



Rules
R003AM01-2025

CHINA CLASSIFICATION SOCIETY

**RULES FOR CONSTRUCTION AND
EQUIPMENT OF SHIPS CARRYING
LIQUEFIED GASES IN BULK**

AMENDMENTS

2025

Effective from 1st January 2025

Beijing

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Brief Introduction

According to the implementation of IMO resolutions and IACS unified requirements which released recently, the contents of IMO resolution MSC.565(108), IMO Circular MSC.1/Circ.1668 and MSC.1/Circ.1679, IACS unified requirement UR G3 Rev.8, IACS unified interpretation UI GC39 are included in this amendments. The underline indicates new contents and the ~~strikeout~~ indicates deleted contents.

This change notice is effective from 1st January 2025.

PART TWO CLASSIFICATION SURVEY AND ADDITIONAL REQUIREMENTS FOR HULL STRUCTURE

Appendix 4 APPLICABLE REQUIREMENTS FOR SHIPS DEDICATED TO CARRY LIQUEFIED CARBON DIOXIDE IN BULK

Section 6 CARGO CONTAINMENT SYSTEM

6.5.2.1 Interbarrier and hold spaces associated with cargo containment systems ([cargo containment systems other than type C independent cargo tanks](#)) and spaces surrounding [type C independent](#) cargo tanks that do not have secondary barriers are to be filled with suitable dry air. Equipment for the provision of sufficient dry air of suitable quality to maintain the environment of such spaces is to be provided on board. If the cargo is carried at ambient temperature, the requirement for dry air is not applicable.

Appendix 5 APPLICABLE REQUIREMENTS FOR RELIQUEFICATION SYSTEMS

Section 1 GENERAL PROVISIONS

1.1 General requirements

1.1.1 This Appendix applies to the design, construction, plan approval and survey of reliquefaction systems fitted on liquefied gas carriers.

1.1.2 Where a reliquefaction system is fitted, requirements for design, construction and testing in 7.3, Chapter 7, PART THREE of the Rules are to be satisfied.

1.1.3 Where a reliquefaction system on LNG carriers is designed, constructed and tested in accordance with the requirements of Chapter 7, PART THREE of the Rules and the requirements of this Appendix, the "RELIQ" notation may be assigned. For other types of liquefied gas carriers, such as liquefied petroleum gas carriers, ethane carriers and ethylene carriers, etc., the "RELIQ" notation may be assigned by referring to the requirements of this Appendix and upon evaluation of CCS.

1.1.4 This Appendix is mainly applicable to direct cooling reliquefaction systems (e.g. nitrogen expansion refrigeration reliquefaction). For indirect cooling (e.g. cryogenic reliquefaction) or other types of reliquefaction systems (e.g. cascade reliquefaction), the "RELIQ" notation may also be assigned by referring to the applicable requirements of this Appendix and upon evaluation of CCS.

1.2 Goal and functional requirements

1.2.1 The reliquefaction system covered in this Appendix is to be designed, constructed, operated, and maintained to satisfy the cargo tank pressure and temperature within design limits of the containment system and/or carriage requirements of the cargo.

1.2.2 The design, construction, operation and maintenance of the reliquefaction system are to be in accordance with the following functional requirements:

(1) Substances that cause damage or pollution to the atmospheric environment are to be avoided insofar as practicable.

(2) Where the reliquefaction system is the only means of satisfying the requirements of 7.1.1, Chapter 7, PART THREE of the Rules, the capacity of reliquefaction systems is to be designed such that the cargo containment system is capable of withstanding the maximum vapor pressure of the cargo under conditions of the highest ambient design temperatures, without considering collection and reuse, reasonable release or treatment of other forms of boil-off gas.

(3) Where the reliquefaction system is the only means of satisfying the requirements of 7.1.1, Chapter 7, PART THREE of the Rules, the system is to be designed such that that a single failure of any component or the system does not cause the loss of its main functions, e.g., by providing redundancy and/or reliability in system or components.

(4) Reliquefaction return line is to have adequate pressure to return LNG to cargo tanks without obstruction.

(5) Means are to be provided to prevent impurities from entering the reliquefaction heat exchanger.

(6) Means are to be provided so that the hazardous area does not compromise the safety of personnel and equipment in non-hazardous areas.

(7) The systems are to withstand the maximum working stresses to which they may be subjected in all service conditions.

(8) Compressors are to be designed, installed and arranged to avoid critical and disabling resonance caused by vibrations during operations.

(9) Spaces where reliquefaction devices are installed are to be provided with sufficient ventilation to prevent the accumulation of flammable boil-off gas. Means for detecting oxygen content and flammable gas are to be provided, with the fitting of audible and visual alarms.

(10) Low-temperature and high-temperature components of the reliquefaction device are to be provided with means for protection against scalding or frostbite for personnel.

(11) Means are to be provided to dispose of or clear accumulated liquids in spaces within the vessel due to condensation, leakage, washing, fire fighting etc. which are to be capable to operate under the defined operating conditions and environmental conditions.

(12) Protective devices are to be provided if the system can be subjected to a pressure more than its design pressure.

(13) Equipment is to be designed to be suitable for ambient temperatures appropriate to the special working condition.

(14) Means for effective monitoring, operation and safe shutdown are to be provided during the normal operation and emergency conditions of the system and its associated auxiliaries.

1.3 Capacity

1.3.1 The capacity of the reliquefaction system is to be based on the requirements of 7.1.1, Chapter 7, PART THREE of the Rules and 1.2.2(2) of this Appendix.

1.3.2 Where the reliquefaction system is the only means of satisfying 7.1.1, Chapter 7, PART THREE of the Rules, the availability of the system is to comply with 7.8, Chapter 7, PART THREE of the Rules.

1.4 LNG return to cargo tanks

1.4.1 The reliquefaction system is to be arranged such that the re-liquefied natural gas cargo can be returned to cargo tanks, and does not cause the liquid level in any cargo tank to exceed the filling limit permitted by 15.1.1, Chapter 15, PART THREE of the Rules.

1.4.2 Where it is proposed that LNG from the reliquefaction system is returned without the use of a pump, by way of a gravity return or pressure return system, pressure drop calculations for the system to be fitted are to be submitted. The calculations are to consider ship motion and fluid motion inside the cargo tanks.

1.5 Plans and data to be submitted

1.5.1 For the approval and inspection of products, necessary plans and documentation are to be submitted to CCS in accordance with the certification requirements for reliquefaction devices in Appendix 1D, Chapter 3, PART ONE of CCS Rules for Classification of Sea-Going Steel Ships and relevant requirements of CCS guidance documents on product approval and inspection of reliquefaction devices.

1.5.2 Plans and data to be submitted for review in the installation, test and survey stage on board:

1.5.2.1 Plans for approval:

(1) General arrangement of the reliquefaction system;

(2) Ventilation system for reliquefaction system space;

(3) Fixed gas detection and alarm system;

(4) Description and schematic diagram of the control and monitoring system;

(5) Details of electrical equipment in the reliquefaction system space;

(6) Emergency shutdown arrangement;

(7) Testing procedures during sea trial/gas trial, including functions, failure responses, performance, interfaces with other systems and human-machine interface, etc. (on-site approval);

(8) Other plans and data as deemed necessary by CCS.

1.5.2.2 Plans for information

(1) Failure Modes, Effects, and Criticality Analysis (FMECA) to determine possible failures and their effects in the safe operation of the reliquefaction system;

(2) Operating and maintenance instruction manual (to be kept onboard).

Section 2 CARGO VAPOR/LNG CIRCUIT

2.1 Boil-off gas compressors

2.1.1 The design and testing of compressor are to satisfy applicable standards acceptable to CCS (such as API Std. 617, API Std. 618 or API Std. 619) and relevant applicable requirements of CCS Guidelines for Type Approval Test of Electric and Electronic Products.

2.1.2 Pressure and temperature measurement and control are to satisfy Table 12.4.1, Section 12 of this Appendix.

2.2 LNG pumps

2.2.1 The LNG pumps are to be designed and tested in accordance with CCS5.13.1.b, Chapter 5, PART THREE of the Rules.

2.3 Separation of impurities (where applicable)

2.3.1 Impurities in the vapor, as well as nitrogen, are to be separated prior to the return of LNG from the reliquefaction system to the cargo tanks.

Section 3 REFRIGERATION SYSTEM

3.1 General requirements

3.1.1 Refrigeration systems are not to use ozone depleting refrigerants (ODP), as defined by the Montreal Protocol on Substances that Deplete the Ozone Layer.

3.2 Refrigerants

3.2.1 Refrigerants are to comply with 7.3.2, Chapter 7, PART THREE of the Rules.

3.2.2 The refrigerant capacities are to be as follows:

(1) Where the reliquefaction system is the only means of satisfying the requirements of 7.1.1, Chapter 7, PART THREE of the Rules, and the refrigerant is supplied by the vessel's nitrogen generation system, there is to be a minimum of two independent units fitted, so that with any one unit inoperative, 100% of the required capacity is available.

(2) Where a cascade system is fitted, there is to be a sufficient capacity of the refrigerant on board to recharge the system.

3.2.3 Where a cascade system is used requiring onboard storage of refrigerant, the refrigeration system is to be fitted with a receiver capable of holding the complete charge of the refrigerating units. Where each refrigeration unit is fitted with an individual receiver, the capacity is to be sufficient to hold the charge of that unit.

3.2.4 In the case of liquid nitrogen, if part of the refrigerant can be discharged to the atmosphere in the design, consideration is to be given to the design and arrangement of discharge so that no damage is caused to the ship and its personnel.

3.2.5 Where nitrogen-helium mixtures or other mixtures are used as refrigerants, a closed-cycle refrigerant system is to be used, and the replenishment of the refrigerant is to be carried out under the guidance of the manufacturer.

3.3 Compressor/Expander/Compressor-Expander All-In-One Machine

3.3.1 The testing of compressor/expander/compressor-expander all-in-one machine is to satisfy applicable standards acceptable to CCS (such as API Std. 617, API Std. 618 or API Std. 619) and relevant applicable requirements of CCS Guidelines for Type Approval Test of Electric and Electronic Products.

3.3.2 Instrumentation, monitoring and control system for the compressors are to comply with Table 12.4.1, Section 12 of this Appendix.

3.3.3 For axial or centrifugal compressors, surge protection is to be provided.

3.3.4 For gas compressors driven by electric motor (Both Cargo and Refrigerant, as applicable), the vibration in all directions on the electric motor casing in the area of bearings are to be provided by manufacturers, and consistent with an internationally recognized standard. Otherwise, when the data on the vibration criteria are not available, the following criteria are to be measured for broadband vibrations:

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(1) Less than 4.5 mm/sec for rigidly mounted compressors, and;

(2) Less than 7.1 mm/sec for flexibly mounted machinery.

Notes:

- A rigid foundation installation is defined as one whose lowest natural frequency of the combined machine and support system in the direction of measurements is higher than its main excitation frequency by at least 25%.

- All other systems may be considered flexible.

Alternative limits may be considered on a case-by-case basis.

3.4 Cryogenic heat exchangers and cold box

3.4.1 The cryogenic heat exchangers are to comply with CCS Rules for Classification of Sea-going Steel Ships and Chapters 5 and 6, PART THREE of the Rules. If nitrogen refrigeration compressors are to be located in gas- safe spaces, to mitigate the risks of boil-off gas returning to the refrigeration compressors through the refrigerant system, the pressure in the refrigerant circuit is to be maintained greater than the pressure in the boil-off gas circuit at all times.

3.4.2 Piping inside the cold box is to be of all-welded construction. Where flanged connections or other form of connection are essential, details indicating the necessity for this connection are to be submitted.

3.4.3 For pressure and temperature measurements and controls, see Table 12.4.1, Section 12 of this Appendix.

3.4.4 Where the heat exchanger is enclosed in a cold box, the following requirements apply:

(1) The cold box is to be designed to withstand nitrogen purge pressures likely to be encountered in service and is to be fitted with pressure and vacuum relief devices to prevent over- and under pressurization.

(2) To prevent overpressuring of the cold box by leaking nitrogen or BOG/LNG, a safety relief valve is to be provided. The vent from the cold box safety relief valve is to be led to the weather.

(3) Means of detecting boil-off gas leakage within the cold box is to be provided. The detection system is to give an audible and visual alarm at the cargo control station and the bridge upon detection of gas leakage.

(4) Where the cold box is insulated, means are to be provided for continuous purging of the insulation spaces with nitrogen or other suitable inert gas.

Section 4 INSTRUMENTATION AND SAFETY SYSTEMS

4.1 General requirements

4.1.1 The control system for the reliquefaction system may be part of an integrated control system or be a stand-alone system.

4.1.2 Where the reliquefaction system is the only means of satisfying the requirements of 7.1.1, Chapter 7, PART THREE of the Rules, the overall system design is to be based on single-fault criteria. The system is to be designed such that a single fault of a component does not lead to catastrophic consequences.

4.1.3 The reliquefaction system is to comply with the ESD control as indicated by 18.10.3, Chapter 18, PART THREE of the Rules.

4.2 Control and monitoring system

4.2.1 Automatic control, alarm and safety functions are to be provided such that operations are within the preset parameters in both laden and ballast conditions.

4.2.2 The temperature and pressures in the reliquefaction system are to be controlled as follows:

(1) A control and monitoring system is to be provided in the cargo control room. Additionally, a motor control panel is to be provided in the vicinity of the boil-off gas compressor and the refrigeration compressor motors.

(2) The design of the control system is to be such that faults in the equipment, as well as the process system are identified. The control and monitoring systems are to comply with the requirements of Chapter 2, PART SEVEN of CCS Rules for Classification of Sea-going Steel Ships, as applicable.

(3) Indications of parameters necessary for the safe and effective operation of the process are to be provided, as per Table 12.4.1, Section 12 of this Appendix.

(4) For all control systems, if power supply safety is taken into account, backup power supply can be added. Each power supply mode is to be monitored separately for faults.

(5) All computer-based control systems are to comply with the applicable requirements of Chapter 2, PART SEVEN of CCS Rules for Classification of Sea-going Steel Ships.

4.3 Safety shutdown system

4.3.1 An independent shutdown system is to be provided. This safety shutdown system is to be based on the following principles:

(1) Means are to be provided to indicate the parameters causing shutdown.

(2) Upon activation of the safety shutdown system, alarms are to be given at the normal control position and at the local control position.

(3) In the event where shutdown by the safety shutdown system is activated or where the shutdown is initiated by the vessel's emergency shutdown system (ESD), the restart is not to occur automatically, unless after the system is reset.

(4) For the safety shutdown system, if system safety is taken into account, backup power supply can be added.

(5) Means are to be provided to evacuate LNG remaining in the system after a shutdown.

4.3.2 Safety shutdowns are to be in accordance with Table 12.4.1, Section 12 of this Appendix.

Section 5 ELECTRICAL SYSTEM

5.1 The electrical installations and control systems intended for the reliquefaction system are to comply with PARTs FOUR and SEVEN of CCS Rules for Classification of Sea-going Steel Ships and Chapter 10, PART THREE of the rules.

Section 6 LOCATION AND INSTALLATION

6.1 The boil-off gas compressors, cryogenic heat exchangers, separator (where installed) and LNG pumps are to be located in the cargo area.

6.2 The refrigeration compressors/expanders, driving motors, and interstage/after coolers etc. are in general to be located in a gas-safe space within the deckhouse or in the machinery spaces. Where the relevant equipment is arranged in a non-gas-safe space, the explosion-proof grade is to satisfy the requirements.

6.3 Structural details of the deckhouse, as well as the under deck strengthening in way of the reliquefaction system, are to be in accordance with Chapter 2, PART TWO of CCS Rules for Classification of Sea-going Steel Ships.

6.4 Doors and openings to the deckhouse are to be in accordance with 3.2, 3.3, 3.6, Chapter 3, PART THREE of the Rules.

Section 7 MECHANICAL VENTILATION

7.1 Ventilation arrangements for spaces containing reliquefaction devices are to be in accordance with 12.1, Chapter 12, PART THREE of the Rules.

7.2 Ventilation arrangements for the gas safe spaces in the deckhouse containing the electric motors are to have a minimum capacity of eight (8) air changes per hour and be of the positive pressure type.

Section 8 GAS DETECTION

8.1 The gas detection system for the spaces in the deckhouse containing boil-off gas compressors, cryogenic heat exchangers and cold box, separator and LNG pumps and associated electric motors are to be in accordance with 13.6, Chapter 13, PART THREE of the Rules.

8.2 The spaces in the deckhouse containing the refrigeration equipment are to be fitted with a low oxygen level detection system (see also Table 12.4.1, Section 12 of this Appendix).

8.3 Where the refrigerant being used is considered to be toxic, a gas detection and alarm system is to be installed to give an alarm when the specified concentration is exceeded and appropriate measures are to be taken.

8.4 The detection and alarm of toxic or flammable boil-off gas leakage are to comply with 7.8.4, Chapter 7, PART THREE of the Rules.

Section 9 ANCILLARY SYSTEMS

9.1 Where cooling water is required in refrigeration systems, the cooling water supply is to be as follows:

(1) Comply with availability criteria as per 7.8, Chapter 7, PART THREE of the Rules.

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(2) Where seawater is used, each pump is to have at least two sea suction lines, preferably one port and one starboard.

(3) The reliquefaction system is to be provided with a designated and independent cooling water system. If the cooling water system is used for other gas machineries, the cooling water system is to be capable of simultaneously supplying the amount of cooling water needed for the reliquefaction system and other gas machineries.

(4) Spaces containing cooling water piping are to be provided with a bilge alarm and means of bilge water drainage.

Section 10 PIPING SYSTEM

10.1 Refrigerant piping systems are to comply with the applicable requirements in Chapter 5, PART THREE of the Rules.

10.2 Automatic expansion valves are to be provided with manually operated bypass valves. Alternatively, redundant automatic expansion valves within redundant refrigeration systems are acceptable.

10.3 Documentation is to be submitted for piping systems connected to the boil-off gas compressor units, demonstrating that the vibration in all directions is in accordance with an internationally recognized standard. Alternative vibration limits are to be subjected to CCS technical assessment and approval. Alternative limits are to be demonstrated by fatigue calculation reports to be submitted for review defining the analysis method and any engineering assumptions made.

Section 11 FIRE EXTINGUISHING SYSTEMS

11.1 Spaces containing the equipment described in Section 6 of this Appendix are to be provided with fire extinguishing arrangements complying with 11.5.1, Chapter 11, PART THREE of the Rules.

Section 12 SURVEYS

12.1 General requirements

12.1.1 This Section pertains to surveys and testing during fabrication at the manufacturer's facility, and installation, testing and survey of reliquefaction systems on board.

12.1.2 Where the reliquefaction system is supplied in parts and assembled on board, the survey and test items for the system are to cover the requirements of 12.2 of this Appendix.

12.2 Surveys and testing at the manufacturer's facility

12.2.1 During survey at the manufacturer's facility, CCS surveyor is to conduct surveys and testing in accordance with the relevant requirements of CCS guidance documents on product approval and inspection of reliquefaction devices, and the type/delivery test program approved by CCS, so as to ensure that the

reliquefaction devices satisfy the design requirements.

12.3 Onboard installation and testing

12.3.1 During the installation and testing on board, surveys and tests on the reliquefaction system and related systems, including but not limited to the following contents, are to be carried out to the satisfaction of CCS surveyors:

- (1) Confirming that the actual arrangement of the equipment on the ship is consistent with the approved drawings.
- (2) For the piping systems installed on board after delivery, visual examination, strength and tightness tests, and non-destructive testing are to be carried out in accordance with the requirements of CCS rules.
- (3) Electrical wiring and connections are to comply with the requirements of CCS rules, and their electrical continuity is to be checked.
- (4) Confirming that relevant instruments have been calibrated and are within the validity period.
- (5) Pressure relief valves and safety valves are to be tested.
- (6) The control system and shutdown functions are to be tested to ensure normal operation.
- (7) Verifying that the operation and maintenance manuals are available on board.

12.4 Surveys during gas trials

12.4.1 During the initial gas trial after the installation of the reliquefaction system, testing of such system is to be carried out in accordance with the test procedures approved by CCS, in order to confirm that the reliquefaction system satisfies the design requirements, including the proper function of relevant controls, alarms and shutdowns. Table 12.4.1 specifies the requirements for instrumentation and alarms, which are provided by taking into full consideration of the safety of the reliquefaction system and are not limited to the requirements in Table 12.4.1.

Table 12.4.1 Instrumentation and Alarms

	<u>Item</u>	<u>Display</u>	<u>Alarm Activated</u>	<u>Automatic Shut Down</u>
<u>BOG Compressor</u>	<u>Flow rate</u>	<u>X</u>	<u>Low</u>	<u>--</u>
	<u>Driving motors</u>	<u>Running</u>	<u>Stop</u>	<u>--</u>
	<u>LO Temperature</u>	<u>X</u>	<u>High</u>	<u>--</u>
	<u>Separator level, if fitted</u>	<u>X</u>	<u>High</u>	<u>--</u>
	<u>Suction line Pressure</u>	<u>X</u>	<u>High/Low</u>	<u>X(High-High))</u>
	<u>Suction line Temperature</u>	<u>X</u>	<u>High</u>	<u>X(High-High))</u>
	<u>Discharge line Pressure</u>	<u>X</u>	<u>Low</u>	<u>X(Low-Low)</u>
	<u>Discharge line Temperature</u>	<u>X</u>	<u>High /Low</u>	<u>X(High-High))</u>
	<u>Gas Detection in cold box</u>	<u>--</u>	<u>X(30%LEL)</u>	<u>X(60%LEL)</u>
	<u>Cryogenic heat exchanger inlet temperature</u>	<u>X</u>	<u>High</u>	<u>X(High))</u>
<u>Refrigerating</u>	<u>LO Temperature</u>	<u>X</u>	<u>High</u>	<u>X(High-High))</u>

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<u>Compressor</u>	<u>Driving motors</u>	<u>Running</u>	<u>Stop</u>	<u>--</u>
	<u>Suction line Pressure</u>	<u>X</u>	<u>Low</u>	<u>X(Low-Low)</u>
	<u>Suction line Temperature</u>	<u>X</u>	<u>High/Low</u>	<u>X(High-High))</u>
	<u>Discharge line Pressure</u>	<u>X</u>	<u>High</u>	<u>X(High-High))</u>
	<u>Discharge line Temperature</u>	<u>X</u>	<u>High /Low</u>	<u>--</u>
	<u>Seal gas pressur</u>	<u>X</u>	<u>Low</u>	<u>X(Low-Low)</u>
	<u>Seal gas leakage expander Pressure</u>	<u>X</u>	<u>High</u>	<u>X(High-High))</u>
<u>Spaces Containing</u>	<u>Oxygen Level Detection System</u>	<u>X</u>	<u>Low</u>	<u>--</u>
<u>Refrigeration</u>	<u>Refrigerant Concentration</u>			
<u>Equipment</u>	<u>Detection System, if Considered</u> <u>Toxic</u>	<u>X</u>	<u>High</u>	<u>--</u>

Appendix 6 APPLICABLE REQUIREMENTS FOR GAS COMBUSTION UNITS

Section 1 GENERAL PROVISIONS

1.1 General requirements

1.1.1 This Appendix applies to the design, construction, plan approval and survey of Gas Combustion Unit (GCU) fitted on liquefied gas carriers.

1.1.2 Where a GCU is fitted, requirements for design, construction and testing in Chapter 7, PART THREE of the Rules are to be satisfied.

1.1.3 Where a GCU on LNG carriers is designed, constructed and tested in accordance with the requirements of Chapter 7, PART THREE of the Rules and the requirements of this Appendix, the "GCU" notation may be assigned. For other types of liquefied gas carriers, such as liquefied petroleum gas carriers, ethane carriers and ethylene carriers, etc., the "GCU" notation may be assigned by referring to the requirements of this Appendix and upon evaluation of CCS.

1.1.4 For other types of thermal oxidation system, the "GCU" notation may be assigned by referring to the applicable requirements of this Appendix and upon evaluation of CCS.

1.1.5 A GCU system contains the following major components:

- (1) Boil-off gas compressors (generally provided on board);
- (2) Heat exchangers (generally provided on board);
- (3) Automatic gas shut-off valve and associated pipe work;
- (4) Gas supply pipeline (e.g. double-wall pipe, etc.);
- (5) Gas valve enclosure and venting of the enclosure/hood;
- (6) Gas burner unit including oil pilot burner (if applicable) and burner management system;
- (7) Combustion chamber and associated refractory;
- (8) Forced draft (combustion) fans, dilution fans and/or combination fans;
- (9) Exhaust trunk;
- (10) Control unit, including control cabinet, distribution cabinet, ignition cabinet, etc.;
- (11) Ethylene glycol water heater (added as required);
- (12) Auxiliary fuel pump set (if applicable);
- (13) Heating fans (if applicable).

1.1.6 Operation modes of the GCU:

- (1) Standby mode: the GCU is available at any time and can be quickly started to 100% load operation;
- (2) Gas mode: After the cargo vapor (BOG) comes from the compressor, fuel can be used to assist ignition, and the gas supply pressure is higher;
- (3) Free flow mode: BOG comes directly from the cargo tank, and fuel can be used to assist ignition. The gas supply pressure is consistent with the cargo tank pressure, and the cryogenic boil-off gas is heated to 0-50°C through the heater to supply the GCU;

(4) Inerting mode of cargo tank (Gas free): The gas comes directly from the cargo tank. For complete combustion, fuel is needed for combustion support or a flint is required for ignition. The concentration of natural gas is not fixed and varies with the progress of inerting.

1.2 Goal and functional requirements

1.2.1 The GCU covered in this Appendix is to be designed, constructed, operated, and maintained to maintain the cargo tank pressure and temperature within design limits of the containment system and/or carriage requirements of the cargo.

1.2.2 To achieve the goals stated in 1.2.1 of this Appendix, the design, construction, and maintenance of GCU are to be in accordance with the following functional requirements:

(1) Where the GCU is the only means of satisfying the requirements of 7.1.1, Chapter 7, PART THREE of the Rules, the capacity of GCU is to be designed such that the cargo containment system is capable of withstanding the maximum vapor pressure of the cargo under conditions of the highest ambient design temperatures, irrespective of any system provided for dealing with boil-off gas.

(2) Provide arrangements to prevent fire/explosion in non-hazardous area due to leakage of gas fuel piping.

(3) Provide means to automatically shut off the fuel supply to each gas burner/oil pilot burner in case of failure of the flame scanner.

(4) Provide means to manually shut off the gas fuel supply to each gas burner in case of failure of automatic shut off.

(5) Where the GCU is the only means of satisfying the requirements of 7.1.1, Chapter 7, PART THREE of the Rules, the system is to be designed such that that a single failure of any component or the system does not cause the loss of its main functions, e.g., by providing redundancy and/or reliability in system or components.

(6) Air flow in the forced draft and the dilution air flow streams is to be measured and monitored to confirm that sufficient air is provided for combustion optimization and emission efficiency.

(7) Means are to be provided to protect the combustion chamber walls from overheating.

(8) Provide means to minimize or prevent hot surfaces contact with the crew during operation.

(9) Combustion chambers are to be designed to be capable of maintaining the temperature of casing at a lower level and to consider all modes of operation.

(10) Sufficient ventilation is to be provided in the space containing GCU to avoid possible accumulation of boil-off gas in the space. The ventilation system is to be separated from those serving other spaces.

(11) Provide Redundancy/Reliability for gas detectors so that a single failure/detector fault does not cause loss of main function.

(12) The arrangement of ignition sources is to be restricted, e.g. avoiding gas fuel double wall piping so as to minimize the possibility of ignition of flammable boil-off gas.

(13) Means are to be provided so that the hazardous area does not compromise the safety of personnel and equipment in non-hazardous areas.

(14) Provide means to detect leakage of gas within the casing in case of GCU double casing.

Appendix 6 APPLICABLE REQUIREMENTS FOR GAS COMBUSTION UNITS

PART TWO CLASSIFICATION SURVEY AND ADDITIONAL REQUIREMENTS FOR HULL STRUCTURE

(15) Be able to operate and control the burner unit from a local position as well as through an automatic or remote-control systems.

(16) Provide means in main control stations to effectively monitor, operate and safety shutdown the equipment and its associated auxiliaries during normal operation and emergency condition/failure of component.

(17) Provide means to analyze safety procedures to ensure, manage and control the safe operation of GCU in all modes.

1.3 Capacity

1.3.1 The capacity of the GCU system is to be based on the requirements of 7.1.1, Chapter 7, PART THREE of the Rules and 1.2.2(1) of this Appendix.

1.3.2 The turn down ratio of the GCU burner system is to have the capability of handling boil-off gas, as well as operating satisfactorily with the reduced boil-off gas during the ballast voyage when there is a residual amount of LNG remaining in the cargo tanks.

1.3.3 The GCU is to be designed to function safely during inerting and purging modes of operations if it is intended that the unit consume the gas displaced from the cargo tanks during these operations.

1.3.4 Where the GCU is intended to be used under a free flow mode, design features such as pipe sizing, electrical ignition system and oil pilot burner are subject to CCS approval.

1.4 Plans and data to be submitted

1.4.1 For the approval and inspection of products, necessary plans and documentation are to be submitted to CCS in accordance with the certification requirements for GCU in Appendix 1D, Chapter 3, PART ONE of CCS Rules for Classification of Sea-Going Steel Ships and relevant requirements of CCS guidance documents on product approval and inspection of GCU.

1.4.2 Plans and data to be submitted for review in the installation, test and survey stage on board:

1.4.2.1 Plans for approval:

(1) General arrangement of the GCU compartment, including location of the gas detectors, electrical equipment and lighting;

(2) Ventilation system for the GCU compartment;

(3) Fixed gas detection and alarm systems, and associated shut-off and shutdown systems;

(4) Gas fuel piping systems including details of piping and associated components, design pressures and temperatures

(5) Diagrams for control and monitoring system including set points for abnormal conditions;

(6) Details of all electrical equipment in the GCU compartment;

(7) Emergency shutdown arrangements;

(8) Testing procedures during sea/gas trials (on-site approval);

(9) Other plans and data as deemed necessary by CCS.

1.4.2.2 Plans for information:

(1) Operating and maintenance instruction manual (to be kept onboard).

Section 2 CARGO VAPOR CIRCUIT

2.1 Compressors

2.1.1 Compressor intended to be used for sending the boil-off gas to the GCU may be also used for other cargo duties.

2.1.2 The design and testing of the BOG compressor are to satisfy applicable standards acceptable to CCS (such as API Std. 617, API Std. 618 or API Std. 619) and relevant applicable requirements of CCS Guidelines for Type Approval Test of Electric and Electronic Products.

2.1.3 The ESD controls of BOG compressor are to be designed in accordance with 16.5.2, Chapter 16, and 18.10.3, Chapter 18, PART THREE of the Rules and BOG compressors are also to be capable of being stopped locally.

2.1.4 For pressure and temperature measurement and control, see Table 12.4.1, Section 12 of this Appendix.

2.2 Heat exchangers

2.2.1 The heat exchangers are to be designed, constructed and tested in accordance with standards acceptable to CCS and relevant requirements of Chapters 5 and 6, PART THREE of the Rules.

2.3 Gas Fuel Supply to GCU

2.3.1 Gas fuel piping is not to pass through accommodation spaces, service spaces or control stations. Gas fuel piping passing through or extending into other spaces is acceptable, provided the arrangements fulfill one of the following:

(1) Gas fuel supply piping is to be installed to comply with 16.4, Chapter 16, PART THREE of the Rules.
(2) If the gas fuel supply piping system is a single wall design, and the associated valves including the burner gas fuel connection at the GCU are located inside a gas tight compartment inside an engine room or other gas safe spaces, the arrangements are to be as follows:

- ① The pressure in the gas fuel supply line is not to exceed 10 bar (10.2 kgf/cm², 145 psi);
- ② The pipes are to be of all-welded construction with flange connections only at connections to equipment;
- ③ This compartment is to have access to the open deck. Where this is not possible, entrance and exits to this compartment from a non-hazardous area are to be via an air-lock in accordance with 3.6, Chapter 3, PART THREE of the Rules;
- ④ The compartment is to be fitted with a mechanical exhaust ventilation system complying with Section 8 of this Appendix;
- ⑤ The compartment is to be fitted with a gas detection system complying with Section 9 of this Appendix;

- ⑥ The gas supply pipes are to incorporate a block and bleed valve arrangement and comply with the purging requirements, as referred to in 16.4.5, Chapter 16, PART THREE of the Rules;
- ⑦ The alarms and shutdowns are to comply with Table 12.4.1, Section 12 of this Appendix and Section 10 of this Appendix respectively.

Section 3 BURNER UNIT AND BURNER MANAGEMENT SYSTEM

- 3.1 The burner management control philosophy for all modes of operation is to be submitted. This is to be accompanied by a safety analysis identifying all modes of failures and shutdown and startup sequences of the system. Risk analysis is to be carried out as necessary.
- 3.2 Where free flow of BOG to the GCU is intended, the GCU control system is to be designed to safely manage such mode of operation.
- 3.3 Gas nozzles are to be fitted in such a way that gas fuel is ignited by the flame of the oil pilot burner described in Section 4 of this Appendix or by an electrical ignition system.
- 3.4 The burner is to be fitted with a flame scanner. The flame scanner is to be dual scanners or a scanner of the self-checking type. The flame scanner control is to provide for a trial-by-ignition period of not more than ten (10) seconds, during which time gas fuel may be supplied to establish a flame. If the flame is not established within ten (10) seconds, the gas fuel supply to the burner is to be immediately shut off automatically. In the case of flame failure, shut-off is to be achieved within four (4) seconds following flame extinguishment. In the case of failure of the flame scanner, the gas fuel is to be shut off automatically. The number of flame scanners should be considered for redundancy setting.
- 3.5 Before the gas fuel enters the gas fuel piping, gas freeing and inerting are to be carried out. After flame extinguishment, the gas burner supply piping and combustion chamber is to undergo the purge sequences required by 7.4.4, Chapter 7, and 16.6.3, Chapter 16, PART THREE of the Rules.
- 3.6 The burner management system is to be arranged such that the burner cannot be ignited until forced draft (combustion) fan, dilution air fan or combination fan flow is established.
- 3.7 The burner unit is to have the capability of automatic operation and manual operation.
- 3.8 A manually operated shut-off valve is to be fitted on the pipe of each burner.

Section 4 OIL PILOT BURNER/ELECTRICAL IGNITION SYSTEM

- 4.1 Each gas fuel burner unit is at least to be fitted with an oil pilot burner and/or electrical igniter. The arrangements of the piping system, storage and heating of the fuel for the oil pilot burner are to be in accordance with the applicable requirements of Section 2, Chapter 4, PART THREE of CCS Rules for Classification of Sea-going Steel Ships.
- 4.2 The oil pilot burner is to be fitted with a flame scanner designed to automatically shut off the fuel supply to the burner in the event of flame failure. The shut-off is to be achieved within six (6) seconds

following flame extinguishment. In the case of failure of the flame scanner, the fuel to the oil pilot burner is to be shut off automatically.

Section 5 FORCED DRAFT (COMBUSTION) FANS, DILUTION FANS **AND/OR COMBINATION FANS**

5.1 For each GCU, in case of failure of one forced draft (combustion) fan, the forced draft (combustion) fans in normal operation are to be sized such that the total capacity is not less than 100% of the total capacity required to support the full rated capacity of the GCU. Forced draft (combustion) fan motors are to be located in a gas-safe space. Where operational or structural requirements are such as to make it impossible to install the motors in the gas-safe space, the following certified safe type motors are to be provided:

- (1) Increased safety type with flameproof enclosure; or
- (2) Pressurized type.

5.2 For each GCU, in case of failure of one dilution fan, the dilution fan in normal operation is to be sized such that the total capacity is not less than 100% of the total capacity required to support the full rated capacity of the GCU. Means are to be provided for measuring and monitoring of air flow in the forced draft and the dilution air flow streams on the discharge side.

5.3 Where combination fans are used to replace forced draft (combustion) fans and dilution fans, in case of failure of one combination fan, the combination fan in normal operation is to be sized such that the total capacity is not less than 100% of the total capacity required to support the full rated capacity of the GCU. At the same time, the other requirements of 5.1 and 5.2 of this Appendix are to be satisfied.

5.4 Where a refrigerating unit is used as the means of controlling the cargo pressure/temperature, it is also to meet the requirements of CCS7.8.1.a, Chapter 7, PART THREE of the Rules.

5.5 The air volume and pressure of the fan are to be calculated to meet the requirements for the GCU in various operating modes.

Section 6 COMBUSTION CHAMBER AND ASSOCIATED REFRACTORY

6.1 The combustion chamber walls are to be protected with insulated fire bricks/refractory and/or a cooling system. Hot surfaces likely to come in contact with the crew during operation are to be suitably guarded or insulated. In general the surface temperature is not to exceed 60°C.

6.2 Where the casing of the combustion chambers is required to be cooled due to temperature limitation of the material used, this may be achieved by dilution fans, as per Section 5 of this Appendix. Alternative means of cooling are to be considered subject to approval of the relevant information.

6.3 The design is to take into consideration factors such as sloshing and vibration of the GCU under foreseeable operating conditions regarding their impact on protection or insulation.

6.4 The design of the combustion chamber is to be such that the flame radius always remains within the

extent of the gas combustion unit under all modes of operation.

Section 7 EXHAUST GAS PIPING

7.1 The exhaust gas piping systems for GCU are to be in accordance with the relevant requirements of PART THREE of CCS Rules for Classification of Sea-going Steel Ships.

Section 8 VENTILATION

8.1 Ventilation arrangements are to comply with 16.3, Chapter 16, PART THREE of the Rules, except that where the gas fuel supply pipe is a single wall design, as described in 2.3.1(2) of this Appendix, the ventilation of the spaces containing the gas fuel supply pipe of a single wall design and the associated valves including the burner gas fuel connection at the GCU is to be in accordance with the following requirements:

(1) The GCU compartment is to be fitted with a mechanical exhaust ventilation system having a capacity of at least thirty (30) air changes per hour. The ventilation system is to be provided with at least two (2) fans. Each fan is to be sized such that the total capacity is not less than 100% of the total capacity required with one fan kept in reserve.

(2) Ventilation ducting is to be situated in the GCU compartment in such a manner as to provide immediate evacuation of the leaked boil-off gas from the entire compartment without the possibility of pockets of boil-off gas remaining in isolated corners. Either a gas dispersion analysis or a physical smoke test under all possible operating modes is to be conducted in order to prove that the inlets in the ducting are strategically positioned for the effective removal of the leaked boil-off gas from the compartment.

(3) The ventilation system in the GCU compartment is to be separated from those intended for other spaces. The ventilation inlet and discharge are to be respectively from and to a safe location.

(4) The ventilation fans are to be of non-sparking construction (see 12.1.7, Chapter 12, PART THREE of the Rules) and electric motors for these fans are to be located outside of the airflow stream.

Section 9 GAS DETECTION

9.1 The gas detection system is to comply with 13.6, Chapter 13, PART THREE of the Rules.

9.2 Where the gas fuel supply pipe is a single wall design as described in 2.3.1(2) of this Appendix, the gas detection system is to be in accordance with the following requirements:

(1) There are to be at least two independent fixed gas detection systems in the GCU compartment for continuous monitoring of the presence of leaked boil-off gas.

(2) Each gas detection system is to be of the self-monitoring type. In the case that a detection system fault is detected by the self-monitoring functions, the output of the detection system is to be automatically disconnected such that the detector fault does not cause false emergency shutdown.

(3) Each gas detection system is to be so arranged that it provides functional redundancy when either one of the systems fails.

(4) Gas detection equipment is to be so designed that it is readily tested.

9.3 Placement of the detectors is critical to the effectiveness of the gas detection and the design should be based on a gas diffusion analysis or a physical smoke test. The exact location of the gas detectors is to be determined taking into consideration the sensitivity of gas detectors under the prevailing airflow.

9.4 When the GCU is fitted with a double casing, considering the possibility of gases leaking into and being trapped in pockets of the outer casing, gas detection probes and explosion-relief doors are to be provided.

Section 10 AUTOMATIC SHUTDOWN SYSTEM

10.1 The monitoring and safety system functions for gas fuel supply systems are to be provided in accordance with Table 12.4.1, Section 12 of this Appendix. The alarms are to be provided at the engine control station. In addition, a summary alarm is to be provided at the navigation bridge and the cargo control room. Shutdown arrangements are to comply with 16.4, Chapter 16, PART THREE of the Rules, except that where the gas fuel supply pipe is a single wall design as described in 2.3.1(2) of this Appendix, the shutdown arrangements are to be as follows:

(1) In the event of leakage of gas in the compartment, an alarm is to be given when the gas concentration within the compartment reaches 30% of LEL by volume.

(2) If the gas concentration in the compartment continues to rise to 60% of LEL by volume, the master gas valve is to close automatically, the block and bleed valves are to operate and all non-certified electrical equipment within the compartment is to be isolated from their electrical supply. The ventilation fans are to continue operating until the gas concentration in the compartment has reached a safe level for entry.

(3) In the event of ventilation system failure in the compartment (see Section 8 of this Appendix), an alarm is to be given in the central control room, cargo control room and navigation bridge, the entire GCU is to shut down and the gas shut-off valve is to close automatically.

10.2 The gas combustion units are to satisfy the relevant requirements for ESD control in 18.10.3, Chapter 18, PART THREE of the Rules.

Section 11 FIRE EXTINGUISHING SYSTEM

11.1 The compartment described in 2.3.1(2) of this Appendix is to be provided with a fixed fire extinguishing system complying with SOLAS Chapter II-2, PART SIX of CCS Rules for the Classification of Sea-going Steel Ships and Chapter 11, PART THREE of the Rules.

Section 12 SURVEYS

12.1 General requirements

12.1.1 This Section pertains to surveys during fabrication at the manufacturer's facility, and installation, survey and testing of gas combustion units on board.

12.1.2 Where the GCU is supplied in parts and assembled on board, the survey and test items for the GCU are to cover the requirements of 12.2 of this Appendix.

12.2 Surveys and testing at the manufacturer's facility

12.2.1 During survey at the manufacturer's facility, CCS surveyor is to conduct survey and testing in accordance with the relevant requirements of CCS guidance documents on product approval and inspection of GCU, and the type/delivery test program approved by CCS, so as to ensure that the GCU satisfies the design requirements.

12.3 Onboard installation and testing

12.3.1 During the installation and testing on board, surveys and tests on the GCU and related systems, including but not limited to the following contents, are to be carried out to the satisfaction of CCS surveyors:

(1) Confirming that the actual arrangement of the equipment on the ship is consistent with the approved drawings.

(2) For the piping systems, visual examination, strength and tightness tests, and non-destructive testing are to be carried out in accordance with the requirements of CCS rules.

(3) Electrical wiring and connections are to comply with the requirements of CCS rules, and their electrical continuity is to be checked.

(4) Confirming that relevant instruments have been calibrated and are within the validity period.

(5) Pressure relief valves and safety valves are to be tested.

(6) Control system and safety protection are to be tested in appropriate operating modes, including shutdown tests.

(7) The GCU is to be checked for proper operation, including forced draft (combustion) fan running test and failure switch-over, dilution fan running test or combination fan running test, etc.;

(8) Verifying that the operation and maintenance manuals are available on board.

12.4 Surveys during gas trials

12.4.1 During the gas trials, the GCU is to be confirmed for compliance with design requirements, including nitrogen purging tests, gas leakage inspections, free flow tests, flame failure tests, full load tests, gas cut-off tests, verification of various operation modes, etc. The tests are to be conducted in accordance with the testing procedure approved by CCS during gas trials. The combustion chamber is to be visually examined after trials. Table 12.4.1 specifies the requirements for instrumentation and alarms, which are provided by taking into full consideration of the safety of the GCU and are not limited to the requirements in Table 12.4.1.

Appendix 6 APPLICABLE REQUIREMENTS FOR GAS COMBUSTION UNITS
PART TWO CLASSIFICATION SURVEY AND ADDITIONAL REQUIREMENTS FOR HULL STRUCTURE

Table 12.4.1 Instrumentation and Alarms

<u>Item</u>	<u>Display</u>	<u>Alarm Activated</u>	<u>Automatic Shut Down</u>
<u>Gas valves enclosure</u>	<u>Gas detection</u>		<u>30%LEL</u>
	<u>BOG flow rate (where applicable)</u>	<u>X</u>	<u>Low</u>
		<u>X</u>	<u>High</u>
	<u>BOG temperature</u>	<u>X</u>	<u>High / Low</u>
<u>Ventilation fan</u>	<u>Running</u>	<u>Stopped</u>	<u>S/D: X (failure)</u>
<u>Gas source controlled by remote control valve</u>	<u>Pressure</u>	<u>X</u>	<u>Low</u>
<u>Fan</u>	<u>Pressure(where applicable)</u>	<u>X</u>	<u>High/Low</u>
<u>Inert gas (for purging)</u>	<u>Pressure</u>	<u>X</u>	<u>Low</u>
<u>Gas supply</u>	<u>Supply pressure</u>	<u>X</u>	<u>High</u>
	<u>Supply temperature</u>	<u>X</u>	<u>High</u>
<u>Oxidizing unit and burner casing</u>	<u>Forced draft (combustion) fan</u>	<u>Running</u>	<u>Stopped/standby auto start</u>
		<u>X</u>	<u>Low</u>
	<u>Dilution Fan</u>	<u>Running</u>	<u>Stopped/standby auto start</u>
	<u>Flame scanner</u>	<u>--</u>	<u>X</u>
	<u>Burner flame</u>	<u>--</u>	<u>X</u>
	<u>Fire or high temperature in flue gas section</u>	<u>X</u>	<u>High</u>
	<u>Gas fuel pressure</u>	<u>--</u>	<u>High/Low</u>
<u>Gas fuel temperature</u>	<u>--</u>	<u>High/Low</u>	
<u>Burner Management and Control System</u>	<u>Control power supply</u>	<u>--</u>	<u>Failed</u>
	<u>Emergency shutdown</u>	<u>--</u>	<u>X</u>
<u>Power failure</u>	<u>Display</u>	<u>X</u>	<u>X</u>
<u>Emergency shutdown button</u>	<u>Display</u>	<u>X</u>	<u>X</u>
<u>Fire in the GCU area</u>	<u>Display</u>	<u>X</u>	<u>X</u>
<u>Flammable gas detection in the GCU area</u>	<u>30%LEL</u>	<u>X</u>	<u>X</u>

PART THREE THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK

CHAPTER 1 GENERAL

1.1 Application and implementation

CCS 1.1.6 For a liquefied hydrogen carrier, IMO has developed and released [the Revised Interim Recommendations for Carriage of Liquefied Hydrogen in Bulk \(MSC.420\(97\)\(MSC.565\(108\)\)](#), in order to facilitate developing the Tripartite Agreement for experimental ships. If the Recommendations are applied to ships other than an experimental ship, review and confirmation can be carried out in line with the Tripartite Agreement.

CHAPTER 4 CARGO CONTAINMENT

4.9 Associated structure and equipment

4.9.1 Cargo containment systems shall be designed for the loads imposed by associated structure and equipment. This includes pump towers, cargo domes, cargo pumps and piping, stripping pumps and piping, nitrogen piping, access hatches, ladders, piping penetrations, liquid level gauges, independent level alarm gauges, spray nozzles, and instrumentation systems (such as pressure, temperature and strain gauges).

CHAPTER 5 PROCESS PRESSURE VESSELS AND LIQUID, VAPOUR AND PRESSURE PIPING SYSTEMS

5.13 Testing requirements

~~CCS5.13.1.b~~ *Cargo Pumps* Cargo Pumps and Gas/Reliquefaction/Refrigeration Compressors

(1) Compressors and pumps are to be suitable for their intended purpose. All equipment and machinery are to be adequately designed to ensure suitability within a marine environment with due consideration to UR E10 and UR M46. Such items to be considered would include, but not be limited to:

- ① environmental;*
- ② shipboard vibrations and accelerations;*
- ③ effects of pitch, heave and roll motions, etc.; and*
- ④ physical and chemical properties of product.*

(2) Cargo Pumps

(1) Prototype Testing

- ① Each size and type of pump is to be approved through design assessment and prototype testing. Prototype testing is to be witnessed in the presence of CCS surveyor. ~~In lieu of prototype testing, satisfactory in-service experience, of an existing pump design approved by a Society submitted by the manufacturer may be considered.~~ For the design assessment of the pumps, ISO 13709:2009 and ISO 24490:2016, as applicable, can be used as well as other applicable recognized standards acceptable to CCS.*

- ② Material Testing: Tests for pump materials need not be witnessed by CCS surveyor except for the boundary components, which are in direct contact with the medium and for a design temperature below - 55°C in accordance with 6.2.2 of this PART.*

Note: The following pump components can, for example, be considered boundary components:

For centrifugal type pump: impeller, inducer, guide vane, casing, shaft and coupling.

For reciprocating type pump: cylinder cover, valve cover, cylinder liner, piston and piston rod, crankshaft, crank case.

②③ Prototype Testing

- (a) Prototype testing is to include hydrostatic test of the pump body equal to 1.5 times the design pressure and a capacity test. For submerged electric motor driven pumps, the capacity test is to be carried out with the design medium or with a medium below the minimum working temperature. For shaft driven deep well pumps, the capacity test may be carried out with water. In addition, for shaft driven deep well pumps, a spin test to*

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demonstrate satisfactory operation of bearing clearances, wear rings and sealing arrangements is to be carried out at the minimum design temperature. The full length of shafting is not required for the spin test but must be of sufficient length to include at least one bearing and sealing arrangements. After completion of tests, the pump is to be opened out for examination.

(b) The vibration criteria of machinery and equipment are to be provided by the pump manufacturer. These are to be compared against an applicable internationally recognised standard^①, as applied to the design, and are to be accepted by the Classification Society.

②④ Unit Production Testing

④ (a) All pumps are to be tested at the plant of manufacturer in the presence of CCS surveyor. Testing is to include hydrostatic test of the pump body equal to 1.5 times the design pressure and a capacity test. For submerged electric motor driven pumps, the capacity test is to be carried out with the design medium or with a medium below the minimum working temperature. For shaft driven deep well pumps, the capacity test may be carried out with water.

② (b) As an alternative to the above, if so requested by the relevant Manufacturer, the certification of a pump may be issued subject to the following:

- i. The pump has been approved as required by CCS5.13.1.b(12) ②&③, and*
 - ii. The manufacturer has a recognized quality system that has been assessed and certified by CCS subject to periodic audits, and*
 - iii. The quality control plan contains a provision to subject each pump to a hydrostatic test of the pump body equal to 1.5 times the design pressure and a capacity test.*
- The manufacturer is to maintain records of such tests.*

(3) Gas Cargo and Reliquefaction/Refrigeration Compressors

① Each size and type of compressor is to be approved through design assessment and prototype testing.

Prototype testing is to be witnessed in the presence of CCS surveyor. For the design assessment of the gas compressors, API standards, 617:2014 (w. Errata 1:2016), 618:2016 or 619:2010, as

① The following standards can be used as guidance:

ISO 7919-3:2009/AMD 1:2017, Mechanical vibration - Evaluation of machine vibration by measurements on rotating shafts – Part3 Coupled industrial machines

ISO 10816-3:2009/AMD 1: 2017, Evaluation of machine vibration by measurements on non-rotating parts — Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ.

ISO 10816-7:2009, Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 7: Rotodynamic pumps for industrial applications, including measurements on rotating shafts

ISO 10816-8:2014, Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 8: Reciprocating compressor systems

ISO 20816-1:2016, Mechanical vibration - Measurement and evaluation of machine vibration – Part 1: General Guidelines

ISO 20816-8:2018, Mechanical vibration - Measurement and evaluation of machine vibration - Part 8: Reciprocating compressor systems.

CHAPTER 5 PROCESS PRESSURE VESSELS AND LIQUID, VAPOUR AND PRESSURE PIPING SYSTEMS

PART THREE THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK

applicable, can be used. Other applicable recognized standards acceptable to CCS may be considered.

② Material Testing: Tests for compressor materials need not be witnessed by CCS surveyor except for the boundary components, which are in direct contact with the medium and for a design temperature below – 55 °C in accordance with 6.2.2 of this PART.

Note: The following compressor components can, for example, be considered boundary components:

For centrifugal type compressor: impeller, inducer, guide vane, casing, shaft and coupling.

For reciprocating type compressor: cylinder cover, valve cover, cylinder liner, piston and piston rod, crankshaft, crank case.

③ Prototype Testing

(a) Prototype testing is to be consistent with the applicable standard as applied for design assessment and is to include hydrostatic test of the compressor pressure boundary components, mechanical running test and a performance test. The hydrostatic test is to be carried out at a pressure equal to 1.5 times the design pressure (or 1.25 times the design pressure where the test fluid is compressible) and for, at least, 30 minutes. The mechanical running test and performance tests should include recording of the gas used, temperatures, pressures, testing of alarms and shut down, pressure relief devices and vibration measurements to ensure that the limits do not exceed those proposed by the manufacturer and that other features relating to the performance of the equipment are in accordance with the specification. Similarly, during the performance test, power consumption and the gas loads are to be recorded.

(b) The vibration criteria of machinery and equipment are to be provided by manufacturers, consistent with the applicable recognized standard^① as applied to the design. Otherwise, when the data on the vibration criteria are not available, justification is to be submitted for criteria used as reference in terms of overall Root Mean Square (RMS) vibrational velocity value for normal operation conditions.

(c) Alternative limits, demonstrated by fatigue calculations, may be accepted by CCS.

^① The following standards can be used as guidance:

ISO 7919-3:2009/AMD 1:2017, Mechanical vibration - Evaluation of machine vibration by measurements on rotating shafts – Part3 Coupled industrial machines

ISO 10816-3:2009/AMD 1: 2017, Evaluation of machine vibration by measurements on non-rotating parts — Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ.

ISO 10816-7:2009, Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 7: Rotodynamic pumps for industrial applications, including measurements on rotating shafts

ISO 10816-8:2014, Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 8: Reciprocating compressor systems

ISO 20816-1:2016, Mechanical vibration - Measurement and evaluation of machine vibration – Part 1: General Guidelines
ISO 20816-8:2018, Mechanical vibration - Measurement and evaluation of machine vibration - Part 8: Reciprocating compressor systems.

CHAPTER 5 PROCESS PRESSURE VESSELS AND LIQUID, VAPOUR AND PRESSURE PIPING SYSTEMS

PART THREE THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK

④ Unit Production Testing

(a) Each compressor is to be tested at the plant of manufacture in the presence of CCS surveyor.

Testing is to include hydrostatic test of the compressor pressure boundary components. The hydrostatic test is to be carried out at a pressure equal to 1.5 times the design pressure (or 1.25 times the design pressure where the test fluid is compressible) and for, at least, 30 minutes

(b) As an alternative to the above, if so, requested by the relevant Manufacturer, the certification of a compressor may be issued subject to the following:

i. The compressor has been approved as required by CCS5.13.1.b(3) ②& ③, and

ii. The manufacturer has a recognised quality system that has been assessed and certified by the Classification Society subject to periodic audits, and

iii. The quality control plan contains a provision to subject each compressor to the hydrostatic test of the compressor body equal to 1.5 times the design pressure (or 1.25 times the design pressure where the test fluid is compressible) for, at least, 30 minutes, and a mechanical running and performance test. The manufacturer is to maintain records of such tests.

⑤ The complete compressor assembly connected to the vessel systems is to be subjected to a leak test using air or other suitable medium, to a pressure depending on the leak detection method applied. The test is to be performed in presence of CCS surveyor and considered satisfactory when no joint leaks are observed.

CHAPTER 11 FIRE PROTECTION AND EXTINCTION

11.1 Fire safety requirements

CCS11.1.3 For liquefied gas bunkering ships, additional cargo transfer equipment including transfer loading arms, bunkering booms, transfer hoses, reducers, spool pieces and transfer hose reels, if provided, are to be installed in different locations around the ship. When in use, this additional cargo transfer equipment should comply, where appropriate, with the requirements of paragraphs 11.3.1.4, 11.3.1.5, 11.4.1, 11.4.3 of this Chapter and 18.10.3.2 for fire detection and fire protection in the cargo area (such as fusible elements, ESD functionality, water spray system protection, dry chemical powder fire-extinguishing systems and drip trays), including hull protection from low temperatures.

11.3 Water-spray system

11.3.1 On ships carrying flammable and/or toxic products, a water-spray system, for cooling, fire prevention and crew protection shall be installed to cover:

- .1 exposed cargo tank domes, any exposed parts of cargo tanks and any part of cargo tank covers that may be exposed to heat from fires in adjacent equipment containing cargo such as exposed booster pumps/heaters/re-gasification or re-liquefaction plants, hereafter addressed as gas process units, positioned on weather decks;
- .2 exposed on-deck storage vessels for flammable or toxic products;
- .3 gas process units positioned on deck;
- .4 cargo liquid and vapour discharge and loading connections, including the presentation flange and the area where their control valves are situated, which shall be at least equal to the area of the drip trays provided;
- .5 all exposed emergency shut-down (ESD) valves in the cargo liquid and vapour pipes, including the master valve for supply to gas consumers;
- .6 exposed boundaries facing the cargo area, such as bulkheads of superstructures and deckhouses normally manned, cargo machinery spaces, store-rooms containing high fire-risk items and cargo control rooms. Exposed horizontal boundaries of these areas do not require protection unless detachable cargo piping connections are arranged above or below. Boundaries of unmanned forecastle structures not containing high fire-risk items or equipment do not require water-spray protection;

CCS11.3.1 The water-spray system shall also be capable of covering the boundaries facing the cargo area of compartments fitted with internal combustion machinery and/or fuel treatment plant, storage rooms of flammable liquids of flash point not more than 60 °C and paint lockers.

- .7 exposed lifeboats, liferafts and muster stations facing the cargo area, regardless of distance to

cargo area; and

CCS 11.3.1.7.a *Water spray protection should be considered for exposed embarkation stations and may be considered for exposed launching routes from the life rafts stowage location to the ship side ~~unless the life rafts are located and ready for launching at both sides~~ if the life rafts are not located and ready for launching at both sides.*

11.3.5 Water pumps normally used for other services may be arranged to supply the water-spray system main supply line ~~upon the approval by CCS.~~

11.4 Dry chemical powder fire-extinguishing systems

11.4.3 The dry chemical powder fire-extinguishing system shall be designed with not less than two independent units. Any part required to be protected by 11.4.2 shall be capable of being reached from not less than two independent units with associated controls, pressurizing medium fixed piping, monitors or hand hose lines. For ships with a cargo capacity of less than 1,000 m³, only one such unit need be fitted ~~at the discretion of CCS.~~ A monitor shall be arranged to protect any load/unload connection area and be capable of actuation and discharge both locally and remotely. The monitor is not required to be remotely aimed, if it can deliver the necessary powder to all required areas of coverage from a single position. One hose line shall be provided at both port- and starboard side at the end of the cargo area facing the accommodation and readily available from the accommodation.

CHAPTER 13 INSTRUMENTATION AND AUTOMATION SYSTEMS

13.6 Gas detection

13.6.2 A permanently installed system of gas detection and audible and visual alarms shall be fitted in:

- .1 all enclosed cargo and cargo machinery spaces (including turrets compartments) containing gas piping, gas equipment or gas consumers;
- .2 other enclosed or semi-enclosed spaces where cargo vapours may accumulate, including interbarrier spaces and hold spaces for independent tanks other than type C tanks;
- .3 airlocks;
- .4 spaces in gas-fired internal combustion engines, referred to in 16.7.3.3;
- .5 ventilation hoods and gas ducts required by chapter 16;
- .6 cooling/heating circuits, as required by 7.8.4;
- .7 inert gas generator supply headers; and
- .8 motor rooms for cargo handling machinery.

CHAPTER 16 USE OF CARGO AS FUEL

16.1 General

16.1.1 Except as provided for in 16.9, methane (LNG) is the only cargo whose vapour or boil-off gas may be utilized in machinery spaces of category A, and, in these spaces, it may be utilized only in systems such as boilers, inert gas generators, internal combustion engines, gas combustion unit and gas turbines.

CCS16.1.1 Gas fuel engine system using methane (LNG vapour or boil-off gas) as fuel is to comply with the relevant requirements of CCS Rules for Classification of Sea-Going Steel Ships and the Guidelines for Design and Installation of Gas Fuel Engine Systems of Liquefied Gas Carriers.

CCS16.1.2 The application of the concept of ESD-protected machinery space is to be subject to the agreement of the Administration

CCS16.1.3 Where LPG cargo is used as fuel in accordance with 16.9 of this Chapter, the provisions of IMO Interim Guidelines for Use of LPG Cargo as Fuel (MSC.1/Circ.1679) are also to be considered.

16.7 Special requirements for gas-fired internal combustion engines

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

CHAPTER 19 SUMMARY OF MINIMUM REQUIREMENTS

a Product name	b	c Ship type	d Independent tank type C required	e Control of vapour space within cargo tanks	f Vapour detection	g Gauging	h	i Special requirements	CCSj Relative density of liquid at atmospheric boiling point(water=1)	CCSk Relative density of gas (air =1)	CCSI Boiling point (°C)	CCSm Critical temperature (°C)	CCSn Temperature	CCSn'' Explosive-proof
Ethylene oxide		1G	Yes	Inert	F+T	C		14.4, 17.2.2, 17.3.2, 17.4.1, 17.5, 17.6.1, 17.14	0.896	1.52	10.73	195.7	T2	II B
Ethylene- oxide oxide -propylene oxide mixtures with ethylene oxide content of not more than 30% by weight*		2G/2PG	-	Inert	F+T	C		14.4.3, 17.3.1, 17.4.1, 17.6.1, 17.9, 17.10, 17.18					T2	II B