



GUIDANCE NOTES
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CHINA CLASSIFICATION SOCIETY

GUIDELINES FOR DESIGN AND INSTALLATION
OF GAS FUEL ENGINE SYSTEMS OF LIQUEFIED
GAS CARRIERS

2018

Effective from May 01, 2018

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CHAPTER 1 GENERAL

1.1 Application and scope

1.1.1 The Guidelines apply to liquefied gas carriers using natural gas as fuel. Where other gas fuels or low-flashpoint liquid fuels are intended to be used, the requirements of 16.9, Chapter 16 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk are to be satisfied.

1.1.2 The Guidelines are only supplementary to CCS rules. In addition to satisfying the requirements of the Guidelines, the power system of gas fuel engines is to comply with relevant provisions of CCS Rules for Classification of Sea-going Steel Ships and Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

1.1.3 The Guidelines mainly specify requirements for the design, installation and arrangement of gas fuel engines, gas fuel supply as well as control, monitoring and testing related to the use of gas fuels.

1.1.4 In the Guidelines, gas fuel engines can be either dual fuel engines or gas fuel only engines. The gas / air mixture in the cylinder can be ignited by the combustion of a certain amount of fuel (pilot injection) or by extraneous ignition (spark plug).

1.2 Class notation

1.2.1 A liquefied gas carrier using natural gas as fuel may be assigned the corresponding class notation as follows upon its request:

DFD - fitted with dual fuel engines as power plant in compliance with the requirements of the Guidelines;

GF - fitted with gas fuel only engines as power plant in compliance with the requirements of the Guidelines.

1.3 Definitions and abbreviations

1.3.1 Definitions

(1) *Certified safe type* means electrical equipment that is certified safe by the relevant organization accepted by CCS for operation in a flammable atmosphere based on a recognized standard (e.g. IEC 60092-502 or other equivalent standards).

(2) *Dual fuel engine* (hereinafter referred to as DF engine) means an engine that can burn natural gas as fuel (with pilot fuel used for ignition) and also has the capability of running on oil fuels only. Oil fuels may include distillate and residual fuels.

(3) *Gas fuel engine* means a gas fuel only engine or a dual fuel engine.

(4) *Gas fuel only engine* (hereinafter referred to as GF engine) means an engine capable of operating on gas fuel only and not able to switch over to oil fuel operation.

(5) *Gas fuel engine room* means a machinery space or enclosure containing gas fuel engine(s).

(6) *Gas fuel injection (admission) valve* means a valve or injector on the engine, which controls gas supply to the cylinder(s) according to the cylinder(s) actual gas demand.

(7) *Gas Valve Unit (GVU)* means a set of manual shutoff valves, actuated shut-off and venting valves, gas pressure sensors and transmitters, gas temperature sensors and transmitters, gas pressure control valve and gas filter used to control the gas supply to each gas consumer. It also includes a connection for inert gas purging.

- (8) *GVU room* means a gastight room or enclosure containing GVU.
- (9) *Double block and bleed valve* means a set of (3) automatic valves fitted on the gas fuel supply pipe to each engine, of which the two shutoff valves are in series in the gas fuel pipe to the engine and the third valve is in a venting pipe that releases the pressure from the gas fuel piping between the two valves in series. The venting pipes are routed to a safe location in the open air.
- (10) *Low pressure gas* means gas with a pressure up to 1.0 MPa.
- (11) *Lower heating value (LHV)* means the amount of heat produced from the complete combustion of a specific amount of fuel, excluding latent heat of vaporization of water.
- (12) *Master gas fuel valve* means an automatic control valve located in the cargo area, which can be remotely controlled and which is fitted on the gas fuel supply pipe to the engines.
- (13) *Methane Number* is a measure of resistance of a gas fuel to knock, which is assigned to a test fuel based upon operation in knock testing unit at the same standard knock intensity.

Note: Pure methane is used as the knock resistant reference fuel, that is, methane number of pure methane is 100, and pure hydrogen is used as the knock sensitive reference fuel, methane number of pure hydrogen is 0.

- (14) *Natural gas* means a gas without condensation at common operating pressures and temperatures (20°C and 1 atm) where the predominant component is methane with some ethane and small amounts of heavier hydrocarbons (mainly propane and butane).
- (15) *Pilot fuel* means the fuel oil that is injected into the cylinder to ignite the main gas-air mixture on DF engines.
- (16) *Pre-mixed engine* means an engine where gas is supplied in a mixture with air before the turbocharger.
- (17) *Safety Concept* is a document describing the safety philosophy with regard to gas as fuel. It describes how risks associated with this type of fuel are controlled under reasonably foreseeable abnormal conditions as well as possible failure scenarios and their control measures.
- Note: A detailed evaluation regarding the hazard potential of injury from a possible explosion is to be carried out and reflected in the safety concept of the engine.
- (18) *Single Failure* means the termination of the ability of a product or component to perform a required function under stated conditions.
- (19) *Unacceptable loss of power* means that normal operation of propulsion machinery cannot be sustained or restored when one of the essential auxiliaries becomes inoperative as specified in SOLAS regulation II-1/26.3.

1.3.2 Abbreviations

- (1) DF: Dual Fuel;
- (2) ESD: Emergency Shut Down;
- (3) GF: Gas Fuel only;
- (4) GVU: Gas Valve Unit;
- (5) LEL: Lower Explosive Limit;
- (6) LNG: Liquefied Natural Gas;
- (7) LHV: Lower Heating Value.

1.4 Plans and documents

1.4.1 The following plans and documents are to be submitted for approval with regard to the approval of gas fuel engines, in addition to those required in 9.1.12.1, Chapter 9, PART THREE of CCS Rules for Classification of Sea-going Steel Ships:

No.	Plans and documents
(1)	Schematic layout or other equivalent documents of gas system on the engine
(2)	Gas piping system (including double-walled arrangement where applicable)
(3)	Parts for gas admission system ^②
(4)	Arrangement and relevant calculations of explosion relief valves (crankcase ^① , scavenging air receivers, charge air manifold, exhaust gas manifold) as applicable
(5)	List of certified safe equipment and evidence of relevant certification
(6)	Schematic layout or other equivalent documents of engine control and safety related to gas fuel combustion
(7)	Schematic layout or other equivalent documents of fuel oil system (main and pilot fuel systems) on the engine (only for DF engine)
(8)	Shielding of high pressure fuel pipes for pilot fuel system, assembly (only for DF engine)
(9)	High pressure parts for pilot fuel oil injection system ^② (only for DF engine)
(10)	Ignition system (only for GF engine)
<p>① If required by 9.1.12, Chapter 9, PART THREE of CCS Rules for Classification of Sea-going Steel Ships.</p> <p>② The documentation to contain specification of pressures, pipe dimensions and materials.</p>	

1.4.2 The following plans and documents are to be submitted for information with regard to the approval of gas fuel engines, in addition to those required in 9.1.12.2, Chapter 9, PART THREE of CCS Rules for Classification of Sea-going Steel Ships:

No.	Plans and documents
(1)	Safety concept (for information)
(2)	Report of the risk analysis (for information)
(3)	Gas specification (for information)
(4)	Other plans and documents as deemed necessary by CCS

1.4.3 For ships intended to be fitted with the power system of gas fuel engines, the following plans and documents are to be submitted for approval in addition to those required in relevant CCS rules:

No.	Plans and documents
(1)	Arrangement of gas fuel engine room
(2)	Arrangement of electrical equipment and lighting of gas fuel engine room
(3)	Ventilation system of gas fuel engine room and for ESD protected gas fuel engine room, calculations of ventilation are to be included
(4)	Fixed gas detection and alarm system
(5)	Gas piping system, including material, size, type, design pressure and design temperature of double-walled pipes or ventilation pipes (where applicable), pipelines and relevant components
(6)	Control and safety protection system related to the use of gas fuel
(7)	Plan of exhaust gas system, including the arrangement of explosion relief devices
(8)	List of alarm and indication points related to the use of gas fuel
(9)	List of certified safe equipment in gas fuel engine room
(10)	Arrangement of electrical earthing of gas fuel piping
(11)	Onboard test program

(12)	Other plans and documents as deemed necessary by CCS
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CHAPTER 2 DESIGN AND ARRANGEMENT OF GAS FUEL ENGINE ROOM

2.1 General requirements

2.1.1 In order to minimize the probability of a gas explosion in gas fuel engine room, one of these two concepts may be applied:

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

In a gas safe machinery space a single failure cannot lead to release of fuel gas into the machinery space.

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

In an ESD protected machinery space a single failure may result in a gas release into the space. The space ventilation is designed to accommodate a probable maximum leakage scenario due to technical failures.

Failures leading to dangerous gas concentrations, e.g. gas pipe ruptures or blow out of gaskets are covered by explosion pressure relief devices and ESD arrangements.

2.1.2 When gas safe machinery space concept is applied, the gas fuel engine room is to be designed and arranged in accordance with the provisions of 2.2 of this Chapter.

2.1.3 Based on the equivalent safety principle, paragraph 2.3 of this Chapter specifies safety requirements for ventilation, gas detection, electrical equipment, emergency shutdown and arrangement of entrances and exits of ESD-protected machinery spaces. When ESD-protected machinery space concept is applied, the gas fuel engine room is to be designed and arranged in accordance with the provisions of 2.3 of this Chapter. This requires acceptance by the Administration under the equivalency clause in CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

2.1.4 Pre-mixed gas fuel engines are to be arranged in the ESD-protected machinery space.

2.2 Requirements for gas safe machinery spaces

2.2.1 A single failure within the fuel system is not to lead to a gas release into the machinery space

2.2.2 All fuel piping within machinery space boundaries is to be enclosed in a gas tight enclosure in accordance with 3.4.1 of the Guidelines.

2.2.3 Apart from the design scheme of double-walled pipes or ventilation pipes/ducts as specified in 3.4.1 of the Guidelines, where other design schemes with equivalent safety level are used for gas fuel piping within the machinery space, they may be accepted subject to special consideration.

2.2.4 Ventilation systems, gas detection systems, electrical equipment and vents and bleed lines

of machinery spaces are to satisfy the requirements of 16.3, Chapter 16 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

2.2.5 The air inlet of the ventilation system is to be arranged in the safe area, with a distance of at least 1.5 m from the boundary of any hazardous area.

2.3 Requirements for ESD-protected machinery spaces

2.3.1 ESD protection is to be limited to machinery spaces that are certified for periodically unattended operation.

2.3.2 The maximum working pressure within the gas fuel piping in the space is not to be greater than 1 MPa.

2.3.3 Measures are to be applied to protect against explosion, damage of areas outside of the machinery space and ensure redundancy of power supply. The following arrangement is to be provided but may not be limited to:

- (1) gas detector;
- (2) shutoff valve;
- (3) redundancy;
- (4) efficient ventilation.

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

- (1) Engines for generating propulsion power and electric power are to be located in two or more machinery spaces not having any common boundaries unless it can be documented that a single casualty will not affect both spaces.
- (2) The machinery space is to contain only gas fuel engine and equipment, components and systems as are required to ensure that the engine maintains its function. Incinerators, inert gas generators or other fuel oil boilers are in general not fitted in the space.
- (3) A fixed gas detection system arranged to automatically shutdown the gas supply, and disconnect all electrical equipment or installations not of a certified safe type, is to be fitted.

2.3.5 Distribution of engines between the different machinery spaces is to be such that shutdown of fuel supply to any one machinery space does not lead to an unacceptable loss of power.

2.3.6 ESD protected machinery spaces separated by a single bulkhead are to have sufficient strength to withstand the effects of a local gas explosion in either space, without affecting the integrity of the adjacent space and equipment within that space.

2.3.7 In order to facilitate ventilation and gas detection, ESD protected machinery spaces are to have a small volume insofar as practicable and provide a simple geometrical shape that will minimize the accumulation of gases or formation of gas pockets, provided that maintenance is not affected.

2.3.8 The ventilation of machinery spaces is to satisfy the following requirements:

- (1) ESD protected machinery spaces are to have ventilation with a capacity of at least 30 air changes per hour (calculated based on the total volume of the room). The ventilation system is to ensure a good air circulation in all spaces, and in particular ensure that any formation of gas pockets in the room is detected.

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

Where the air suction of engine is located within the machinery space, the amount of air required

for the operation of engine is to be considered in the total amount of ventilation above.

(2) The ventilation arrangements are to provide sufficient redundancy to ensure a high level of ventilation availability as defined in a standard (e.g. IEC 60079-10-1) acceptable to CCS.

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

(4) The ventilation duct is to be so arranged that the leaked gas within the machinery space can be removed quickly.

(5) The ventilation system of each ESD-protected machinery space is to be independent of each other and independent of ventilation systems of any other space.

(6) The air inlet and outlet of the ventilation system are to be separately led from and to a safe position.

(7) Ventilation fans are to comply with the provisions of 12.1.7, Chapter 12 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

(8) The ventilation system is to maintain operation in normal conditions when gas fuel exists in the piping and scavenging is carried out before maintenance.

2.3.9 The gas detection of machinery spaces is to satisfy the following requirements:

(1) In each ESD-protected machinery space, at least 2 sets of independent fixed gas detection system are to be provided to detect any leakage continuously and without delay. In case of failure of any detection system, the remaining gas detection system(s) are still to satisfy detection requirements.

(2) The number of detectors in each space is to be considered taking into account the size, layout and ventilation of the space.

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

(4) Gas detection equipment is to be designed, installed and tested in accordance with a recognized standard (e.g. IEC 60079-29-1).

(5) The gas detection system is to maintain operation in normal conditions when gas fuel exists in the piping and scavenging is carried out before maintenance.

(6) An audible and visible alarm is to be activated at a gas vapour concentration of 20% of the lower explosion limit (LEL). The safety system is to be activated at 40% of LEL at two detectors (see note 2 in Table 5.3.1).

(7) The gas detection system and its relevant emergency shutdown system are to be capable of maintaining the stability of performance during operation through testing and maintenance. Periodical calibration is to be carried out in accordance with the provisions of the maintenance and instruction manual. The maintenance and testing procedures are to be documented and kept on board for use by the crew.

2.3.10 The ESD-protected machinery space is considered a non-hazardous area during normal operation. However, the electrical equipment required to operate after the ESD-protected machinery space is shut down due to detection of gas leakage, is to be certified safe for zone 1.

2.3.11 The entrances and exits in ESD-protected machinery spaces are to be arranged in accordance with the following requirements:

(1) Each machinery space is to have at least two completely independent entrances which are

located far apart from each other insofar as practicable.

(2) The entrances to the machinery space are to be arranged with self-closing doors. Audible and visible alarm is to sound at a permanently manned location if the door is open continuously for more than 1 minute.

(3) If the access to an ESD-protected machinery space is from another enclosed space in the ship, the entrances are to be arranged with an airlock which complies with the requirements of 3.6, Chapter 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

CHAPTER 3 GAS FUEL SUPPLY

3.1 General requirements

3.1.1 Gas supply piping is to be designed, manufactured, installed, arranged and tested according to the relevant requirements of Chapter 5 and 16.4 of Chapter 16 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

3.1.2 Fully welded fuel gas vent pipes led through mechanically ventilated spaces may not be protected by gastight enclosure according to 16.4.3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

3.1.3 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. Such valves are to be fail-safe type.

3.1.4 Means for inerting and purging gas supply piping are to be provided.

3.1.5 Gas supply piping is to be colour marked based on standards acceptable to CCS, e.g. GB/T 3033, EN ISO 14726, etc.

3.1.6 Gas supply piping is not to be located less than 800 mm from the ship's side.

3.1.7 Gas supply piping is to be provided with necessary means of protection against potential external mechanical damage.

3.1.8 High-pressure gas fuel pipes are to be installed and protected so as to minimize the risk of injury to personnel in case of pipe rupture.

3.1.9 If the fuel gas contains heavier components that may condense in the system, means for safely removing the liquid are to be fitted.

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

3.2 Redundancy requirements for fuel supply

3.2.1 The fuel supply system of gas-fuelled ships is to be so designed that safety actions after any gas leakage do not lead to an unacceptable loss of power.

3.2.2 For single fuel installations, the gas fuel is to be obtained from two or more cargo tanks or fuel tanks (if fitted). The fuel supply system is to be arranged with full redundancy and segregation all the way from the cargo tanks or fuel tanks (if fitted) to the consumer, so that safety actions after any leakage in one system do not lead to an unacceptable loss of power.

For type C independent cargo tank or fuel tank (if fitted) only, one cargo tank or fuel tank (if fitted) may be accepted if either of the following conditions is met:

(1) all connections and valves of the cargo tank or fuel tank (if fitted) related to fuel supply are located above the open deck;

(2) two completely separate tank connection spaces are installed for the one tank, and fuel can be supplied separately from the two connection spaces.

3.3 Safety functions of gas supply system

3.3.1 The main gas supply line of each gas fuel engine room is to be equipped with a manually operated stop valve and an automatically operated master gas fuel valve coupled in series or a combined manually and automatically operated valve. The valves are to be situated in the part of

the piping which is located within the cargo area, and placed as near as possible to the installation for heating the gas, if fitted.

3.3.2 The master gas fuel valve is to comply with the following requirements:

(1) Where safety actions are triggered due to failures specified in Tables 5.2.1 and 5.3.1, Chapter 5 of the Guidelines, the master gas fuel valve is to automatically cut off gas supply to the corresponding engine room.

(2) Cutting off gas supply of one engine room is not to affect gas supply to gas consumers in other spaces (when gas consumers are arranged in two or more spaces) nor to cause the loss of propulsion or electrical power.

(3) The master gas fuel valve is to be operable from safe locations on escape routes inside the gas fuel engine room, the engine control room, if applicable; outside the machinery space, and from the navigation bridge.

3.3.3 Each gas fuel engine is to be provided with double block and bleed valves arrangement and comply with the following requirements:

(1) The two shutoff valves are to be in series in the gas fuel pipe to the engine. The bleed valve is to be in a pipe that vents to a safe location in the open air that portion of the gas fuel piping that is between the two valves in series.

(2) In case of failures specified in Tables 5.2.1 and 5.3.1, Chapter 5 of the Guidelines, the shutoff valves that are in series are to close automatically and the bleed valve is to open automatically.

(3) The function of one of the shutoff valves in series and the bleed valve can be incorporated into one valve body, so arranged that the flow to the gas utilization unit will be blocked automatically and the ventilation opened automatically in case of failures specified in Tables 5.2.1 and 5.3.1, Chapter 5 of the Guidelines.

(4) The three valves above are to be able to manually reset.

(5) The two valves in series are to be of the fail-to-close type, while the ventilation valve is to be fail-to-open.

3.3.4 The two valves in series are to be closed automatically and the ventilation valve is to be opened automatically according to the procedures for normal stop of the engine.

3.3.5 An alarm for faulty operation of the double block and bleed valves is to be activated, e.g. when block valves and bleed valve open simultaneously, and block valves open at stop of the engine.

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

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

3.3.8 For single-engine installations and multi-engine installations, where a separate master valve is provided for each engine, the master gas fuel valve and the double block and bleed valve functions can be combined, i.e. the master gas fuel valve can be used as one block valve in the double block and bleed valves to cut off fuel supply.

3.3.9 For each main gas supply line entering an ESD protected machinery space, and each gas supply line to high pressure installations means are to be provided for rapid detection of a rupture in the gas line in the engine-room. When rupture is detected fuel supply is to be automatically cut

off. The valve to that end can be a separate valve or combined with other functions, e.g. the master valve. The shutdown is to be time delayed to prevent shutdown due to transient load variations. The valve is to 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.

Acceptable means of detecting pipe rupture include, but are not limited to:

- (1) an orifice or flow fuse detecting excess flow located close to the point of entry to the engine room; or
- (2) a combined excess flow detector with automatic shut off valve located close to the point of entry to the engine room; or
- (3) a low pressure detector located at the engine inlet.

3.4 Gas piping in gas-safe machinery spaces

3.4.1 Gas piping in gas safe machinery spaces are to be a double wall piping system or installed within a ventilated pipe or duct and to comply with the provisions of 16.4.3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

3.4.2 The connecting of gas piping and ducting to the gas injection valves is to be completely covered by the ducting. The arrangement is to facilitate replacement and/or overhaul of injection valves and cylinder covers. The double ducting is also required for all gas pipes on the engine itself, until gas is injected into the chamber. If gas is supplied into the air inlet directly on each individual cylinder during air intake to the cylinder on a low pressure engine, such that a single failure will not lead to release of fuel gas into the machinery space, double ducting may be omitted on the air inlet pipe.

3.4.3 Where the gas piping is completely enclosed by a double-wall ventilation pipe or duct, necessary means are to be provided to prevent vapour from condensing in the ventilation pipe or duct, such as keeping the fuel temperature higher than the air inlet temperature or drying the ventilation air, etc.

3.4.4 Where high pressure gas is supplied in the gas piping, relevant requirements of 1.9, Appendix 1, Chapter 9 of PART THREE of CCS Rules for Classification of Sea-going Steel Ships are also to be complied with.

3.4.5 For ventilation pipes or ducts required in 3.4.1, the ventilation system is to comply with the following requirements in addition to the provisions of 16.4.3(2) of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk:

- (1) The ventilation system for double piping is to be independent of all other ventilation systems.
- (2) The ventilation inlets of double-wall pipes are always to be in non-hazardous areas far away from ignition source. The inlet opening is to be fitted with a suitable wire mesh guard and protected from ingress of water. The ventilation outlet is to be covered by a protection screen and located in a position where no flammable gas-air mixture may be ignited.
- (3) The capacity of the ventilation for a double-wall pipe or duct may be below 30 air changes per hour if a flow velocity of minimum 3 m/s is ensured. The flow velocity is to be calculated for the duct with fuel pipes and other components installed.

3.4.6 The design pressure of the ventilation pipe or duct specified in 3.4.1 is not to be less than the maximum working pressure of the inner pipe. Alternatively for high-pressure fuel piping systems, the design pressure of the ventilation pipe or duct is not to be less than the maximum built-up pressure arising in the annular space or the local instantaneous peak pressure in way of

any rupture, whichever is greater.

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

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

(2) local instantaneous peak pressure in way of the rupture P_c is to be calculated by the following expression:

$$P_c = P_0 \left(\frac{2}{k+1} \right)^{\frac{k}{k-1}}$$

where:

P_0 —maximum working pressure of the inner pipe;

k —ratio of constant pressure specific heat to the constant volume specific heat, i.e.

$$k = C_p / C_v ; k=1.31 \text{ for CH}_4.$$

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

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

3.4.8 Verification of the strength is to be based on calculations demonstrating the duct or pipe integrity. As an alternative to calculations, the strength can be verified by representative tests.

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

3.5 Gas fuel piping in ESD protected machinery spaces

3.5.1 The gas fuel supply lines are to have a design pressure not less than 1 MPa.

3.5.2 Joints are to be kept to a minimum and are to be of full penetration butt-welded type. The welded connections are to be examined using 100% radiographic or ultrasonic tests.

3.5.3 Where flanged connections are used, welded neck flanges, i.e. Type A flanges, are generally to be used, and the welded connections are to be examined using 100% radiographic tests.

3.5.4 Gas fuel piping in ESD protected machinery spaces is to be protected against mechanical damage if there are risks of damages from objects falling from above.

3.5.5 Gas fuel piping in ESD protected machinery spaces is to be located as far as practicable from the electrical installations and tanks containing flammable liquids.

3.6 Gas Valve Unit (GVU) Room

3.6.1 Where GVU is located in a dedicated compartment, the safety principles and arrangements of that compartment are to be the same as those required for ESD protected machinery spaces. The ventilation system, gas detection system, electrical installations as well as inlet and outlet

arrangements are to comply with the provisions in 2.3.8 to 2.3.11 of the Guidelines respectively.

3.6.2 Gas valve unit rooms in gas safe machinery spaces need not comply with the requirement for an air lock in 3.6, Chapter 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk on the condition that the door or tank cover of the GVU room is normally locked, and is only to be opened after gas supply system is shut down and gas-freeing is carried out. The door or tank cover must be fitted with a permanent signboard to this effect, with words “the door or tank cover can only be opened after gas supply system is shut down and gas-freeing is carried out. The gas valve unit room is considered part of the double-wall ventilation pipe or duct of the gas fuel supply system. The design, ventilation, gas detection, electrical installations are to comply with the relevant requirements in 16.3 and 16.4, Chapter 16 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk as well as 3.4 of the Guidelines.

CHAPTER 4 GAS FUEL ENGINES

4.1 General requirements

4.1.1 In addition to the requirements of this Chapter, gas fuel engines are to comply with the provisions of Chapter 9 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships and 16.7 of Chapter 16 of Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

4.1.2 In addition to the elements defining the type of engine as specified in 9.1.2.1(1) of Chapter 9 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships, the type of gas engine is defined by the following:

- (1) gas admission method (direct cylinder injection, charge air space or pre-mixed);
- (2) gas supply valve operation (mechanical or electronically controlled);
- (3) ignition system (pilot injection, spark ignition, glow plug, gas self-ignition);
- (4) ignition system (mechanical or electronically controlled).

4.1.3 The safety, reliability and dependability of gas fuel engines are to be equivalent to that achieved with oil-fuelled engines.

4.1.4 The manufacturer is to declare relevant limits and range of parameters if there are specific requirements for the properties of gas fuel (e.g.: gas composition, methane number).

4.1.5 Components containing or likely to contain gas are to be designed to:

- (1) minimize the risk of fire and explosion so as to demonstrate an appropriate level of safety commensurate with that of an oil-fuelled engine;
- (2) mitigate the consequences of a possible explosion to a level providing a tolerable degree of residual risk, due to the fitting of suitable pressure relief devices of an approved type or components designed with the strength to withstand the worst case over pressure due to ignited gas leaks;
- (3) Relief devices are to be fitted with a flame arrester. Discharge from pressure relief devices is to prevent the passage of flame to the machinery space and be arranged such that the discharge does not endanger personnel or damage other engine components or systems.

4.1.6 Gas piping as mentioned in this Chapter means piping containing gas or air/gas mixtures, including venting pipes.

4.2 System design

4.2.1 The on-engine gas piping is to comply with the following requirements:

- (1) The on-engine gas piping is to be designed and fabricated in accordance with relevant requirements of Chapters 5 and 16 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.
- (2) Pipes and equipment containing fuel gas are defined as hazardous area Zone 0, and the space between the gas fuel piping and the wall of the outer pipe or duct is defined as hazardous area Zone 1.
- (3) The gas piping of engines installed in gas safe machinery spaces is to be designed and arranged in accordance with relevant requirements of 3.1, 3.3 and 3.4 of Chapter 3 of the Guidelines.
- (4) Single walled gas piping is only acceptable for engines installed in ESD protected machinery

spaces as defined in Chapter 2 of the Guidelines and relevant requirements of 3.1, 3.3, and 3.5 of Chapter 3 of the Guidelines are to be complied with.

In case of gas leakage in an ESD-protected machinery space, which would result in the shut-down of the engine(s) in that space, a sufficient propulsion and manoeuvring capability including essential and safety systems is to be maintained. Therefore the safety concept of the engine is to clearly indicate application of the “double wall” or “single wall” arrangement.

Note: The minimum power to be maintained is to be assessed on a case-by-case basis from the operational characteristics of the ship.

(5) The arrangement and installation of gas piping is to provide the necessary flexibility to accommodate the oscillating movements of the engine without the risk of fatigue damage in way of the piping connections to the engine.

4.2.2 The charge air system on the engine is to comply with the following requirements:

(1) The charge air system on the engine is to be designed in accordance with the requirements of 4.1.5 above.

(2) In case of a single engine installation, the engine is to be capable of operating at sufficient load to maintain power to essential consumers after opening of the pressure relief devices caused by an explosion event. Sufficient power for propulsion capability is to be maintained.

Note: Load reduction is to be considered on a case by case basis, depending on engine configuration (single or multiple) and relief mechanism (self-closing valve or bursting disk).

(3) In case the air inlets of engines are located within the gas fuel engine room, they are to be as far away from the gas fuel supply piping as possible to reduce the risk of gas fuel entering the air inlets due to leakage.

4.2.3 The exhaust gas system is to comply with the following requirements:

(1) The exhaust gas system on the engine is to be designed in accordance with the requirements of 4.1.5 above.

(2) In case of a single engine installation, the engine is to be capable of operating at sufficient load to maintain power to essential consumers after opening of the pressure relief devices caused by an explosion event. Sufficient power for propulsion capability is to be maintained. Continuous relief of exhaust gas (through open rupture disc) into the engine room or other enclosed spaces is not acceptable.

(3) Means to ensure that any unburned gas is purged away from the exhaust system are to be provided.

4.2.4 Protection of crankcase is to comply with the following requirements:

(1) For trunk piston type low pressure gas fuel engine, the crankcase is to be fitted with relief valves in accordance with the requirements of 9.7.4 of Chapter 9 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.

(2) For engines where the space below the piston is in direct communication with the crankcase a detailed evaluation regarding the hazard potential of fuel gas accumulation in the crankcase is to be carried out and reflected in the safety concept of the engine.

(3) Each engine other than two-stroke crosshead diesel engines is to be fitted with vent systems independent of other engines for crankcases and sumps to ensure that the leaked gas is vented to a safe location in the atmosphere and the ventilation outlet is to be covered by a protection screen. For maintenance purposes, a connection, or other means, is to be provided for crankcase inerting and ventilating and gas concentration measuring.

(4) Warning notice fitted in accordance with the requirements of 9.7.12 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships is to specify that necessary measures are to be taken to ensure that there is no gas fuel in the crankcase before the crankcase is opened.

4.2.5 Other auxiliary systems are to comply with the following requirements:

(1) Where gas can leak directly into the auxiliary system medium (lubricating oil, cooling water), an appropriate means is to be fitted after the engine outlet to extract gas in order to prevent gas dispersion. The gas extracted from auxiliary systems media is to be vented to a safe location in the atmosphere.

(2) The ventilation outlet is to be covered by a protection screen.

4.2.6 Gas ignition in the cylinder is to comply with the following requirements:

(1) For engines fitted with ignition systems, prior to admission of gas fuel, correct operation of the ignition system on each unit is to be verified.

(2) Combustion monitoring is to be carried out for each cylinder of the gas fuel engine in accordance with the provisions of 16.7.3.5 of Chapter 16 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk. In the event that poor combustion or misfiring of individual cylinder is detected, gas operation may be allowed provided that the gas supply to the concerned cylinder is shut off and provided that the operation of the engine with one cylinder cut-off is acceptable with respects to torsional vibrations.

(3) If monitoring of combustion for each individual cylinder is not practicable due to engine size and design, common combustion monitoring may be accepted.

4.2.7 Control, monitoring, alarm and safety systems of gas fuel engine are to comply with relevant requirements of Chapter 5 of the Guidelines.

4.2.8 Gas admission valves are to comply with the following requirements:

(1) Gas admission valves are to be capable of being controlled through the engine control system or based on the engine's need for gas fuel.

(2) Gas admission valves are to be certified safe as follows:

- ① The inside of the valve contains gas and is therefore to be certified for zone 0.
- ② When the valve is located within a pipe or duct in accordance with 4.2.1(3), the outside of the valve is to be certified for zone 1.
- ③ When the valve is arranged without enclosure in accordance with the "ESD-protected machinery space" concept, no certification is required for the outside of the valve, provided that the valve is de-energized upon gas detection in the space.

However, if they are not rated for the zone they are intended for, it is to be documented that they are suitable for that zone. Documentation and analysis is to be based on IEC 60079-10-1 or IEC 60092-502.

(3) Necessary measures are to be taken to prevent the leakage of gas fuel from the surrounding spaces of gas admission valve rod (or gas fuel valve).

4.3 Additional requirements for DF engines

4.3.1 The maximum continuous power that a DF engine can develop in gas mode may be lower than the approved MCR of the engine (i.e. in oil fuel mode), depending in particular on the gas quality. This maximum power available in gas fuel mode and the corresponding conditions are to be stated by the engine manufacturer and demonstrated during the type test.

4.3.2 DF engines are to be arranged to use either oil fuel or gas fuel for the main fuel charge and

with pilot oil fuel for ignition. The amount of pilot fuel injected into each cylinder is to be sufficient to ignite the gas-air mixture in the cylinder. The engines are to be arranged for rapid changeover from gas use to fuel oil use. In the case of changeover to either fuel supply, the engines are to be capable of continuous operation using the alternative fuel supply without interruption to the power supply.

4.3.3 An automatic system is to be fitted to change over from gas fuel operation to oil fuel operation and vice versa with minimum fluctuation of the engine power. Acceptable reliability is to be demonstrated through testing. In the case of unstable operation on engines when gas firing, the engine is to automatically change to oil fuel mode. Manual activation of gas system shutdown is always to be possible.

4.3.4 Changeover to gas fuel operation is to be only possible at a power level and under conditions where it can be done with acceptable reliability and safety as demonstrated through testing. Changeover from gas fuel operation mode to oil fuel operation mode is to be possible at all situations and power levels.

4.3.5 For the starting, operation with low load and prior to normal stop of the engine, generally only oil fuel is allowed to be used. The starting, operation with low load and normal stop of the engine with gas fuel may be acceptable if it has been demonstrated by the risk analysis and by tests that the level of safety and reliability of starting, operation with low load and normal stop of the engine with gas fuel is not lower than that of oil fuel mode. For DF engines started in gas mode, the gas supply is to be shut off automatically and the starting is to be terminated if combustion has not been detected by the engine monitoring system within the period specified by the manufacturer after the gas fuel supply valve is opened. Means to ensure that any unburnt fuel mixture is purged away from the exhaust system are to be provided.

4.3.6 In case of a normal stop or an emergency shutdown, the gas fuel supply is to be shut off not later than the ignition source. It is not to be possible to shut off the ignition source without first or simultaneously closing the gas supply to each cylinder or to the complete engine.

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

4.3.8 Gas supply to the combustion chamber is not to be possible without operation of the pilot oil injection.

Note: Pilot injection is to be monitored for example by fuel oil pressure and combustion parameters.

4.4 Additional requirements for GF engines

4.4.1 In case of a normal stop or an emergency shutdown, the gas fuel supply is to be shut off not later than the ignition source. It is not to be possible to shut off the ignition source without first or simultaneously closing the gas supply to each cylinder or to the complete engine.

4.4.2 In case of failure of the spark ignition, the engine is to be shut down except if this failure is limited to one cylinder, subject to immediate shut off of the cylinder gas supply and provided that the safe operation of the engine is substantiated by the risk analysis and by tests.

4.4.3 During the starting process, the gas fuel may be allowed to be supplied to the cylinder only when the engine reaches the lowest ignition speed and the ignition is started.

4.4.4 When the starting of engine fails, any unburned gas mixture in the exhaust system is to be purged away and the engine can not be started again before the purging of exhaust system is completed.

4.5 Additional requirements for pre-mixed engines

4.5.1 Inlet manifold, turbo-charger, charge air cooler, etc. are to be regarded as parts of the fuel gas supply system. Failures of those components likely to result in a gas leakage are to be considered in the risk analysis.

4.5.2 Flame arrestors are to be installed before each cylinder head, unless otherwise justified in the risk analysis, considering design parameters of the engine such as the gas concentration in the charge air system, the path length of the gas-air mixture in the charge air system, etc.

4.6 Type testing, factory acceptance tests and shipboard trials

4.6.1 According to the definition of the type of gas fuel engine in 4.1.2, type approval of each new type of gas fuel engine is to be carried out in accordance with the requirements of 9.10.1 and 9.10.2 of Chapter 9, PART THREE of CCS Rules for Classification of Sea-Going Steel Ships, taking into account the following additional requirements:

(1) Type tests are to be carried out in accordance with the procedures specified in 1.3 of Appendix 4 of Chapter 9 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships. For DF engines, the load tests are to be carried out in gas mode at the different percentages of the maximum power available in gas mode. The 110% load tests are not required in the gas mode. The influence of the methane number and LHV of the fuel gas is not required to be verified during the Stage B type tests. It is however to be justified by the engine designer through internal tests or calculations and documented in the type approval test report.

(2) Measures to verify that gas fuel piping on engine is gas tight are to be carried out prior to start-up of the engine.

(3) In addition to the measurements and records required in 1.4 of Appendix 4 of Chapter 9 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships, the following engine data are to be measured and recorded:

- ① Each fuel index for gas and diesel as applicable (or equivalent reading);
- ② Gas pressure and temperature at the inlet of the gas manifold;
- ③ Gas concentration in the scavenge box (two-stroke)/crankcase (four-stroke).

Additional measurements may be required in connection with the design assessment.

(4) Internal tests are to be carried out in accordance with the provisions of 2.1 of Appendix 4 of Chapter 9 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships, taking into account the following requirements for DF engines:

- ① DF engines are to run the load points in both gas and diesel modes (with and without pilot injection in service) as found applicable for the engine type.
- ② For DF engines with variable liquid/gas ratio, the load tests are to be carried out at different ratios between the minimum and the maximum allowable values.
- ③ For DF engines, switch over between gas and diesel modes are to be tested at different loads.

(5) Witnessed tests are to be carried out in accordance with the provisions of 2.2 of Appendix 4 of Chapter 9 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships, taking into account the following requirements:

- ① The following test conditions are to be considered for DF engines during the load test:

- (a) In case of DF engine, all load points must be run in both gas and diesel modes that apply for the engine type. This also applies to the overspeed test.
 - (b) In case of DF engines with variable liquid / gas ratio, the load tests are to be carried out at different ratios between the minimum and the maximum allowable values.
- ② The following tests are to be carried out:
- (a) For DF engines, the lowest specified speed is to be verified in diesel mode and gas mode.
 - (b) For DF engines, switch over between gas and diesel modes are to be tested at different loads.
 - (c) The efficiency of the ventilation arrangement of the double walled gas piping system is to be verified.
 - (d) Simulation of a gas leakage in way of a cylinder gas supply valve.

Engines intended to produce electrical power are to be tested as follows:

- (a) Capability to take sudden load and loss of load in accordance with the provisions of 9.7.10.1 of Chapter 9 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.
- (b) For GF and premixed engines, the influences of LHV, methane number and ambient conditions on the dynamic load response test results are to be theoretically determined and specified in the test report. Referring to the limitations as specified in 4.1.4 of the Guidelines, the margin for satisfying dynamic load response is to be determined.

Note 1: For DF engines, switchover to oil fuel during the test is acceptable.

Note 2: Application of electrical load in more than 2 load steps can be permitted in the conditions stated in 9.7.10.1 of Chapter 9 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.

- ③ GF and DF engines are to undergo integration tests to verify that the response of the complete mechanical, hydraulic and electronic engine system is as predicted for all intended operational modes. The scope of these tests is to be agreed with CCS for selected cases based on the risk analysis, and is at least to include the following incidents:
- (a) failure of ignition (spark ignition or pilot injection systems), both for one cylinder unit and common system failure;
 - (b) failure of a cylinder gas supply valve;
 - (c) failure of the combustion (to be detected by e.g. misfiring, knocking, exhaust temperature deviation, etc.);
 - (d) abnormal gas pressure;
 - (e) abnormal gas temperature.

Note: This test may be carried out using a simulation signal of the temperature.

(6) Stage C – Component inspection

Component inspection is to be carried out in accordance with the provisions of 2.3 of Appendix 4 of Chapter 9 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships. The components to be inspected after the test run are to include also:

- ① gas supply valve including pre-chamber as found applicable;
- ② spark igniter (for GF engines);

- ③ pilot fuel injection valve (for DF engines).

4.6.2 Factory acceptance tests are to be carried out in accordance with Appendix 6 of Chapter 9 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships, taking into account the additional requirements below:

(1) Measures to verify that gas fuel piping on engine is gas tight are to be carried out prior to start-up of the engine.

(2) The following engine data are to be measured and recorded:

- ① fuel index, both gas and diesel as applicable (or equivalent reading);
- ② gas pressure and temperature at the inlet of the gas manifold.

(3) The scope of the load tests may be expanded depending on the engine application, service experience, or other relevant reasons. For DF engines, the following test conditions are to be considered for load tests:

- ① All load tests are to be carried out in both gas and diesel modes as found applicable for the engine type.
- ② The load tests are to be carried out in gas mode at the different percentages of the maximum power available in gas mode.
- ③ The 110% load tests are not required in the gas mode.

(4) Gas fuel engines are to undergo integration tests to verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes. The scope of these tests is to be agreed with CCS for selected cases based on the risk analysis and is at least to include the following incidents:

- ① failure of ignition (spark ignition or pilot injection systems), both for one cylinder unit and common system failure;
- ② failure of a cylinder gas supply valve;
- ③ failure of the combustion (to be detected by e.g. misfiring, knocking, exhaust temperature deviation, etc.);
- ④ abnormal gas pressure;
- ⑤ abnormal gas temperature.

Note: The above tests may be carried out using simulation or other alternative methods, subject to special consideration by CCS.

4.6.3 Shipboard trials are to be carried out in accordance with the provisions of Appendix 6 of Chapter 9 of PART THREE of CCS Rules for Classification of Sea-Going Steel Ships.

For DF engines, the test loads are to be carried out in all operating modes (gas mode, diesel mode, etc.).

CHAPTER 5 CONTROL, MONITORING AND SAFETY SYSTEMS

5.1 General requirements

5.1.1 The control, monitoring and safety systems of gas fuel engines and their gas fuel supply are to comply with the applicable requirements of Chapter 9, PART THREE and PART SEVEN of CCS Rules for Classification of Sea-going Steel Ships and Chapter 16 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk in addition to the requirements of this Chapter.

5.1.2 The control, monitoring and safety systems of the gas fuel engines are to be so arranged that the remaining power for propulsion and power generation is in accordance with 3.2.1 of the Guidelines in the event of single failure.

5.1.3 For gas fuel engines, measures are to be taken to prevent consequential trip of an engine caused by sudden overload in case one engine is shut down.

5.1.4 A gas safety system is to be arranged to close down the gas supply system automatically, upon failure in systems as described in Tables 5.2.1 and 5.3.1 and upon other fault conditions which may develop too fast for manual intervention.

5.1.5 For ESD protected machinery spaces, the safety system is to shut off gas supply upon gas leakage and in addition disconnect all non-certified safe type electrical equipment in the machinery space.

5.1.6 The safety functions are to be arranged in a dedicated gas safety system that is independent of the gas control system in order to avoid possible common cause failures. This includes power supplies and input and output signal.

5.1.7 The safety systems including the field instrumentation are to be arranged to avoid spurious shutdown, e.g. as a result of a faulty gas detector or a wire break in a sensor loop.

5.1.8 Where two or more gas supply systems are required to meet the requirements of the rules, each system is to be fitted with its own set of independent gas control and gas safety systems.

5.1.9 Suitable instrumentation devices are to be fitted to allow a local and a remote reading of essential parameters to ensure a safe management of the whole fuel-gas system.

5.2 Control, monitoring and safety systems for gas fuel engines

5.2.1 Risk analysis is to be carried out for all failures that may affect the safe operation of gas fuel engines and monitoring items related to safe usage of gas fuel are to be determined based on the analysis results. Table 5.2.1 lists the monitoring items for gas fuel engines for references. The control station for gas fuel engines is to be provided with alarms and indicators. In addition, the navigation bridge is to be provided with group alarm.

Note: for dual fuel engines, Table 5.2.1 is only applicable to the gas mode.

5.2.2 For risk analysis, refer to CCS Guidelines for Application of Failure Mode and Effects Analysis.

5.2.3 Indicators are to be fitted on the navigation bridge, the engine control room and the manoeuvring platform for:

- (1) operation of the engine in case of gas-only engines; or
- (2) operation and mode of operation of the engine in the case of dual fuel engines.

Monitoring and Safe Protection of Gas fuel engines

Table 5.2.1

Monitoring items	Alarm	Automatic activation of double block and bleed valve	Automatic changeover to oil fuel mode ¹⁾	Engine shutdown
Abnormal pressure of gas fuel supply	×	×	×	×
Failure of gas fuel supply system	×	×	×	×
Failure of pilot fuel injection or spark ignition system	×	×	×	×
Exhaust gas temperature after each cylinder- high	×	×	×	×
Deviation of exhaust gas temperature after each cylinder from average temperature -large ³⁾	×	×	×	×
Cylinder pressure or ignition failures, including misfire, knocking and unstable combustion	×	×	×	×
Oil mist concentration in crankcase or bearing temperature ⁶⁾ - high	×	×		×
Pressure in the crankcase -high ⁸⁾	×	×	×	
Engine stop (any causes)	×	×		
failure of the control-actuating medium of the double block and bleed valve	×	×	×	
<p>Note for the symbol: × Applicable</p> <p>Notes:</p> <ol style="list-style-type: none"> 1) Only applicable to dual fuel engines operating in gas mode. 2) For GF engines, when the failure only affects one cylinder, the concerned cylinder can be shutoff individually, and the double block and bleed valve may not be activated provided that the risk analysis proves that the engine can still operate safely in such conditions. The engine will continue to operate by gas fuel. 3) Only applicable when necessary for misfiring detection. 4) Where failures can be corrected by an automatic mitigation action, only alarm may be activated. Where failures continue after a given time, the safety action is to be activated. 5) Only applicable to GF engines. 6) Where required according to the requirements of 9.7.6, Chapter 9, PART THREE of CCS Rules for Classification of Sea-going Steel Ships. 7) Slow-down is permitted for low-speed diesel engines. 8) Only applicable to trunk piston engines. Where failures can be corrected by an automatic mitigation action, only alarm may be activated. Where failures continue after a given time, the safety action is to be activated. 9) Except for normal stop of engines. 				

5.3 Monitoring and safety protection of gas fuel engine rooms

5.3.1 Alarms and safety protection of gas fuel engine rooms are to comply with the provisions of Table 5.3.1. The control station of gas fuel engines is to be provided with relevant alarms and indicators. In addition, the navigation bridge is to be provided with group alarm.

Monitoring and Safe Protection of Gas fuel engine rooms **Table 5.3.1**

Monitoring items	Alarm	Automatic shutoff of master gas fuel valve and double block and bleed valve	Automatic changeover to oil fuel mode ^①	Disabling ESD protected engine rooms
Loss of ventilation in ESD protected gas fuel engine rooms	×	×	×	
Decrease of ventilation capability in ESD protected gas fuel engine rooms	×			
Overpressure loss of inert gas between concentric pipes in the double wall gas supply system in gas-safe engine rooms	×	× ^④	×	
Loss of ventilation in ventilation ducts or pipes inside gas-safe engine rooms	×	× ^④	×	
Fire detection in gas fuel engine rooms	×	×		
Gas detection in double duct or pipe gas supply systems in gas-safe engine rooms at 30% LEL	×			
Gas detection on two detectors ^② in double duct or pipe gas supply systems in gas-safe engine rooms at 60% LEL	×	× ^④		
Gas detection in ESD protected gas fuel engine rooms at 20% LEL	×			
Gas detection on two detectors ^② in ESD protected gas fuel engine rooms at 40% LEL	×	×		× ^③
Rupture of gas supply lines in gas fuel engine rooms	×	× ^⑤		× ^⑥
<p>Note for the symbol: × Applicable</p> <p>Notes:</p> <p>① Only applicable to dual fuel engines.</p> <p>② Two independent gas detectors located close to each other are required for redundancy reasons. If the gas detector is of self-monitoring type the installation of a single gas detector can be permitted.</p> <p>③ When gas leakage is detected in ESD protected gas fuel engine rooms, before the concentration reaches 60% LEL, all engines in the engine room are to be shut down, and power supply to all electrical installations are to be cut off automatically, except for the certified safe type.</p> <p>④ If the gas is supplied to more than one engine and the different supply pipes are completely separated and fitted in separate ducts and with the master valves fitted outside of the duct and outside of the machinery space containing gas fuel engines, only the master valve on the supply pipe leading into the duct where gas or loss of ventilation or pressure loss of inert gas is detected is to close.</p> <p>⑤ See the requirement of 3.3.9. Where a dedicated check valve is provided in case the pipes are ruptured, the check valve is to close automatically.</p> <p>⑥ Applicable to ESD protected gas fuel engine rooms. All engines in the engine room are to be shut down, and power supply to all electrical installations are to be cut off automatically, except for the certified safe type.</p>				