation Systems

I 100 General

101 Any ducting used for the ventilation of hazardous spaces shall be separate from that used for the ventilation of non-hazardous spaces. Electric fan motors shall not be located in ventilation ducts for hazardous spaces unless the motor is certified for the same hazard zone as the space served.

102 For design of ventilation fans serving spaces containing sources of release see requirements in the Rules for Classification of Ships, Pt.5 Ch.5 Sec.10 A200.

103 Air inlets for hazardous enclosed spaces shall be taken from areas which, in the absence of the considered inlet, would be non-hazardous.

Air inlets for non-hazardous enclosed spaces shall be taken from non-hazardous areas at least 1.5 m away from the boundaries of any hazardous area.

Where the inlet duct passes through a more hazardous space, the duct shall have over-pressure relative to this space, unless mechanical integrity and gas-tightness of the duct will ensure that gases will not leak into it.

104 Air outlets from non-hazardous spaces shall be located outside hazardous areas.

105 Air outlets from hazardous enclosed spaces 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.

106 The required capacity of the ventilation plant is normally based on the total volume of the room. An increase in required ventilation capacity may be necessary for rooms having a complicated form.

I 200 Non-hazardous spaces

201 Spaces with opening to a hazardous area, shall be arranged with an air-lock, and be maintained at overpressure, relative to the external hazardous area.

The overpressure ventilation shall be arranged according to the following requirements:

1) During initial start-up or after loss of overpressure ventilation, it is required before energising any electrical installations not certified safe for the space in the absence of pressurisation, to:
   - — proceed with purging (at least 5 air changes) or confirm by measurements that the space is non-hazardous; and
   - — pressurise the space.
2) Operation of the overpressure ventilation shall be monitored.
3) In the event of failure of the overpressure ventilation:

— an audible and visual alarm shall be given at a manned location.
— if overpressure cannot be immediately restored, automatic or programmed disconnection of electrical installations is required according to IEC 60092-502, Table 5.

I 300 *Gas tank room*

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

I 400 Engine room

401 The ventilation system for ESD protected machinery spaces shall be independent of all other ventilation.

402 ESD protected engine rooms shall have ventilation with a capacity of at least 30 air changes per hour. The ventilation system shall ensure a good air circulation in all spaces, and in particular ensure that any formation of gas pockets in the room are detected. As an alternative, arrangements whereby under normal operation the machinery spaces is ventilated with at least 15 air changes an hour is acceptable provided that, if gas is detected in the machinery space, the number of air changes will automatically be increased to 30 an hour.

403 The number and power of the ventilation fans shall 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.

I 500 Pump and compressor rooms

501 Pump and compressor rooms shall be fitted with effective mechanical ventilation system of the underpressure type, providing a ventilation capacity of at least 30 air changes per hour.

502 The number and power of the ventilation fans shall 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.

503 Ventilation systems for pump and compressor rooms shall be in operation when pumps or compressors are working. Warning notices to this effect shall be placed in an easily visible position near the control stand.

504 When the space is dependent on ventilation for its area classification, the following requirements apply:

1) During initial start-up, and after loss of ventilation, the space shall be purged (at least 5 air changes), before connecting electrical installations which are not certified for the area classification in absence of ventilation.
2) Operation of the ventilation shall be monitored.
3) In the event of failure of ventilation, the following requirements apply;

— an audible and visual alarm shall be given at a manned location.
— immediate action shall be taken to restore ventilation.
— electrical installations shall be disconnected if ventilation cannot be restored for an extended period. The disconnection shall be made outside the hazardous areas, and be protected against unauthorised re-connection, e.g. by lockable switches.

Guidance note:
Intrinsically safe equipment suitable for Zone 0, is not required to be switched off. Certified flameproof lighting, may have a separate switch-off circuit.

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J. Nitrogen Installations

J 100 Nitrogen installation spaces

101 ***Where a nitrogen generator or nitrogen storage facilities are installed in a separate compartment, outside of the engine room, the separate compartment shall be fitted with an independent mechanical extraction ventilation system, providing 6 air changes per hour. A low oxygen alarm shall be fitted. Such separate compartments shall be treated as one of other machinery spaces, with respect to fire protection.***

102 ***Nitrogen pipes shall only be led through well ventilated spaces. Nitrogen pipes in enclosed spaces shall:***

— ***be fully welded***
— ***have only a minimum of flange connections as needed for fitting of valves***

— ***be as short as possible.***

The need for other precautions to prevent suffocation of personnel in case of leakage should be considered in each case.

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 A compressor room or gas pump room shall be regarded as a machinery space of category A for fire protection purposes.

B. *Fire Protection*

B 100 *Construction*

101 ***Tanks or tank batteries located above deck shall 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 shall 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 ***The fire and mechanical protection of gas pipes lead through ro-ro spaces on open deck shall be subject to special consideration by the Society depending on the use and expected pressure in the pipes. Gas pipes lead through ro-ro spaces on open deck shall be provided with guards or bollards to prevent vehicle collision damage.***

104 ***The bunkering station shall 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 shall be fire insulated to class A-60 standard.

106 ***A compressor room in a ship that is not a gas carrier shall be regarded as a machinery space of category A for fire insulation requirements.***

107 ***Approved automatic fail-safe fire dampers shall be fitted in the ventilation trunk for tank room.***

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 for operation of both the required numbers of hydrants and hoses and the water spray system simultaneously.***

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

C 200 *Water spray systems*

201 ***A water spray system shall be fitted for cooling and fire prevention and to cover exposed parts of storage tank located on open deck.***

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

203 ***For the purpose of isolating damaged sections, stop valves shall 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 shall 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 shall 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 shall be arranged to ensure an effective distribution of water throughout the space being protected.***

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

C 300 ***Dry chemical powder fire extinguishing system***

301 ***In the bunkering station area a permanently installed dry chemical powder extinguishing system shall cover all possible leak points. The capacity shall be at least 3.5 kg/s for a minimum of 45 s discharge. The system shall be arranged for easy manual release from a safe location outside the protected area.***

302 ***One portable dry powder extinguisher of at least 5 kg capacity shall be located near the bunkering station.***

303 ***Main engine rooms where the gas fuel is heavier than air shall 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 shall 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 shall be arranged on separate loops.***

E. Spark arresters

E 100 General

101 Exhaust outlet from internal combustion machinery and boilers shall be provided with spark arrestors.

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 and wiring shall in general not to be installed in hazardous areas unless essential for operational purposes. The type of equipment and installation requirements shall comply with Pt.4 Ch.8 Sec.11 according to the area classification as specified in B.

103 Electrical equipment fitted in an ESD protected machinery space shall fulfil the following:

— In addition to fire and hydrocarbon detectors and fire and gas alarms, lighting and ventilation fans shall be certified safe for hazardous area zone 1.
— all electrical equipment in the engine room not certified for zone 1 shall be automatically disconnected if gas concentrations above 20% LEL is detected on two detectors in the engine room.

B. Area classification

B 100 General

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

102 In order to facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2 according to the principles of the standards IEC 60079-10 and guidance and informative examples given in IEC 60092-502 for tankers. Main features of the guidance are given in 200.

103 Areas and spaces other than those classified in 200 shall be subject to special consideration. The principles of the IEC standards shall be applied.

104 Area classification of a space may be dependent of ventilation as specified in IEC 60092-502, Table 1. Requirements for such ventilation are given in Sec.3 H400.

105 A space with opening to an adjacent hazardous area on open deck, may be made into a less hazardous or non-hazardous space, by means of overpressure. Requirements for such pressurisation are given in Sec.3 H200.

106 Ventilation ducts shall have the same area classification as the ventilated space.

B 200 Definition of zones

201 *Hazardous areas zone 0*

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

Guidance note:

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

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202 *Hazardous areas zone 1*

1) Tank room, as defined in Sec.3 A300.
2) Gas compressor room arranged with ventilation according to Sec.3 H503.
3) Areas on open deck, or semi- enclosed spaces on deck, within 3 m of any gas tank outlet, gas or vapour outlet (see note), bunker manifold valve, other gas valve, gas pipe flange, gas pump-room ventilation outlets and gas tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation.

Guidance note:

Such areas are, for example, all areas within 3 m of gas tank hatches, ullage openings or sounding pipes for gas tanks

located on open deck and gas vapour outlets

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

5) Areas on the open deck within spillage coamings surrounding gas bunker manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck.

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

Guidance note 1:

The ESD protected machinery space is considered as non-hazardous area during normal operation, but changes to zone 1 at gas detection.

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Guidance note 2:

Open ended ventilation pipes from gas piping systems will not create a hazardous zone in a surrounding well ventilated space.

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203 Hazardous areas zone 2

Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1 as specified in 202, if not otherwise specified in this standard.

C. Inspection and testing

C 100 General

101 Before the electrical installations in hazardous areas are put into service or considered ready for use, they shall be inspected and tested. All equipment, including cables, shall be verified as having been installed in accordance with installation procedures and guidelines issued by the manufacturer of the equipment and cables, and that the installations have been carried out in accordance to Pt.4 Ch.8 Sec.11.

102 For spaces protected by pressurisation it shall be examined and tested that purging can be fully accomplished. Purge time at minimum flow rate shall be documented. Required shutdowns and / or alarms upon ventilation overpressure falling below prescribed values shall be tested.

For other spaces where area classification depends on mechanical ventilation it shall be tested that ventilation flow rate is sufficient, and that required ventilation failure alarm operates correctly.

103 For equipment for which safety in hazardous areas depends upon correct operation of protective devices (for example overload protection relays) and / or operation of an alarm (for example loss of pressurisation for an Ex(p) control panel) it shall be verified that the devices have correct settings and / or correct operation of alarms.

104 Intrinsically safe circuits shall be verified to ensure that the equipment and wiring are correctly installed.

105 Verification of the physical installation shall be documented by the yard. Verification documentation shall be available for the Society's surveyor at the site.

D. Maintenance

D 100 General

101 The maintenance manual referred to in Sec.1 Table C1, shall be in accordance with the recommendations in IEC 60079-17 and 60092-502 and shall contain necessary information on:

— overview of classification of hazardous areas, with information about gas groups and temperature class
— records sufficient to enable the certified safe equipment to be maintained in accordance with its type of protection (list and location of equipment, technical information, manufacturer's instructions, spares etc.)
— inspection routines with information about level of detail and time intervals between the inspections, acceptance/rejection criteria
— register of inspections, with information about date of inspections and name(s) of person(s) who carried out the inspection and maintenance work.

102 Updated documentation and maintenance manual, shall be kept onboard, with records of date and names of companies and persons who have carried out inspections and maintenance.

Inspection and maintenance of installations shall be carried out only by experienced personnel whose training has included instruction on the various types of protection of apparatus and installation practices to be found on the vessel. Appropriate refresher training shall be given to such personnel on a regular basis.

SECTION 6
CONTROL, MONITORING AND SAFETY SYSTEMS

A. *General*

A 100 *Introduction*

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

102 ***Pressure gauges shall 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 containing liquid gas shall be provided with both a level indicator and a temperature sensor. Alarm shall be given at high level in bilge well. Temperature sensor low temperature indication shall lead to automatic closing of main tank valve.***

B. Monitoring

B 100 Gas tank monitoring

101 ***Gas tanks shall be monitored and protected against overfilling. Tanks for liquefied gas shall be monitored and protected as outlined in the Rules for Classification of Ships,*** **Pt.5 Ch.5 Sec.13 B100** ***and B200.***

102 ***Each tank shall be monitored with at least one local indicating instrument for pressure and remote pressure indication at the control position. The manometers and indicators shall 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 shall be provided on the bridge. The alarms shall 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 shall 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, control and monitoring as given in Table B2 is required for gas engines. 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					
System	*Item*	*Gr.1 Indication alarm load reduction*	*Gr.2 Automatic start of standby pump with alarm* 1)	*Gr.3 Shutdown with alarm*	*Comments*
1.0 Ignition system	Ignition failure each cylinder 2)	A			Automatic stop of gas supply 3)
2.0 Lubricating oil system	Cylinder lubrication flow 4)	LA			
3.0 Fuel injection valve cooling system 5)	Fuel injection valve cooling medium pressure	LA	AS		Automatic start of standby pump is not required if main pump is engine driven
	Fuel injection valve cooling medium temperature	HA			
4.0 Gas injection valve sealing oil system	Gas injection valve sealing oil pressure	LA			For high-pressure injection only
5.0 Gas fuel knock-out drums, if fitted	Gas fuel knock-out drums liquid level	HA			

Gr 1: Common sensor for indication, alarm, load reduction
Gr 2: Sensor for automatic start of standby pump
Gr 3: Sensor for shut down.

LA = Alarm for low value
HA = Alarm for high value
A = Alarm activated
AS = Automatic start of standby pump with alarm
LR = Alarm with request for either manual or automatic load reduction. For auxiliary engines other than prime mover of generators, slow down may be accepted (depending on application) as alternative means of load reduction
SH = Shut down.

1) Only for propulsion engines
2) Exhaust temperature deviation may be accepted as means of detecting ignition failure, individually on each cylinder
3) Gas shut down to the specific cylinder or the engine can be accepted
4) At least one measuring point for each lubricator unit
5) Dual fuel engines only.

B 400 Gas supply system safety functions

401 The gas supply system shall have safety functions as given in Table B3.

Table B3 Gas supply system safety functions				
Parameter	*Alarm*	*Automatic shutdown of main tank valve*	*Automatic shutdown of gas supply to engine room* 1)	*Comment*
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 6)	***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***			

Table B3 Gas supply system safety functions (Continued)

Parameter	*Alarm*	*Automatic shutdown of main tank valve*	*Automatic shutdown of gas supply to engine room* [1]	*Comment*
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 [6]	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	
Rupture detection in gas supply piping to ESD protected engine room and for high pressure gas supply	X		X	

1) Automatic shutdown of gas supply to engine room has different requirements for high and low pressure gas with regard to valve action. See Sec.3 E103 to E105.

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

3) This parameter shall not lead to shutdown of gas supply for single fuel gas engines, only for dual fuel engines.

4) Only double block and bleed valves to close.

5) If the duct is protected by inert gas (see Sec.3 F101) then loss of inert gas overpressure shall lead to the same actions as given in this table.

6) Ventilation to the space shall stop automatically and fire dampers shall close.

B 500 Ventilation monitoring

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

502 ***If the ventilation in the ducting around the gas bunkering lines stop, an alarm shall sound at the bunkering control location.***

503 Full stop of ventilation in an engine room for a single fuelled gas system shall, additionally to what is given in Table B3, lead to one of the following actions:

a) *For a gas electric propulsion system with more than one engine room:* Another engine shall start. When the second engine is connected to bus-bar the first engine shall be shutdown automatically.

b) *For a direct propulsion system with more than one engine room:* The engine in the room with defect ventilation shall 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 shall close automatically provided the other gas supply unit is ready to deliver.

C. Gas Detection

C 100 Locations

101 Permanently installed gas detectors shall be fitted ***in the tank room***, in all ducts around gas pipes, in engine rooms, compressor rooms, and other enclosed spaces containing gas piping or other gas equipment, but not including spaces where completely ducted gas pipes are passing through. In each ESD protected machinery space two independent gas detector systems are required.

Guidance note:

Gas detectors may be required also in inherently safe engine rooms in any of the following cases:

- the ventilation air to the double pipe/duct is taken from the engine room
- the gas is supplied into the charge air before the inlet valve in the cylinder head if the components in contact with the gas air mixture are not protected by a double duct

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

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

103 The detection equipment shall be located where gas may accumulate and or in the ventilation outlets.

Gas dispersal analysis or a physical smoke test shall be used to find the best arrangement.

104 An audible and visible alarm shall 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.

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

However for gas detection in the ducting around the bunkering lines an alarm shall sound at the bunkering control location.

106 Gas detection for gas pipe ducts and engine rooms shall be continuous without delay.

D. Signboards

D 100 General

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

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

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

SECTION 7
COMPRESSORS AND GAS ENGINES

A. Gas Compressors

A 100 General

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

102 The gas compressor and fuel gas supply shall 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 shall 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 shall 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.

104 When gas is supplied in a mixture with air via a common inlet manifold, explosion relief venting of the manifold shall be arranged; alternatively the manifold shall be of sufficient strength to withstand an explosion.

B 200 Functional requirements dual fuel engines

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

In case of shut-off of the gas fuel supply, the engines shall 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 shall be automatic. On power reduction the changeover to oil fuel shall be automatic (compressor and auxiliaries may continue to run unloaded).

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

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

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 shall be automatically shut off and the starting sequence terminated.

303 When restarting after a failed start attempt admission of fuel gas to the cylinders shall not 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 shall be fed to each cylinder via a special gas valve. For small engines gas feed to a common manifold may be considered.

SECTION 8
MANUFACTURE, WORKMANSHIP AND TESTING

A. *Gas Tanks*

A 100 *Manufacture and testing*

101 ***Tests related to welding and tank testing shall be in accordance with the Rules for Classification of Ships,* Pt.5 Ch.5 Sec.5 K, L, M, *and* N.**

B. Gas Piping Systems

B 100 Gas pipes

101 The gas pipes shall be tested as given in the Rules for Classification of Ships, 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 shall be subjected to 100% radiographic testing.

B 200 Ducting

201 If the gas piping duct contains high-pressure pipes the ducting shall be pressure tested to at least 10 bar. Ducts for low pressure gas piping shall be tightness tested.

B 300 Valves

301 Each type of valve to be used at working temperatures below minus 55°C shall be prototype tested as given in the Rules for Classification of Ships, Pt.5 Ch.5 Sec.6 C801.

B 400 Expansion bellows

401 Expansion bellows intended for use in gas systems shall be prototype tested as given in the Rules for Classification of Ships, Pt.5 Ch.5 Sec.6 C802.