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

The present edition of the rules includes amendments and additions approved by the Executive Committee as of November 2011 and supersedes the January 2011 edition of the same chapter.

The rule changes come into force as described below.

Text affected by the main rule changes in this edition is highlighted in red colour. However, where the changes involve a whole chapter, section or sub-section, only the title may be in red colour.

This chapter is valid until superseded by a revised chapter.

Main changes coming into force 1 July 2012

- **General**
  - Clarification and amendments of rule requirements in general (arrangement of spaces, accesses, valve arrangements, relief valves, drip trays, ventilation). Revised requirement for tank location.
  - Added requirements about gas heating systems, portable tanks, access to tanks, inert gas systems, included boilers and gas turbines in scope of rules.
  - Clarification of control system requirements, separated the requirements for control systems and safety systems.
  - Documentation requirements have been amended in Sec.1 Table C1.

Corrections and Clarifications

In addition to the above stated rule requirements, a number of corrections and clarifications have been made to the existing rule text.
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B. 燃气管道系统
   B 100 燃气管道
   B 200 风管
   B 300 阀门
   B 400 扩张波纹管

C. 在船测试
   C 100 一般
SECTION 1
GENERAL REQUIREMENTS

A. Classification

100 Objective
The goal of this rule chapter is to provide criteria for the arrangement and installation of machinery for propulsion and auxiliary purposes, using gas as fuel, which will have an equivalent level of integrity in terms of safety and availability as that which can be achieved with a new and comparable conventional oil-fuelled main and auxiliary machinery.

200 Scope
This rule chapter includes requirements from the ship’s gas fuel bunkering connection up to and including the gas consumers. The chapter has requirements for arrangement and location of gas fuel tanks and all spaces with gas piping and installations, including requirements to entrances to such spaces.

Hazardous areas and spaces due to the gas fuel installations are defined.

Requirements for control, monitoring and safety systems for the gas installations are included, also additional monitoring requirements for gas engines and compressors.

For tank design and gas piping detail design reference is made to Pt.5 Ch.5.

Requirements for manufacture, workmanship and testing are included, mainly referring to details given in Pt.5 Ch.5.

Bunkering procedures are required for approval, but apart from this the bunkering processes are not part of the scope for this rule chapter. Crew training is not part of the scope for this rule chapter.

300 Application
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 gas 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.

Guidance note 2:
IMO resolution MSC.285(86) ‘Interim Guidelines on Safety for Gas Fuelled Engine Installations in Ships’ provides international guidelines, and may be enforced by the flag. In addition to what is required in this rule chapter, the Interim Guidelines require safety assessments to be done for new designs and concepts.

Guidance note 3:
Requirements not relevant for LNG carriers are shown in bold italic text.

This rule chapter can also be applied to gas fuelled gas turbine and boiler installations in ships.

Guidance note:
Dual fuel boilers: Rules for Classification of Ships Pt.5 Ch.5 Sec.16 should be used for approval of main boilers for propulsion or other main functions, while safety related requirements from the same chapter should be used for boilers that are not supporting the ship main functions.

Gas turbines: Gas turbine requirements are found in Pt.4 Ch.3 Sec.2. A gas tight turbine enclosure can be approved using the ESD protected engine room principles, even though the pressure exceeds 10 bar in the piping. Particular focus should be given to ventilation rate in such an enclosure.

303 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.

400 Class notation
Ships built with machinery satisfying the requirements in this chapter will be given class notation: GAS FUELLED.
A 500 Survey extent

501 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 are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, game and hobby rooms, barber shops, pantries containing no cooking appliances and similar spaces.

102 Control stations are those spaces in which the ship's radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralized. Spaces where the fire recording or fire control equipment is centralized are also considered to be a fire control station.

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).

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.

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

108 Fuel containment system is the arrangement for the storage of fuel including tank connections. It includes where fitted, a primary and secondary barrier, associated insulation and any intervening spaces, and adjacent structure if necessary for the support of these elements. If the secondary barrier is part of the hull structure it may be a boundary of the fuel storage hold space.

109 Fuel storage hold space is the space enclosed by the ship's structure in which a fuel containment system is situated. If tank connections are located in the fuel storage hold space, it will also be a tank connection space, and will have to fulfil the requirements for both spaces.

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

111 Gas control systems are providing control and monitoring for bunkering, gas storage and gas supply to machinery.

112 Gas safety systems are the safety systems for bunkering, gas storage and gas supply to machinery.

113 Gas valve unit spaces are spaces or boxes containing valves for control and regulation of gas supply before the consumer.

Guidance note:
The gas valve unit is by different suppliers also called for instance GVU, gas regulating unit, GRU or gas train.

114 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.

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

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

116 **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.

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

118 **LEL** is lower explosion limit.

119 **Main tank valve** is the remote operated valve on the gas supply outlet from a gas storage tank.

120 **MARVS** is the maximum allowable relief valves setting of a gas tank.

121 **Master gas fuel valve** is an automatic valve in the gas supply line to each engine located outside the engine room.

122 **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.

123 **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.

124 **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.

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

126 **Tank connection space** means the gastight space surrounding the bunker tank connections and tank valves.
## C. Documentation

### C 100 Plans and particulars

**101 Documentation shall be submitted as required by Table C1.**

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| 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                           | Including testing of safety shut downs in accordance with the cause and effect diagram G130 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | AP   |
| Z160 Operational manual                                               | Including procedures for: | — bunkering  
— gas freeing and inerting  
— normal operation  
— emergency operation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | AP   |
| Fuel gas tanks                                                        | C030 Detailed drawing | — tanks  
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— insulation  
— marking plates.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | AP   |
| C040 Design analysis                                                  | Including:         | — 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   |
| Fuel gas tanks safety relief valves and associated ventilation piping | C030 Detailed drawing |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | AP   |
| Z030 Capacity analysis                                                | Including back pressure. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | AP   |
| Z100 Specification                                                    |                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | AP   |
| Fuel gas tanks gas freeing and purging system                         | S010 Piping diagram |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | AP   |
| Gas control system                                                    | I200 Control and monitoring system documentation | — tank level monitoring  
— tank system control and monitoring  
— gas ramp control and monitoring  
— bunkering control  
— gas system mode selection.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | AP   |
| Gas safety system                                                     | I200 Control and monitoring system documentation | functionality as required by Sec. 3 Table C1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | AP   |
| G130 Cause and effect diagram                                         | Including:         | — shall cover the safety functions as required by Sec. 3 Table C1  
— interfaces to other safety and control systems shall be included.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | AP   |
<table>
<thead>
<tr>
<th>System</th>
<th>Documentation type</th>
<th>Additional description</th>
<th>Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel gas piping system</td>
<td>C030 Detailed drawing</td>
<td>Insulation of low temperature piping.</td>
<td>FI</td>
</tr>
</tbody>
</table>
|                                             | C050 Non-destructive testing (NDT) plan | Including:  
  — Specification of pressure tests (structural and tightness tests)  
  — Specification of post-weld heat treatment                                     | AP   |
|                                             | M010 Material specification |                                            |      |
|                                             | 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 |                                            |      |
|                                             | 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   |
| 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   |
| Fuel gas compressors control and monitoring system | I200 Control and monitoring system documentation |                                            | AP   |
| Exhaust gas system                          | S010 Piping diagram | Including arrangement of explosion relief or verification of strength of piping system, ref. Sec.3 D | 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       | S012 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   |
|                                            | I200 Control and monitoring | Including detection of ventilation function, safety actions and sequences, arrangement of powering of fans etc. | AP   |
| Installation in hazardous areas             | G080 Hazardous area classification drawing | An approved Area classification drawing where location of electric equipment in hazardous area is added (Except battery room, paint stores and gas bottle store). | FI   |
|                                            | E090 Table of Ex-installation | Based on approved area classification. Refer to Pt.4 Ch.8 for details.                  | 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   |
| Fire protection                             | G060 Structural fire protection drawing |                                            | AP   |
D. Certification

D 100 Gas engines
101 Gas engines shall, in addition to the requirements in this chapter, 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.

Tanks for compressed natural gas (CNG) may also be certified based on Rules Pt.5 Ch.15 Compressed Natural Gas Carriers.

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.

Valves in low temperature service of which correct operation is important for safety shall have DNV product certificate even for diameters below 100 mm.

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 with 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.

D 500 Control and monitoring system
501 The following control and monitoring system shall be certified according to Pt.4 Ch.9:

— gas control system
— gas safety system
— ventilation control system
— gas detection system.

D 600 Electric motors and motor-starters
601 Electric motors and motor-starters for gas supply system and ventilation system are considered to be important consumers, and shall be certified in accordance with Pt.4 Ch.8 Sec.1 B300.
E. Onboard Documentation

E 100  Contents

101  *An operational manual as described in Table C1 shall be kept on board.*

102  A plan for periodic test of all field instruments specified in these rules shall be kept on board. The plan shall include test intervals, description of how to perform the tests and description of what to observe during the tests.

Test intervals for shutdown inputs and outputs (as required by Sec.6 Table C1) shall not exceed 6 months. For other signals the test intervals shall not exceed 12 months.

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

**Guidance note:**
See Pt.6 Ch.3 Sec.1 D for information about plan for periodic test.

---end---of---Guidance---note---

F. Signboards

F 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.

104  A signboard shall be permanently fitted on access hatches to tank connection spaces stating that the space containing the access hatch will be hazardous when the hatch is open, and that all non ex certified equipment shall be de-energized prior to the opening of this hatch. This is not necessary if the access to the tank connection space is arranged with an air lock.

105  A signboard shall be permanently fitted on direct access doors or hatches to gas valve unit spaces/boxes in engine rooms (without air lock) stating that the door or hatch shall only be opened after the gas supply system is shut down and gas free.
SECTION 2
MATERIALS

A. General

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 enclosed 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°C 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.

The same applies if a duct or outer pipe containing warm gas pipes can be exposed to liquid gas leakage from other sources or spaces.
SECTION 3
ARRANGEMENT AND SYSTEM DESIGN

A. Location and Separation of Spaces, Arrangement of Entrances and Other Openings

A 100 General

101 Access from a hazardous space or hazardous open deck area to a non-hazardous space shall be through an air lock which complies with the requirements of B100. Specific requirements and restrictions for access to different types of spaces are found below.

Guidance note:
Gas valve unit spaces in gas safe engine rooms will not need to comply with the requirement for an air lock on the condition that the gas valve unit space is normally locked, and shall only be entered after gas supply system is shut down and gas free. The door must be fitted with a signboard to this effect. The gas valve unit room is considered part of the double duct in the engine room and shall therefore be extraction ventilated with at least 30 air changes per hour and fitted with a gas detection system typically giving shut down of gas supply into the area at detection of gas.

---end of Guidance note---

102 Cofferdams shall be of sufficient size for easy access to all parts. Minimum distance between bulkheads: 600 mm.

Guidance note:
For cofferdams protecting gas fuel tanks from fire risk spaces see A404, and for access around tanks see H211.

---end of Guidance note---

103 Spaces containing piping or equipment for cryogenic liquids shall be fitted with low temperature drip trays under leakage points (sources of release). For high pressure compressed gas, low temperature steel shielding should be provided to prevent cold jets impinging on surrounding structure.

The surrounding hull or deck structures shall not be exposed to unacceptable cooling, in case of leakage of liquid or compressed gas.

If the piping and equipment in such a space is connected to liquid gas tanks in such a way that risk of leakages from the tanks into the space cannot be efficiently excluded, the requirements as for tank connection spaces in 400 shall be made applicable to this space.

104 Bilge suction from the tank connection space, compressor room, pump room or similar spaces with gas equipment, if provided, shall not be connected to the bilge system for the rest of the ship.

A 200 Gas compressor or pump room

201 Compressor or pump rooms, if arranged, shall be located on open deck, or arranged in accordance with A400 Tank connection spaces.

202 If the compressor room is 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 B100 shall be provided.

203 Where compressors are driven by shafting passing through a bulkhead or deck, the bulkhead penetration shall be of gas tight type.

A 300 Engine rooms

301 When more than one engine room is required (ESD protected engine rooms) 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.

302 Engine rooms of the ESD protected type shall have as simple geometrical shape as possible and be arranged to minimize potential gas-traps e.g. between beams and bulkheads.

303 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.

304 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.

305 Access to engine rooms shall not be from hazardous spaces. It is however accepted to have access to gas valve units in engine rooms.
A 400 Tank connection spaces

401 The fuel storage tank connections, flanges and tank valves not located on open deck must be enclosed in a tank connection space. The space shall be able to safely contain leakage from the tank in case of leakage in the tank connections. 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. However, based on maximum leakage calculations, arrangements without full extent of the low temperature material barriers may be approved. Ship movements must be taken into consideration.

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 isolated thermally so that the surrounding hull is not exposed to unacceptable cooling, in case of leakage of liquid gas. This secondary barrier space is in other parts of this chapter called “tank connection space”.

402 A leakage of liquid gas into the gas connection space shall not render necessary safety functions out of order due to the cryogenic temperatures.

Guidance note:
Valves, actuators, control systems are to be designed and arranged for being able to operate after liquid gas leakage.

---end---of---Guidance---note---

403 Tank connection space boundaries shall be gas tight towards other enclosed spaces in the ship.

404 Gas fuel tanks in enclosed spaces including secondary barriers where required and tank connection spaces shall not be located adjacent to machinery spaces of category A or other high fire risk areas.

The protective cofferdam shall have a minimum distance of 900 mm between bulkheads or decks.

For vacuum insulated type C fuel tanks the fuel storage hold space may act as the protective cofferdam, if the bulkhead is at least 900 mm from the outer shell of the tank. This can however not be applied to tanks located directly above machinery spaces of category A or other high fire risk areas.

Common boundaries of protective cofferdams with engine rooms or high fire risk areas shall kept to a minimum.

Fuel gas tanks shall be protected from external fires by class divisions as given in Sec.4.

Guidance note:
High fire risk areas are for instance cargo areas for carriage of dangerous goods and cargo decks for cars with fuel in the tanks.

---end---of---Guidance---note---

405 The tank connection space entrance shall be arranged with a sill height of at least 300 mm or the level of liquid gas based on calculated maximum leakage.

406 Access to the tank connection space is as far as practicable to be independent and direct from open deck. This requirement shall be applied to the room where the opening to the tank connection space is located, if the tank connection space access is through a hatch.

Where a separate access from deck is not practicable, an air lock which complies with the requirements of B100 shall be provided. It should not be possible to have unauthorized access to the tank connection space during normal operation of the gas system.

407 If the tank connection space access is not from open deck and is not arranged with an air lock directly on the tank connection space access, certain requirements will be made applicable to the room containing the access to the tank connection space:

--- Separate ventilation with at least 8 air changes per hour.
--- The room is considered non-hazardous under normal conditions, but when access to tank connection space is required it has potential to become gas hazardous.

In this case non-explosion protected equipment shall be de-energized, while equipment in use shall be of explosion protected design suitable at least for zone 2. Electrical cables led through the spaces are exempted.

A 500 Fuel storage hold space

501 The fuel storage hold space shall not be used for machinery or equipment that may have a fire risk.

A 600 Other spaces containing gas equipment

601 Other spaces containing gas equipment like valves, vaporizers, heaters etc. should generally follow the requirements for compressor and pump rooms in A200.
B. Arrangement of air locks

B 100 General

101 An air lock is a space enclosed by gastight steel bulkheads with two substantially gastight doors spaced at least 1.5 m and not more than 2.5 m apart. The doors shall be self-closing without any holding back arrangements.

102 Air locks shall be mechanically ventilated at an overpressure relative to the adjacent hazardous area or space. The ventilation inlets and outlets for air locks are to be located in open air. For ventilation of the protected space see J201.

103 Air locks shall have a simple geometrical form. They shall provide free and easy passage, and shall have a deck area not less than about 1.5 m². Air locks shall not be used for other purposes, for instance as store rooms.

104 An audible and visual alarm system to give a warning on both sides of the air lock shall be provided to indicate if more than one door is moved from the closed position.

105 The air lock space shall be monitored for flammable gas.

106 For gas safe spaces with access from hazardous open deck where the access is protected by an air-lock, electrical equipment which is not of the certified safe shall be de-energized upon loss of overpressure in the space.

For gas safe spaces with access from hazardous spaces where the access is protected by an air-lock, electrical equipment which is not of the certified safe type shall be de-energized upon loss of underpressure in the hazardous space.

The requirement for de-energizing is not applicable for safe spaces having access through air lock from a gas safe space containing a tank connection space access (as outlined in A407). It is also not applicable to engine rooms with access to gas valve unit spaces.

Guidance note:
The de-energizing requirement consequently means that electrical equipment needed for maintaining ship main functions or safety functions cannot be located in spaces protected by air locks unless the equipment is of certified safe type.

---end---of---Guidance---note---

C. General Gas Piping Design

C 100 General

101 All automatic and remotely operated valves are to be provided with indications for open and closed valve positions at the location where the valves are remotely operated.

102 Valves shall fail to a safe position.

Guidance note:
“Fail to close” is generally considered to be the safe mode. For Double-Block-and-Bleed arrangements, the bleed valve shall fail to open position. Valves in vent lines intended to relieve trapped liquid gas in piping systems shall also fail to open.

---end---of---Guidance---note---

103 Gas pipes shall in general comply with the applicable parts of the Rules for Classification of Ships, Pt.5 Ch.5 Sec.6.

104 Gas piping shall not be located less than 800 mm from the ship's side.

105 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.

106 The gas piping system shall be installed with sufficient flexibility. Bellows shall not be arranged in enclosed spaces.

107 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.

---end---of---Guidance---note---

108 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.
109 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.

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

[IACS UR M59]

111 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.

112 Gas piping shall be protected against mechanical damage.

Guidance note:
Gas pipes lead through ro-ro spaces on open deck shall be provided with guards or bollards to prevent vehicle collision damage. Gas pipes in other types of cargo areas with risk of damage from cargo operations shall be similarly protected.

Gas pipes in double ducts in other areas are generally regarded as sufficiently protected.

Gas pipes in ESD protected machinery spaces shall be mechanically protected if they are so located that objects can fall onto them. If the pipes are located high up and close to the bulkheads additional protection is not needed.

113 High-pressure gas lines shall be installed and protected so as to minimise the risk of injury to personnel in case of rupture.

D. Exhaust system

D 100 General

101 The exhaust system 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 system.

102 The explosion venting shall be led away from where personnel may normally be present.

Guidance note:
Both explosion impact and amount of potentially suffocating combustion gases shall be taken into account when deciding where explosion relief can be located. The distance from a relief valve to gangways and working areas should generally be at least 3 meters, unless efficient shielding is provided. Bursting discs shall not open into engine rooms, but may be located inside the casing.

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 Exhaust gas piping shall be arranged to avoid possibility for accumulation of unburned gas.
E. System Configuration

E 100 General

101 The propulsion and fuel supply system shall be so designed that the remaining power after any safety actions required by Sec.6 Table C1 (except fire alarm) shall be sufficient to maintain propulsion, power generation and other main functions defined in Pt.1 Ch.1 Sec.1 A200.

E 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.

E 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.

E 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 are 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 such that in the case of shutdown of fuel supply to any one engine room it is possible to maintain sufficient propulsion power plus normal electrical power supply for sea going services. Incinerators, inert gas generators, other oil fired boilers or other ignition sources which can not be de-energized are not located within the ESD protected machinery space.

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

c) A gas detection system is arranged in the engine room. At gas detection the safety system shall automatically shutdown the gas supply (also oil fuel supply if dual fuel) and de-energize all non-explosion protected equipment or installations in the engine room.

F. Gas supply system arrangement

F 100 Gas supply system general

101 For single gas fuel systems (gas only) the fuel supply system shall be arranged with redundancy and segregation all the way from the gas tank to the consumer, so that a leakage in the fuel supply system with following necessary safety actions does not lead to loss of propulsion, power generation or other main functions.

The fuel storage shall be divided between two or more tanks, including separate secondary barriers when required.

If transfer piping is arranged between tanks, this is to be so arranged that a leakage will not affect both supply systems.

In the case LNG tanks of type C are used, one tank may be accepted if two completely separate tank connection spaces are installed for the one tank.

102 Gas storage tank inlets and outlets shall be provided with valves located as close to the tank as possible. Valves required to be operated during normal operation which are not accessible shall be remotely operated. Normal operation in this context is when gas is supplied to consumers and during bunkering operations. Regarding automatic operation of tank valves, see Sec.6 Table C1.

103 The main supply lines for gas to each engine room shall be equipped with automatically operated
“Master gas fuel valves”. The valve shall be situated outside the engine room. The master gas fuel valve is automatically to cut off the gas supply to the engine room as given in Sec.6 Table C1.

104 The gas supply to each consumer shall be provided with a set of “double block and bleed” valves. These valves shall be arranged for automatic shutdown as given in Sec.6 Table C1, and for normal stop and shutdown of the engine. An alarm for faulty operation of the valves shall be provided.

**Guidance note:**
Block valves open and bleed valve open is an alarm condition. Similarly engine stopped and block valves open is an alarm condition.

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

105 An arrangement that automatically ventilates the pipe between the master gas valve and the double block and bleed valve when these are closed, shall be fitted. For high-pressure systems the pipe pieces between the double block and bleed valve and the gas injection valves, shall also be automatically vented. For high-pressure systems the ventilation valves shall open at normal stop of engine.

See Fig.1 and Fig.2.

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

Fig. 1
Alternative supply valve arrangements for high-pressure installations (single engine or separate master valve arrangement)
There shall be one manual shutdown valve in the gas supply line to each engine to assure safe isolation during maintenance on the engine.

Where a separate master gas fuel valves is provided for each consumer, 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.

Each gas supply line entering an ESD protected machinery space, and each gas supply line to high pressure installations, shall be provided with means 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 at the engine inlet.

**Guidance note:**
The shutdown should be time delayed to prevent shutdown due to transient load variations.
F 200 Distribution outside of machinery spaces

201 Gas fuel piping shall normally 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 that is gas tight towards surrounding spaces. This duct shall be ventilated as outlined in J600, and gas detection as required in Sec.6 shall be provided.

203 The duct shall be dimensioned according to G103 and G104.

F 300 Gas heating

301 If the heating medium for the liquefied gas vaporizer has a freezing point above the boiling temperature of the liquefied gas the following arrangement shall be provided:

— alarm for low temperature of outlet of heating medium
— automatic stop of liquefied gas feed pump (if fitted) and closing of tank valve at stop of circulation of heating fluid.

302 Circulation pumps for the heating fluid shall be arranged with redundancy, if circulation is necessary to prevent freezing in the heating circuit. Power supply shall then be from an UPS or alternative means for maintaining circulation for a sufficiently long period in case of loss of electric power supply.

303 The heating circuit expansion tank shall be fitted with a gas detector and shall be vented to open air.

G. Gas Supply System in Machinery Spaces

G 100 Gas supply system for inherently gas safe machinery spaces

101 Gas supply lines in inherently gas safe machinery 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 extraction 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 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 = \frac{C_p}{C_v} constant pressure specific heat divided by the constant volume specific heat

k = 1.31 for CH_4

The tangential membrane stress of a straight pipe 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.

G 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.

H. Gas Fuel Storage Tanks

H 100 General

101 A fuel gas containment system located below deck shall be gas tight towards adjacent spaces. For fuel gas containment systems where leakage through the primary barrier is part of the design assumptions the gas tight barrier will be the secondary barrier or in case of partial secondary barriers, the fuel storage hold space.

H 200 Liquefied gas storage tanks

201 The storage tank used for liquefied gas shall be an independent tank or a membrane tank designed in accordance with the Rules for Classification of Ships, Pt. 5 Ch. 5 Sec. 5.

Guidance note:
Additional requirements for membrane tanks, A and B type tanks used as fuel tanks will be considered specially. Particular focus will be given on having sufficient operational simplicity of membrane tank systems. Location of membrane tanks below accommodation will not be accepted unless the leakage risks are properly considered and mitigated.

202 The secondary barrier requirements for the tank type will apply as outlined in Pt. 5 Ch. 5.

203 Pipe connections to the tank shall be in accordance with the Rules for Classification of Ships, Pt. 5 Ch. 5 Sec. 6 C304.

204 Pressure relief valves as required in the Rules for Classification of Ships, Pt. 5 Ch. 5 Sec. 9 B200 to B400 shall be fitted.

205 All tanks shall have at least two completely independent pressure relief valves.

206 Stop valves are to be fitted before and after the pressure relief valves. This is to enable in-service maintenance, to stop gas from escaping in case of a leaking pressure relief valve and to be able to maintain tank pressure in cases where this is used to drive gas supply to engine room.

An interlocking mechanism shall be arranged in order to prevent all pressure relief valves for the same tank from being out of service simultaneously.

The in service remaining pressure relief valves shall have the combined relieving capacity required by Pt. 5 Ch. 5 Sec. 9 B300, when one valve is disconnected.

207 The outlet from the pressure relief valves shall be located at least 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.

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

209 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%.

210 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.

211 Access for external inspection of gas fuel tanks shall be in accordance with Pt.5 Ch.5 Sec.4 A100.

212 Access for internal inspection of gas fuel tanks is generally required.

Guidance note:
Vacuum insulated type C tanks below about 700 m³ size may be accepted without access.

213 With the exception of gas fuel tanks designed to withstand the full gauge vapour pressure of the fuel under conditions of the upper ambient design temperature, means should be provided to keep the tank pressure below the MARVS by safely utilizing or disposing of the boil-off at all times, including when in port, while manoeuvring or standing by. Systems and arrangements that may be used for this purpose may include one or a combination of the following:

— energy consumption by the ship (engines, gas turbines, boilers etc.)
— re-liquefaction
— thermal oxidation of vapours (gas combustion unit)
— tank insulation or tank design pressure sufficient to maintain the tank pressure below the MARVS and for the tank not to become liquid full for a period of 15 days under all tank filling conditions, starting at the tank working pressure

Guidance note:
For design of re-liquefaction systems and gas combustion units, Classification Note No.61.2 can be used as guidance.

214 Venting of fuel vapour for control of the tank pressure is not acceptable except in emergency situations.

H 300 Compressed gas storage tanks

301 The storage tanks to be used for compressed gas shall be in accordance with Pt.4 Ch.7 or Pt.5 Ch.15 and shall be certified by the Society.

302 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.

H 400 Storage on open deck

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

402 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 may be accepted.

The inboard distance shall in no case be less than the distance ‘d’ as following:

(i) for Vc below or equal 1000 m³, d = 0.80 m
(ii) for 1000 m³ < Vc < 5000 m³, d = 0.75+ Vc × 0.20/4000
(iii) for 5000 m³ <= Vc < 30 000 m³, d = 0.8 + Vc/25000
(iv) for Vc >= 30 000 m³, d = 2 m

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

Note: ‘d’ is measured at any cross section at a right angle from the moulded line of outer shell.
403  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.

404  Gas storage tanks on open deck shall be protected against mechanical damage.

405  Deck tanks shall be fitted with drip trays under potential leakage points. Drip trays shall be of sufficient size to contain the calculated maximum leakage volume, but need not be intended to hold the full volume of the tank. Ship movement shall be taken into consideration when deciding drip tray volume. Drip trays shall be drained over board.

The material of the drip tray shall be stainless steel or other material suitable for low temperatures, and there shall 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.

Guidance note:
The maximum leakage shall be determined based on detail design, detection and shut down systems.

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406  If tank connection spaces are arranged instead of drip trays, and these spaces are fully located in open air the ventilation rate required in J300 may be reduced to 8 air changes per hour, and fan redundancy is not required.

H 500  Storage in enclosed spaces

501  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 A400:

— adequate means are provided to depressurize the tank in case of a fire which can affect the tank; and
— all surfaces within the tank connection space and fuel storage hold space 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 connection space and the fuel storage hold space.

Guidance note:
An approved water based high pressure fog system would fulfil this requirement.

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502  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.

The distance shall be measured inboard from the moulded line of the outer shell at right angles to the centreline at the level of the summer water line.

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

measured from the moulded line of the bottom shell plating at centreline

The inboard distance shall in no case be less than the distance ‘d’ as following:

(i) for \( V_c \) below or equal 1000 \( m^3 \), \( d = 0.80 \) m
(ii) for \( 1000 m^3 < V_c < 5000 m^3 \), \( d = 0.75 + V_c \times 0.20/4000 \)
(iii) for \( 5000 m^3 \leq V_c < 30\ 000 m^3 \), \( d = 0.8 + V_c/25000 \)
(iv) for \( V_c \geq 30\ 000 m^3 \), \( d = 2 \) m

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

Note: ‘d’ is measured at any cross section at a right angle from the moulded line of the outer shell.

Gas fuel tanks located closer than B/5 from the ship side may be accepted and approved by the Society. This does not apply to tanks in passenger ships and to tanks located below accommodation in cargo ships, which will have to fulfil the B/5 requirement.

Guidance note:
For independent tanks the protective distance shall be measured to the tank shell (the primary barrier of the tank containment system). For membrane or semi-membrane tanks the distance shall be measured to the bulkheads surrounding the tank insulation.

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503  For multi-hulls the breadth B to be used for the above calculations can be taken as the combined
breadth of each single hull, where the single hull breadth is as defined in the HSC code. Additional tank protection may however be needed for high speed light craft.

H 600 Portable tanks

601 Portable tanks shall be certified by the Society.

602 Gas fuel systems utilising portable gas fuel tanks shall be specially considered, and shall have equivalent safety as permanent gas fuel tanks.

As a minimum the following aspects shall be considered:

— The tanks shall be located in dedicated areas fitted with:
  — spill protection
  — arrangements for supporting/fixing the tanks
  — water spray systems for cooling if located on open deck
  — mechanical protection of the tanks depending on location and cargo operations
  — if in enclosed spaces: tank connection spaces as for permanent tanks.

— Connections to the ship systems, including shut down systems for tank valves and a fixed safety relief valve outlet
— Tank monitoring systems and their interface with ship systems
— Leak/ gas detection systems.

I. Fuel Bunkering System

I 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. A water curtain shall be fitted for high capacity bunkering systems as outlined in Sec.4.

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, as well as monitoring of ventilation and gas detection for the duct containing bunkering pipes.

  Guidance note:
  See section 6 for detail requirements for control, monitoring and safety requirements.

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I 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.

203 Bunkering pipes shall be self draining.

204 Bunkering lines shall be arranged for inerting and gas freeing. During operation of the vessel the bunkering pipes shall be gas free, unless the consequences of not gas freeing is evaluated and approved.

J. Ventilation Systems

J 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.

107 Ventilation inlets and outlets for spaces required to be fitted with mechanical ventilation in this rule chapter shall be so located that they according to the International Load Line Convention will not be required to have closing appliances.

J 200 Non-hazardous spaces

201 Spaces with opening to a hazardous area on open deck, 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 de-energizing of electrical installations is required according to IEC 60092-502, Table 5.

J 300 Tank connection space

301 The tank connection space below deck shall be provided with an effective mechanical ventilation system of the extraction type, providing a ventilation capacity of at least 30 air changes per hour.

302 The number and power of the ventilation fans for tank connection spaces 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.

J 400 Engine room

401 The ventilation system for double piping and for gas valve unit spaces in inherently gas safe engine rooms shall be independent of all other ventilation systems.

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

403 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 per hour is acceptable provided that, if gas is detected in the machinery space, the number of air changes will automatically be increased to 30 per hour.

404 The number and power of the ventilation fans for ESD protected engine rooms and for double pipe ventilation systems for inherently gas safe engine rooms 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.
J 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 for compressor rooms and pump rooms 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 600  Ducts and double pipes

601  Ducts and double pipes containing gas piping shall be fitted with effective mechanical ventilation system
of the extraction type, providing a ventilation capacity of at least 30 air changes per hour.
This is not applicable to double pipes in engine room if fulfilling G101 a).

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

Guidance note:
E302 gives an exemption for ventilation inlets in inherently gas safe engine rooms, applicable for gases lighter than
air only.

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K. Nitrogen Installations

K 100  Inert gas systems

101  To prevent the return of flammable gas to any gas safe spaces, the inert gas supply line shall be fitted with
two shutoff valves in series with a venting valve in between (double block and bleed valves). In addition a
closable non-return valve shall be installed between the double block and bleed arrangement and the gas fuel
system.
These valves shall be located outside non-hazardous spaces and must function under all normal conditions
of trim, list and motion of the ship.
The following conditions apply:

a)  The operation of the valves shall be automatically executed.
    Signals for opening and closing shall be taken from the process directly, e.g. inert gas flow or differential
    pressure.

b)  An alarm for faulty operation of the valves shall be provided.

102  Where the connections to the gas piping systems are non-permanent, two non-return valves may
substitute the non-return devices required in 101.

103  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

K 200 Nitrogen installation spaces

201 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.
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 Any boundary of accommodation up to bridge windows, machinery spaces and cargo spaces facing gas fuel tanks on open deck shall have A-60 fire integrity and bridge windows A-0 (with fire load from outside).  

102 Tank connection spaces, their ventilation trunks and fuel storage tank hold spaces with their protective cofferdams (if required) shall be fire insulated to class A-60 standard towards machinery spaces of category A, accommodation, and high fire risk spaces. For fire integrity towards other spaces the fuel tank hold space and the tank connection spaces shall be treated as machinery spaces having little or no fire risk.  

Guidance note:  
High fire risk spaces are for instance cargo areas for carriage of dangerous goods and cargo decks for cars with fuel in the tanks.  

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103 Boundaries of gas fuel bunkering stations shall normally be enclosed by permanent steel bulkheads towards inboard ship structure and be open towards outboard during bunkering.  

An alternative to fitting steel bulkheads is to add the same fire integrity requirement as required with gas tanks on open deck in 101 to accommodation/ cargo areas/ machinery space boundaries facing the bunkering station.  

If the bunkering station is arranged more than 10 meters away from accommodation or other deck houses, bulkheads and fire protection may be omitted.  

104 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.  

105 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.  

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, the fire main serving the weather deck shall be arranged as a ring main supplied by fire pumps or as a single main by fire pumps positioned fore and aft. Isolating valves shall be fitted in the fire main in order to isolate damaged sections of the main.  

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 as well as tank connection spaces above deck.  

202 The system shall 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 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 full bore type and they shall be arranged to ensure an effective and even distribution of water towards the protected objects/surfaces.

Guidance note:
Alternatives to full bore may be accepted if data sheets for nozzles confirm correct application rate at the working pressure and area coverage.

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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.

209 For fuel temperatures below −110°C and when bunkering flow through the bunkering station is more than 150 m³/hour, a water distribution system shall be fitted in way of the hull under the shore connections to provide a low-pressure water curtain for additional protection of the hull steel and the ship's side structure. This system shall be operated when fuel transfer is in progress.

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 during bunkering operation.

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 addressable fire detection system shall be provided for the fuel storage hold space below deck and served by a loop not serving machinery spaces of category A.

E. Spark arrestors

E 100 General

101 Exhaust outlet from internal combustion machinery and boilers shall be provided with spark arrestors.
SECTION 5
ELECTRICAL SYSTEMS

A. General

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.

Guidance note:
With reference to IEC 60079-20, the following temperature class and equipment groups can be used for potential ship fuels:

<table>
<thead>
<tr>
<th>Temperature class</th>
<th>Equipment group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas</td>
<td>T1 IIA</td>
</tr>
<tr>
<td>LPG (propane, butane)</td>
<td>T2 IIA</td>
</tr>
<tr>
<td>Methanol</td>
<td>T2 IIA</td>
</tr>
<tr>
<td>DME (dimethylether)</td>
<td>T3 IIB</td>
</tr>
</tbody>
</table>

103 Electrical equipment fitted in an ESD protected machinery space shall fulfill 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

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 J400.

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.
202 **Hazardous areas zone 1**

1) Tank connection space, as defined in Sec.3 A400.

2) Gas compressor or pump room arranged with ventilation according to Sec.3 J503.

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, ventilation outlets from zone 1 hazardous spaces 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.

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

**Guidance note 2:**
Open ended ventilation pipes from gas piping systems will not create a hazardous zone in a surrounding well ventilated space.

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

203 1) **Hazardous areas zone 2**

1) 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.

2) Air locks.

---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 System arrangement

101 A dedicated gas safety system, independent of the gas control system, shall be arranged in accordance with the general principles in Pt.4 Ch.9 Sec.3 A103.

Guidance note:
Given the propulsion system arrangement of the vessel, two independent gas safety systems may be required, see C100.

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

102 The gas control system shall be so arranged that the remaining power after single failure shall be sufficient to maintain propulsion and other main functions defined in Pt.1 Ch.1 Sec.1 A200.

103 The gas safety system shall be so arranged that the remaining power after single failure shall be sufficient to maintain propulsion and other main functions defined in Pt.1 Ch.1 Sec.1 A200.

A 200 Gas engine shut down prevention system

201 Measures must be taken to prevent unintentionally shut down of gas engines in case of other engines suddenly failing.

Guidance note:
For gas engine driven generators operating in parallel, a control system may be installed preventing consequential trip of an engine caused by sudden overload in case one engine is shut down.

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

B. Gas control system

B 100 General

101 Two independent gas control systems shall be fitted for propulsion arrangements where two gas supply systems are required.

102 Independent power supplies to gas control systems shall be arranged in accordance with Pt.4 Ch.8 Sec.2 F303. In addition each gas control system shall be arranged with uninterruptible power supply (UPS) in accordance with Pt.4 Ch.8 Sec.2 F305.

B 200 Field instrumentation

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

202 Pressure gauges shall be fitted to gas pump discharge lines and to the bunkering lines.

B 300 Bunkering and tank monitoring

301 Monitoring related to bunkering shall be available at the control location for bunkering.

302 Gas tanks level shall be monitored. Tanks for liquefied gas shall have monitoring arranged as outlined in the Rules for Classification of Ships, Pt.5 Ch.5 Sec.13 B100 and B201. Sensors for gauging and for high alarm can be handled by a common control system.

303 Each tank shall be monitored for pressure and also fitted with local indicating instrument. The indicators shall be clearly marked with the highest and lowest pressure permitted in the tank. High-pressure alarm, and if vacuum protection is required, low pressure alarm shall be provided. These alarms shall also be indicated on the bridge. The alarms shall be activated before the set pressures of the safety valves are reached.
B 400 Gas supply monitoring

401 The gas compressor monitoring system shall include items given in Table B1.

<table>
<thead>
<tr>
<th>Table B1 Monitoring system requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas heater outlet, temperature, high</td>
</tr>
<tr>
<td>Gas compressor outlet, temperature, high</td>
</tr>
<tr>
<td>Gas compressor inlet, pressure, low</td>
</tr>
<tr>
<td>Gas compressor outlet, pressure, high</td>
</tr>
<tr>
<td>Gas compressor outlet, pressure, low</td>
</tr>
<tr>
<td>Control system failure</td>
</tr>
<tr>
<td>Sealing gas pressure, low</td>
</tr>
<tr>
<td>Lubrication oil pressure, low</td>
</tr>
<tr>
<td>Lubrication oil temperature, high</td>
</tr>
<tr>
<td>Master gas valve close</td>
</tr>
</tbody>
</table>

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.

C. Gas safety system

C 100 General

101 Two independent gas safety systems shall be fitted for propulsion arrangements where two gas supply systems are required.

102 For ESD protected machinery space configurations where two engine rooms are required, a gas safety system shall be arranged for each ESD protected room.

103 Gas detection system functionality as described in C300 can be included in the gas safety system. The redundancy requirement given in C304 will then apply for the gas safety system if ESD protected machinery space configuration.

104 Fire detection system functionality as described in C400 can be included in the gas safety system.

105 The safety functions given in Table C1 shall be implemented in the gas safety system.

106 The signals required to support the safety functions given in Table C1 shall be hardwired.

107 The signals required to support the safety functions given in Table C1 shall be arranged with loop monitoring if they are not inherently fail safe.

108 Independent power supplies to gas safety systems shall be arranged in accordance with Pt.4 Ch.8 Sec.2 F303. In addition each gas safety system shall be arranged with uninterruptible power supply (UPS) in accordance with Pt.4 Ch.8 Sec.2 F305.

C 200 Bunkering and tank safety

201 Indications and means for safety activation related to bunkering shall be available at the control location for bunkering.

Guidance note:
Tank pressure and tank level shall be monitored. Overfill alarm and automatic shutdown are to be indicated at this location, as well as monitoring of ventilation and gas detection for the duct containing bunkering pipes.

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

202 Gas tanks shall be protected against overfilling. Tanks for liquefied gas shall be protected as outlined in the Rules for Classification of Ships, Pt.5 Ch.5 Sec.13 B202.

203 Closing of the bunkering shutdown valve required by Sec.3 I202 shall be possible from the control location for bunkering and or from another safe location.

C 300 Gas detection

301 Fixed gas detectors shall be installed in the tank connection space, in all ducts around gas pipes, compressor rooms, and in other enclosed spaces containing gas piping or other gas equipment. Fixed gas
detectors shall be installed in ESD protected machinery space configuration gas engine rooms. In spaces where all gas pipes are completely ducted gas detectors are not required.

**Guidance note:**
Gas detectors may be required also in inherently gas 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.

---end---of---Guidance---note---

302 Where gas detection shall cause shutdown in accordance with Table C1, detector voting shall be applied.

**Guidance note:**
A common voting principle is 2oo2 (meaning two out of two) where both units must detect gas to activate shutdown. A failed detector shall be considered as being active.

---end---of---Guidance---note---

303 Two independent gas detector systems shall be fitted for propulsion arrangements where two gas supply systems are required.

304 For ESD protected machinery space configuration a gas detector system of redundant design shall be arranged for each gas engine room.

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

306 The detectors 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.

307 Gas detection shall be alarmed on the bridge, in the engine control room and at the control location for bunkering, as well as locally. Gas alarms are required as specified in Table C1. Gas alarms with no safety action can be handled by the gas detection system.

308 Gas detection shall be continuous.

C 400 Fire detection

401 Where fire detection shall cause shutdown in accordance with Table C1, detector voting shall be applied.

**Guidance note:**
A common voting principle is 2oo2 (meaning two out of two) where both units must detect gas to activate shutdown. A failed detector shall be considered as being active.

---end---of---Guidance---note---

402 Failure in, or loss of the fire central shall not initiate shutdown as required by 401.

C 500 Ventilation

501 Loss of ventilation shall cause shut down in accordance with Table C1. A running signal from the ventilation fan motor is normally not sufficient to verify the performance of the ventilation; a flow- or overpressure detection or an equivalent detection principle is required.

502 Full stop of ventilation in an ESD protected engine room shall, additionally to what is given in Table C1, lead to one of the following actions:

a) For a gas electric propulsion system: Engine(s) in another space shall start. When the engine in the other space is connected to bus-bar the engine in the space without ventilation shall be shutdown automatically.

b) For a direct propulsion system: The engine in the room with defect ventilation shall be manually shutdown when sufficient propulsion power is still available after the shutdown.

503 Full stop of ventilation in the double pipe supplying gas to single fuel gas engine(s) shall, additionally to what is given in Table C1, lead to one of the following actions:

a) If another gas supply system is arranged, the one with defect ventilation shall shut down as soon as the other supply system is ready to deliver.

b) For a direct propulsion system with only one gas supply line: The engine with defect ventilation in the gas supply system shall be manually or automatically shutdown if sufficient propulsion power is still available after such a shutdown. If the ventilation system is without any openings in the engine room, continued operation after ventilation failure may be approved.

c) For a gas electric propulsion system: Another engine supplied by a different fuel system shall start. When the second engine is connected to bus-bar the first engine shall be shutdown automatically.
C 600 Manual shutdown buttons

601 Means of manual emergency shutdown of fuel supply to the engine room as required by Table C1 shall be provided at a reasonable number of places in the engine room, at a location outside the engine room and at the bridge. The activation device shall be arranged as a physical button, duly marked and protected against inadvertent operation.

C 700 Safety actions

701 The output signals as specified in Table C1 shall be electrically independent of the gas control system.

<table>
<thead>
<tr>
<th>Table C1 Gas safety functions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameter</strong></td>
</tr>
<tr>
<td>Bunkering system</td>
</tr>
<tr>
<td>Tank overfilling protection</td>
</tr>
<tr>
<td>Loss of ventilation in ducting around gas bunkering lines</td>
</tr>
<tr>
<td>Gas detection in ducting around bunkering lines</td>
</tr>
<tr>
<td>Manual shut down</td>
</tr>
<tr>
<td>Fuel storage</td>
</tr>
<tr>
<td>Gas detection in tank connection space, one detector above 20% LEL</td>
</tr>
<tr>
<td>Gas detection in tank connection space, two detectors above 40% LEL</td>
</tr>
<tr>
<td>Fire detection in fuel storage hold space</td>
</tr>
<tr>
<td>Bilge well high level tank connection space</td>
</tr>
<tr>
<td>Bilge well low temperature tank connection space</td>
</tr>
<tr>
<td>Gas supply system between tank and engine room</td>
</tr>
<tr>
<td>Gas heating circuit, gas detection in expansion tank</td>
</tr>
<tr>
<td>Gas heating circuit, low temperature at outlet</td>
</tr>
<tr>
<td>Gas heating circuit, no circulation</td>
</tr>
<tr>
<td>Gas detection in duct between tank connection space and engine room, one detector above 20% LEL</td>
</tr>
<tr>
<td>Gas detection in duct between tank connection space and engine room, two detectors above 40% LEL</td>
</tr>
<tr>
<td>Gas detection in compressor/pump room, one detector above 20% LEL</td>
</tr>
</tbody>
</table>
### Table C1 Gas safety functions (Continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Alarm</th>
<th>Automatic shut-down of tank valves</th>
<th>Automatic shut-down of master gas fuel valve</th>
<th>Automatic shut-down of double block and bleed valves</th>
<th>Automatic shut-down of bunkering connection valve</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas detection in compressor/pump room, two detectors above 40% LEL</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>Only main tank valve to close. If the tank is supplying gas to more than one consumer and the different supply systems are completely separated and fitted in separate rooms and with shut off valves fitted outside of the room, the shut off valve on the supply pipe leading into the room where gas is detected shall close instead of the main tank valve.</td>
</tr>
<tr>
<td>Loss of ventilation in duct between tank connection space and engine room</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>If the duct is protected by inert gas, loss of inert gas overpressure shall lead to the same actions. This parameter shall only lead to gas supply shutdown for dual fuel engines.</td>
</tr>
<tr>
<td>Engine room general</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire detection in engine room, one detector</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire detection in engine room, two detectors activated</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>This parameter shall only lead to gas supply shutdown for dual fuel engines, and for gas supply for ESD protected engine rooms.</td>
</tr>
<tr>
<td>Rupture detection in gas supply piping (applicable for ESD protected engine room and for high pressure gas supply)</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>Disconnection of non-safe equipment (ignition sources) and machinery in ESD protected engine room</td>
</tr>
<tr>
<td>Faulty operation of double block and bleed valves</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Refer to Sec.3 F104</td>
</tr>
<tr>
<td>Engine room inherently gas safe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas detection in duct/ double pipe inside engine room, one detector above 30% LEL</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas detection in duct/ double pipe inside engine room, two detectors above 40% LEL</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>If the duct/double pipe is protected by inert gas, loss of inert gas overpressure shall lead to the same actions. Manual shut-down may be approved for ventilated ducts if the duct has no openings in ER.</td>
</tr>
<tr>
<td>Loss of ventilation in duct inside engine room</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>If the duct is protected by inert gas, loss of inert gas overpressure shall lead to the same actions. This parameter shall only lead to gas supply shutdown for dual fuel engines.</td>
</tr>
<tr>
<td>Gas detection in inherently gas safe engine room 10% LEL</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>If gas detectors required by Sec.3 E302 or Sec.3 G102.</td>
</tr>
<tr>
<td>Engine room ESD protected</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas detection in ESD protected engine room, one detector above 20% LEL</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas detection in ESD protected engine room, two detectors above 40% LEL</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>Disconnection of non-safe equipment (ignition sources) and machinery</td>
</tr>
<tr>
<td>Loss of ventilation in ESD protected engine room</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual shutdown</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>See C600</td>
</tr>
</tbody>
</table>

1) May utilise a dedicated valve in case of pipe rupture in engine room, see F108.
2) Vent valves to open as specified in Sec.3 F104 and 105.
3) Double block and bleed valves will normally be controlled by the engine control and/or safety system. Hence a signal shall be given from the safety system to the engine system that this valve action is to be performed.
4) High pressure compressors to stop automatically.
D. Ventilation control, monitoring and safety

D 100 Ventilation monitoring

101 Reduced ventilation from what is required per area in Sec.3 J shall be alarmed.

102 Reduced ventilation in the ducting around the gas bunkering lines during bunkering operations shall also be alarmed at the control location for bunkering.

D 200 Spaces dependent on ventilation for its area classification

201 Functional requirements for ventilation in safe spaces protected by air locks and spaces dependent on ventilation for its area classification are given in Sec.3 J201 and J504.

D 300 Safety

301 Requirements for ventilation related inputs to the gas safety system are given in C500 and Table C1.

E. Gas engine monitoring

E 100 General

101 In addition to the requirements given in Pt.4 Ch.3 Sec.1 E, control and monitoring as given in Table E1 is required for gas engines.

<table>
<thead>
<tr>
<th>Table E1 Monitoring of dual fuel diesel or gas-only engines</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System</strong></td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1.0 Ignition system</td>
</tr>
<tr>
<td>2.0 Lubricating oil system</td>
</tr>
<tr>
<td>3.0 Fuel injection valve cooling system 5)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>4.0 Gas injection valve sealing oil system</td>
</tr>
<tr>
<td>5.0 Gas fuel knock-out drums, if fitted</td>
</tr>
<tr>
<td>6.0 Combustion</td>
</tr>
</tbody>
</table>

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

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.
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 its fuel gas supply shall be arranged for manual remote emergency stop from the following locations:
   — navigation bridge
   — engine control room.

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 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.
   Guidance note:
   If it can be documented that a dual fuel engine can safely start, stop and operate on low load in gas mode, this may be approved.

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.
   Guidance note:
   More than 10 seconds may be accepted between gas injection start and automatic starting sequence shut off, if the gas is not injected directly to each cylinder or to each cylinder air inlet, but is mixed with combustion air in a common system.

---end of Guidance note---
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.
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.

C. Onboard testing

C 100  General

101  Control, monitoring and safety systems required by these rules, shall be tested onboard in accordance with Pt.4 Ch.9 Sec.1 D500.

102  The functionality of the cause and effect diagram required by Sec.1 Table C1 shall be tested onboard.