



CHINA CLASSIFICATION SOCIETY

RULES FOR THE CONSTRUCTION
AND EQUIPMENT OF LIQUEFIED
NATURAL GAS FLOATING STORAGE
AND REGASIFICATION UNITS

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CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1 Application

1.1.1.1 The Rules for the Construction and Equipment of Liquefied Natural Gas (LNG) Floating Storage and Regasification Units (hereinafter referred to as the Rules) apply to new ship-type or barge-type LNG floating storage and regasification units, floating storage units and floating regasification units (hereinafter referred to as units).

1.1.1.2 Rebuilt units are to comply with the relevant requirements in 1.1.2.

1.1.2 General Requirements

1.1.2.1 Unless expressly provided in the Rules, units are to comply with the relevant requirements of the Rules for Classification of Offshore Floating Units, Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk and Rules for Offshore Oil and Gas Process System (hereinafter referred to as the Relevant Rules) of China Classification Society (hereinafter referred to as CCS), such as for structures, cargo containment systems, LNG transfer systems, regasification systems, position mooring systems and electrical equipment.

1.1.2.2 Attention is to be paid to complying with any relevant requirements of the National Authority of the coastal state in which the units are located and of the flag State (if applicable).

1.1.2.3 In cases where existing ships or offshore floating facilities are converted to units, the conversions shall be carried out in accordance with the provisions of the Rules and satisfactorily inspected by CCS.

1.1.2.4 In cases where LNG carriers are converted to ships having the functions of regasification and offloading cargo, the vessels are to comply with the relevant requirements given for LNG transfer systems and regasification systems in the Rules.

1.1.2.5 In cases where LNG carriers are converted to floating storage units, the units are to comply with relevant requirements given for structures and arrangements, LNG transfer systems, position mooring systems and electrical equipment in the Rules.

1.1.2.6 LNG carriers moored to a jetty to serve as FSUs are to comply with CCS Guidelines for Liquefied Natural Gas (LNG) Carriers Serving as Floating Storage Units (FSUs).

1.1.2.7 In addition to relevant requirements of the Rules, the survey and certification of the products shall comply with the relevant requirements of CCS rules, such as CCS Rules for Classification of Offshore Floating Units and Rules for Offshore Oil and Gas Process System and regulations and CCS guidelines for survey of products.

1.1.3 Definitions

For the purpose of the Rules, unless expressly provided in the Relevant Rules:

1.1.3.1 An *LNG floating storage and regasification unit* is the Gas Floating Offshore Facility positioned at specific sea areas either temporarily or for long period of times, which receives LNG from ships carrying liquefied gases in bulk or other liquefied gas production facilities, and

which is also fitted with systems for LNG storage, regasification and offloading of gas to onshore facilities.

1.1.3.2 *Gasification (Regasification)* is the process of heating LNG by the addition of heat from an external source to make the temperature above its saturation temperature.

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

1.1.3.4 *Semi-enclosed space* means a space where the natural conditions of ventilation are notably different from those on open deck due to the presence of structure such as roofs, wind breakers and bulkheads and which are so arranged that dispersion of gas may not occur¹.

1.1.3.5 *Hazardous area* means an area in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment.

Hazardous areas are divided into:

Hazardous area zone 0 is an area in which an explosive gas atmosphere is present continuously or is present for long periods.

Hazardous area zone 1 is an area in which an explosive gas atmosphere is likely to occur in normal operation.

Hazardous area zone 2 is an area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only.

1.1.3.6 *Non-hazardous area* means an area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of equipment.

1.1.3.7 *LNG transfer system* is a system used for transferring LNG which consists of transfer equipment, booster units (if applicable), connecting equipment and associated piping systems etc.

1.1.3.8 *Regasification system* is the complete gasification process plant from the LNG cargo storage tanks to the gas export (send-out) shore connection including regasification units, suction drum, associated pumps (submerged pump included), piping systems and auxiliary systems.

1.1.3.9 *Regasification unit* is referring to vaporisers, heaters, LNG booster pumps and associated piping intended for gasification of LNG.

1.1.3.10 *Boil-off gas (BOG) processing system* is a system for processing BOG, consisting of BOG compressor, reliquefaction systems (if applicable) and torch systems (if applicable).

1.1.3.11 *Emissions* means the relief of the portion of system or system and its equipment to achieve safe disposal of vapors and / or liquids discharged from pressure relief valves. Relieving pipelines and vessels before they can potentially fail can reduce the rate of leakage and / or leakage in the event of a leak in pipelines or vessels to reduce the consequences of the leak.

1.1.3.12 *High pressure* refers to the maximum working pressure is greater than 1.0MPa.

1.1.3.13 *Send-out* is the discharge of the high pressure gas after the vaporisation and heating process.

1.1.3.14 *LNG special area* refers to the special area associated with LNG on units compared

¹ Refer to IEC 60092-502 Electrical installations in ships – Part 502: Tankers – Special features or GB/T 22189 Electrical installations in ships - Special features – Tankers.

with floating production and storage offloading units, as shown in Table 1.1.3.14. When the requirements of Rules for Classification of Offshore Floating Units are inconsistent with the Rules, the Rules are to be complied with.

LNG Special Area

Table 1.1.3.14

Structure, systems and equipment	Area
LNG containment systems and adjacent structures	LNG special area
LNG transfer systems and equipment	
LNG regasification systems and equipemnt	
Other systems and equipment associated with LNG	

1.1.4 Characters of classification and class notations

1.1.4.1 The main structure (including equipment) and machinery (including electrical installations) of a unit that comply with the relevant requirements of CCS Rules, Guidelines or equivalent provisions will be assigned the appropriate characters of classification and class notations by CCS.

1.1.4.2 Units or ships applying for classification and satisfying the requirements in the Rules will be given the class notations in table 1.1.4.2 after the characters of classification specified by CCS.

Class Notations

Table 1.1.4.2

Service notation	Description	Technical requirements to be complied with	
LNG-FSRU	Floating units for LNG storage, regasification and offloading	The Rules, the applicable requirements of Rules for Classification of Offshore Floating Units, Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk and Rules for Offshore Oil and Gas Process System	
LNG-FSU	Floating units for LNG storage and offloading	The Rules, the applicable requirements of Rules for Classification of Offshore Floating Units and Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk	
LNG-FRU	Floating units for LNG regasification	The Rules, the applicable requirements of Rules for Classification of Offshore Floating Units and Rules for Offshore Oil and Gas Process System	
Special systems and facilities notation	Description		Technical requirements to be complied with
PM	Position mooring system	Units provided with positional mooring systems are to be added with this notation	Chapter 1 and 5 of the Rules
REGAS	LNG regasification system	Units or ships provided with LNG regasification systems are to be added with this notation	Chapter 1 and 4 of the Rules

The characters of classification and class notations of units (where applicable) are to be entered into classification certificates in accordance with the Relevant Rules and the sequence

required in 1.1.4.2, using “;” to separate each group of notations. For instance:

For a barge type LNG floating storage and regasification unit constructed under the supervision by CCS, it is provided with lifting installations, in-water survey notation, regasification systems, the unit operates in the North Sea of South China Sea, cyclic inspection mode is used to inspect the hull structure and machinery. The characters of classification and class notations are given below:

★CSA LNG-FSRU; Barge type; REGAS; CHS; CMS; Lifting Appliance; IWS; China Nanhai Beihai XXXX

For LNG carriers constructed under the supervision by CCS, they are provided with lifting installations, in-water survey notation, regasification systems, cyclic inspection mode is used to inspect the hull structure and machinery. The characters of classification and class notations are given below:

★CSA LNG Carrier; REGAS; CHS; CMS; Lifting Appliance; In-Water Survey

1.1.5 Risk assessments

1.1.5.1 Risk assessments need be conducted where explicitly required by the Rules.

1.1.5.2 The risks are to be analysed using acceptable and recognized risk analysis techniques, and loss of function, component damage, fire, explosion and electric shock is to as a minimum be considered. The risk assessment is to ensure that risks are eliminated wherever possible. Risks which cannot be eliminated are to be mitigated as necessary. The analysis, including the details of risks and the means by which they are mitigated, is to be documented and submitted to CCS for approval.

1.1.5.3 The risk analysis may be conducted in accordance with Annex 1 of the Rules.

Section 2 PLANS AND DOCUMENTS

1.2.1 Plans and documents for approval

1.2.1.1 Plans and documents related to cargo containment systems and cargo handling systems on units are to be submitted to CCS for approval in accordance with the applicable requirements of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk and Rules for Offshore Oil and Gas Process System; Plans and documents related to structures and stability are to be submitted to CCS in accordance with the relevant requirements of CCS Rules for Classification of Offshore Floating Units.

1.2.1.2 In addition to those specified in 1.2.1.1, at least 3 copies of relevant plans and documents or electronic drawings are to be submitted to CCS for review in accordance with the requirements of this Section.

1.2.1.3 Regasification system description document: a description of apparatus, arrangements, the intended operating capability, design criteria and functionality of the regasification system. It is to include the following information:

(1) particulars of piping arrangements and control systems, including materials specifications, design pressure, design temperature, and design ambient weather conditions;

(2) operating design criteria that may include, as applicable:

① design maximum throughput and turn-down ratio for the regasification system. For

closed loop operation, the maximum available heat input is also to be stated;

② design maximum discharge pressure and minimum gas superheat temperature for the regasification system;

③ the maximum and minimum permissible variations from the design conditions;

④ the maximum permissible back pressure occurring in the discharge pipeline;

⑤ design maximum transfer rates where ship to ship transfer is involved and the method and control used to handle boil-off gas and displacement gas to and from the offloading vessel;

⑥ the minimum required gas output for a specific sea-water temperature and throughput, as applicable;

⑦ the design minimum temperature and throughput of the heated water or heat transfer fluid;

⑧ the output of the boiler or alternative heating arrangement;

⑨ the minimum allowable sea-water outlet temperature.

(3) procedures for connecting/disconnecting the gas sendout hose, isolation arrangements and inerting and gas-freeing of the transfer lines;

(4) emergency procedures to be followed during regasification and ship-to-ship operations. These are to include guidance on procedures to be followed in the event of sudden closure of the land-based send-out gas master valve.

1.2.1.4 Regasification system general arrangement. Plans showing the general arrangement of all areas where equipment (vaporisers, heat exchangers, LNG drums, liquid receivers and other pressure vessels), components and piping systems are located.

1.2.1.5 Plans for strengthened structure at the bottom of regasification system skids.

1.2.1.6 Heat and material balance sheet.

1.2.1.7 The thermodynamic calculations confirming the design send-out rates for the vaporisers.

1.2.1.8 LNG regasification process flow chart.

1.2.1.9 Capacity calculations for pressure relief valves and discharge pipes.

1.2.1.10 Piping and instrumentation drawings of regasification system, at least including:

(1) design and operation conditions;

(2) name, size and parameters of all major equipment;

(3) pipeline components (such as pipes, fittings, valves, flanges, expansion joints, filters) levels and specifications;

(4) measurement, sensing, monitoring, alarm and safety control instrumentations;

(5) signal circuits;

(6) shutdown and pressure relief units and their settings;

(7) boundaries of blocks and skids;

(8) Drainage, inerting and degassing of piping, equipment and components of regasification systems.

1.2.1.11 Pipe specifications showing pipe material, welding, manufacturing, survey, testing and pipe supporting, insulation and cryogenic protection etc.

1.2.1.12 Piping information is to include schematic plans, full particulars of piping and instrumentations for:

(1) low and high pressure LNG supply pipework;

(2) intermediate thermal fluid systems;

- (3) heating system for closed loop operation (if applicable);
- (4) depressurisation system (knock-out drum or shock load verification arrangements);
- (5) high pressure gas send-out systems;
- (6) cooling water systems;
- (7) other associated ancillary systems.

1.2.1.13 Safety system plans: ESD systems, fire-fighting details, gas detection details, fire and general alarm details, breakaway valves (if applicable), all related to the additional regasification system and to the send-out arrangements.

1.2.1.14 Escape plan: details of the arrangements for safe escape protection in relation to the additional regasification system and to the send-out arrangements.

1.2.1.15 Loading arms (if applicable)

- (1) general arrangement and envelope charts;
- (2) structural details, including swivels and supporting, emergency release couplings, insulated flanges / short tubes, electrical continuity and earthed systems, valves, flanges and takeovers;
- (3) other component and part diagrams required;
- (4) welding process specification;
- (5) specifications of components and parts and material details;
- (6) information of non-destructive testing, strength and low temperature test, tightness test, functional test programme for welds;
- (7) technical documents of design load and structural analysis of loading arms;
- (8) plans of hydraulic control systems (if applicable);
- (9) plans of emergency release systems;
- (10) instructions for use.

1.2.1.16 Hose offloading systems

- (1) arrangement of offloading hoses and their support structures;
- (2) description of hose material;
- (3) instructions for use;
- (4) details of active or passive break away devices, including breakaway couplings.

1.2.1.17 Breakaway couplings (if applicable)

- (1) product standards, or product technical conditions;
- (2) assembly diagram;
- (3) drawing of main components and parts;
- (4) main technical parameters;
- (5) specifications of components and parts and materials lists;
- (6) strength and performance calculations;
- (7) instructions for use;
- (8) product test program.

1.2.1.18 Hazardous Area Plan for regasification equipment.

1.2.1.19 Other plans and information as deemed necessary by CCS.

1.2.2 Plans and documents for information

1.2.2.1 In addition to those specified in the Relevant Rules, the following plans and documents are to be submitted to CCS for information:

- (1) safety operation manual;
- (2) emergency operation manual;
- (3) jetty arrangement, including dock mooring components and equipment;
- (4) risk assessment report of regasification systems.

1.2.3 Plans and documents kept on board

1.2.3.1 In addition to those specified in the Relevant Rules, the following documents are to be kept on board:

(1) safety operation manual, intended to provide operators of units with appropriate guidance, is to include the following information:

- ① overview of units;
- ② relevant data for each approved operating mode, including design, variable loads, environmental conditions and schemes;
- ③ minimum design temperature applicable to the atmosphere and sea water;
- ④ general arrangement showing watertight bulkheads, closing units, vents and allowable deck loads;
- ⑤ static pressure curves or equivalent data;
- ⑥ documents showing the capacities of tanks, centres of gravity, free surface corrections, etc.;
- ⑦ instructions for operation, including any precaution to be taken in adverse weather, changing modes of operation, any inherent operational limitations, etc.;
- ⑧ plans and descriptions of the ballast system and instructions for ballasting. If permanent ballast is to be used, the weight, location and substance used are to be clearly indicated;
- ⑨ fuel oil supply systems drawing;
- ⑩ fuel gas supply systems drawing (if applicable);
- ⑪ hazardous area division;
- ⑫ firefighting schemes;
- ⑬ arrangements of life-saving appliances together with escape routes;
- ⑭ light ship data based on the results of inclining experiments, etc.;
- ⑮ stability information;
- ⑯ representative examples of loading conditions for each approved mode of operation together with a means for the evaluation of other loading conditions;
- ⑰ diagrams of the main and auxiliary wiring systems;
- ⑱ emergency shutdown procedures of electrical equipment;
- ⑲ instructions for the operation of mooring systems together with information regarding the maximum offset;
- ⑳ instructions for the operation of loading and offloading and transfers of cargo and ballast;
- ㉑ other plans and information as deemed necessary by CCS.

(2) Emergency operation manual, referring to as all parts of the general system and emergency system of units, shows all the necessary instruments / equipment and their required functions.

Section 3 SURVEYS

1.3.1 General requirements

1.3.1.1 The survey procedures, survey methods, types of surveys, intervals between the surveys, survey conditions, preparations before survey, survey and testing requirements and preservation of plans, documents, certificates, records and reports of units, are to comply with the relevant requirements of CCS Rules for Classification of Offshore Floating Units. The surveys of cargo containment systems and handling systems are to comply with the applicable requirements of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk and Rules for Offshore Oil and Gas Process System.

1.3.1.2 At the first transferring and regasification operation, the surveyors are to be in the field to ensure that the instruments, valves and related safety control systems associated with cargo containment systems, LNG transfer systems and LNG regasification systems are in good condition.

1.3.2 Surveys under construction

1.3.2.1 In addition to the requirements for units of the Relevant Rules, the surveys during construction are to cover the following items:

(1) inspection of regasification systems to ensure that their structures, equipment, installations, arrangement and materials of regasification systems are in accordance with the approved plans, diagrams, specifications, calculations and other technical documents;

(2) the survey and test items of regasification systems are at least to include:

① pressure and tightness tests of LNG and gas pipes;

② tightness tests of suction drums with a pressure not less than the design pressure of the drum body;

③ safety valves setting;

④ performance tests of fire safety systems, emergency shutdown systems, process shutdown systems, gas detection systems, active pressure relief and venting systems, pressure relief and venting systems, instrumentations and automation systems;

⑤ performance tests of pumps and compressors.

(3) commissioning of regasification systems

① the commissioning program is to be submitted to the attending surveyors to CCS for review;

② during the preliminary commissioning, the performance test is to be carried out with small amount of LNG;

③ all performance tests are to be carried out in the field after installation;

④ the commissioning report is to be submitted to the attending surveyors to CCS for review after commissioning.

(4) installation and testing of LNG transfer systems, including LNG pumps, LNG loading arms (if applicable), hoses (if applicable), valves and pipes;

(5) installation and testing of ESD of LNG transfer systems;

(6) installation position and quantity of gas probes, and testing of gas detection and alarm system;

- (7) installation and test of ventilation system in hazardous area;
- (8) confirmation and safety inspection of explosion-proof equipment or anti-ignition equipment;
- (9) installation and testing of fire prevention and fire extinguishing devices in cargo areas;
- (10) performance tests of LNG transfer system, liquid nitrogen can be used as a medium;
- (11) checking the information that should be saved on units, such as the safety operation manual, etc;
- (12) inspection of structure of regasification system, including inspection of weld quality and connection to units (including welding and bolting). If bolted, check the grounding if necessary.

1.3.3 Surveys after construction

1.3.3.1 General requirements

(1) during annual surveys, a general inspection of regasification systems and their structures, equipment, installations, arrangement and materials is to be conducted to ensure that they are in good condition and fit for the service for which they are intended;

(2) during intermediate surveys, an overall examination of safety devices, auxiliary equipment, affiliated pumps and piping systems associated with the regasification systems is to be conducted to ensure that they are in good condition and satisfy the relevant requirements of the Rules;

(3) during special surveys, full inspections of regasification systems and structure, equipment, installation, arrangement and materials are to be conducted to ensure that they are in good condition and satisfied with the requirements of the rules.

1.3.3.2 Annual surveys

In addition to the survey items in the Relevant Rules, the following items are to be carried out:

(1) checking the operation records of the regasification system since the last survey to verify the performance of the systems during this time and confirm whether any abnormality occurs;

(2) overall examination of the vaporizer is to be conducted to confirm that its operation conditions and heating capacity satisfy the technical specifications;

(3) inspecting vaporizers for freezing and corrosion etc.;

(4) inspecting the tightness of expansion tanks/drums and the integrity of their accessories (if applicable);

(5) inspecting seawater pumps and their inlet filters to verify that they are in good condition;

(6) examining and testing the gas detection systems to confirm that they are in normal working condition, and if necessary, checking them with the gas sample;

(7) inspecting the manual ESD systems, send-out manifold valves, LNG pumps and compressors to confirm that their automatic shutdown are in normal working condition;

(8) inspecting the process shutdown systems of regasification systems to confirm the manual operation function;

(9) inspecting active pressure relief and venting systems to verify that the manual and automatic start functions are in order;

(10) inspecting pressure relief and venting systems, including buffer/drainage tanks connected to the liquid safety relief valves;

(11) examining whether the electrical equipment in hazardous areas is in good condition, and

checking the maintenance and repair records;

(12) inspecting fire detection and fire extinguishing installations, and start one main fire fighting pump;

(13) examining whether the water-spraying and water curtain systems are in normal condition;

(14) loading arms (if applicable)

① inspecting the whole conditions of loading arms;

② examining visually the pipelines and verifying their tightness;

③ performance testing of emergency release systems;

④ examining the lubrication of pivotal bearings, primary seal of swivels, resistance of insulating flanges and stretching of steel ropes of main drive (if applicable).

(15) hoses (if applicable)

① visual examination of the hose to confirm its integrity;

② inspecting the hose for damage or defect;

③ conducting pressure test with the maximum allowable setting value of pressure relief valves (MARVS);

④ examining integrity of hose end joints, and confirming that measurements of the insulation resistance is in good condition;

⑤ examining integrity of emergency release couplings (breakaway couplings).

(16) performance test of regasification systems, which may be conducted by visual examination of the pipes, installations and accessories during regasification system operations;

(17) verifying that safety operation manuals and other documents are available on board;

(18) checking structure of regasification system for any defects such as corrosion and cracks. If there are suspected defects, further examination could be conducted by thickness measurement, NDT and other means. If necessary, check the tightening and corrosion of bolts (if fitted), as well as the corrosion and disconnection (wire) of grounding wire (if fitted), etc.

1.3.3.3 Intermediate surveys

In addition to the intermediate survey items in the Relevant Rules and 1.3.3.2 of this Chapter, the following items are to be carried out:

(1) inspecting the equipment, installations, venting piping of LNG transfer systems and regasification systems as far as practicable, and pressure test or thickness measurement or both for suspected piping inspection;

(2) examining electric grounding between the pipes and installations of LNG transfer and regasification systems and hull/main structure;

(3) checking the pressure, temperature measurement system and related alarm functions of LNG transfer and regasification systems; random testing of gas detectors, temperature, pressure and level gauge devices to confirm that they are in good operating conditions;

(4) examining visually the corrosion and damage of pipes of gas detection system as far as practicable, and verifying the integrity of pipes between the suction point and the analytical equipment as far as practicable;

(5) examining the control systems of loading arms to confirm that they are in good condition (if applicable).

1.3.3.4 Special surveys

In addition to the special survey items in the Relevant Rules and 1.3.3.3 of this Chapter, the

following items are to be carried out:

(1) overhaul of vaporizers and pressure vessels and performance test of pressure relief valves. If it is impracticable to do the internal examination of pressure vessels, a pressure test is to be carried out for pressure vessels and a performance test for pressure release valves;

(2) The pipes and liquid nitrogen piping are to be opened out for examination as deemed necessary and if necessary, enough insulation is to be removed to confirm the pipe condition. The sealing conditions are to be specially examined under examination. If upon visual examination there is any doubt as to the integrity of the piping, a pressure test is to be carried out on the piping with a pressure not less than 1.25 times the MARVS. A leakage test is to be carried out for the whole piping after installation;

(3) inspecting and verifying ESD valves, check valves, remote control valves, isolation valves of pressure release valves of LNG transfer and regasification systems, disassembling a valve at random for examination;

(4) overhaul of LNG pumps, gas compressors and gas turbochargers and their prime movers and performance test of safety installations; the overhaul may be exempted for an electric motor used as a prime mover²;

(5) loading arms (if applicable)

① A general and thorough examination and in particular opening up for swivels. If necessary, replacing components and parts or sealings;

② A general examination of liquid and gas pipes, and in general including visual inspection, pressure tests and leakage tests.

² If a planned mechanical maintenance system is carried out, a visual inspection may be used as alternative to opening up during special survey.

CHAPTER 2 STRUCTURES AND ARRANGEMENTS

Section 1 GENERAL PROVISIONS

2.1.1 General requirements

2.1.1.1 This Chapter applies to the units having a length of not more than 500m and a width of not more than 1/5 of the length or 2.5 times the depth. Units not meeting the above requirements are to be considered on a case by case basis.

2.1.1.2 Unless those expressly specified in this Chapter, structures and arrangements of units are to comply with the relevant requirements of Part 2 of CCS Rules for Classification of Offshore Floating Units.

2.1.1.3 LNG tanks are to be designed in accordance with the relevant requirements of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

2.1.1.4 The corrosion margins for cargo areas are to comply with the relevant requirements of Chapter A4 of Part 2 and Chapter 4 of Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

2.1.1.5 Corrosion margins need not be required for the outer surface of structural members which keeps being exposed to the non-corrosive environment (e.g. dry inert gas).

2.1.1.6 The sloshing effect of LNG tanks is to be assessed in accordance with the requirements of CCS Rules for Classification of Offshore Floating Units and in addition, for membrane tanks, it is also to comply with the relevant requirements of Chapter 20, PART 2 of CCS Rules for Classification of Sea-going Steel Ships.

2.1.1.7 For units with special structural arrangements, special consideration is to be given by CCS according to the design.

2.1.1.8 The structure of regasification systems is to comply with the relevant requirements of Chapter 11, Part 2 of CCS Rules for Classification of Offshore Floating Units.

Section 2 STABILITY

2.2.1 General requirements

2.2.1.1 In addition to the requirements of this section, stability of units is to comply with the relevant requirements of Part 3 of CCS Rules for Classification of Offshore Floating Units. If units have the capability of self-navigation, its stability shall meet the relevant requirements of Chapter 2, Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

2.2.1.2 The free surface effects of partially filled tanks are to be taken into account in the stability calculations of units. When calculating the effect of free surfaces of consumable liquids for loading conditions, it shall be assumed that, for each type of liquid, at least one transverse pair or a single centre tank has a free surface, the tank or combination of tanks to be taken into account shall be those where the effect of free surfaces is the greatest. The free surface effect in undamaged compartments shall be calculated by a method according to the International Code on

Intact Stability, 2008 (2008 IS Code).

2.2.1.3 Units in cold areas should take into account the possible overloading effects of icing and snow in stability calculations.

2.2.1.4 The master of units shall be supplied with a loading and stability information booklet. This booklet shall contain details of typical service conditions, loading, unloading and ballasting operations, provisions for evaluating other conditions of loading and a summary of the units' survival capabilities. The booklet shall also contain sufficient information to enable the master to cargo operations and maneuver units in a safe and seaworthy manner.

2.2.1.5 Units shall be fitted with a stability instrument, capable of verifying compliance with intact and damage stability requirements, approved by CCS having regard to the performance standards³ recommended by IMO.

2.2.1.6 If the Administration has other relevant regulations, the stability of units should meet the requirements of the Administration.

2.2.2 Damage stability

2.2.2.1 In the damage stability calculations of units, the extent of damage on the bottom need not to be considered (except units that are capable of self-propulsion). The assumed maximum extent of damage on the side shell is to be as follows:

longitudinal extent: $L^{2/3}/3$ or 14.5m, whichever is the lesser;

transverse extent, measured inboard from the side shell plating, at right angle to the centreline, at the level of summer load line: $B/5$ or 11.5m, whichever is the lesser;

vertical extent, from the moulded line of the bottom shell plating at centreline: upwards without limits.

2.2.2.2 If any damage of a lesser extent than the maximum damage specified above would result in a more severe condition, such damage is to be considered.

2.2.2.3 Standard of damage

Regardless of the effect of wind speed, units shall be capable of surviving the damage indicated in 2.2.2.1, according to the following standards:

(1) units of more than 150 m in length shall be assumed to sustain damage anywhere in its length;

(2) units of 150 m in length or less shall be assumed to sustain damage anywhere in its length, except involving either of the bulkheads bounding a machinery space located aft.

2.2.2.4 Location of cargo tanks of units shall meet the relevant requirements of Chapter 2, Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

2.2.2.5 If the Administration has other relevant regulations, the damage stability of units should meet the requirements of the Administration.

³ Refer to Chapter 4 of Part B of the International Code on Intact Stability, 2008 (2008 IS Code), as amended; Section 4 of the Annex of the Guidelines for the Approval of Stability Instruments (MSC.1/Circ.1229), as amended; and the technical standards defined in Part 1 of the Guidelines for Verification of Damage Stability Requirements for Tankers (MSC.1/Circ.1461).

Section 3 ARRANGEMENTS

2.3.1 Arrangement principles

2.3.1.1 Areas which contain cargo containment systems, regasification systems, LNG transfer systems, venting/exhaust systems and gas flare (if any) and so on are to be arranged in order to provide:

- (1) easy access for operation and maintenance;
- (2) easy access for fire fighting;
- (3) adequate ventilation;
- (4) minimized explosion and overpressure in the case of ignited gas release.

2.3.1.2 Units are to be arranged taking full account of personnel safety, prevention of environmental pollution and property protection based on the following design principles:

- (1) minimizing the risks due to accidents occurring, spreading and escalating;
- (2) being divided into areas of different levels of risk based on the functions and potential hazards;
- (3) the areas and modules classified as hazardous areas being kept away from those containing sources of ignition and detonation as far as practicable by applying the principle of risk-remoteness. If this is impracticable, a suitable fire and/or explosion-proof bulkhead or a cofferdam is to be used for isolation;
- (4) applying the principle of hazardous levels from low to high, that is, the low-risk area is to be located between the high-risk area and the safe area;
- (5) accommodation spaces, control stations and similar spaces being located in a non-hazardous area and as far from the cargo area as practicable. The accommodation spaces and control stations are to be protected from the accidents and provided with means for safe escape.

2.3.1.3 All manual valves necessary for cargo operations are to be so arranged that they are easily operable for personnel in protective suits.

2.3.2 Cargo areas

2.3.2.1 The cargo areas are to be properly arranged and isolated in accordance with the requirements of Chapter 3, Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

2.3.2.2 Where cargo areas are isolated as required above, the ballast tanks may be accepted as cofferdams as approved by CCS.

2.3.3 Regasification systems

2.3.3.1 The space where a regasification unit is located is to be considered as part of the cargo areas as defined in 1.2.7 of Chapter 1, Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk. Arrangements of such spaces are to be in accordance with the requirements for ship arrangements of Chapter 3, Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

2.3.3.2 Regasification units together with associated equipment are to be considered as cargo handling units, and the place where they are located is to be considered as a cargo machinery space.

2.3.3.3 When the regasification units are located on the open deck, they are to be placed in a sheltered location protected from green water.

2.3.3.4 Regasification units and its accessories and other areas where possible LNG cryogenic spills occur shall be provided with low temperature protection measures to prevent the hull and related structures from withstanding cryogenic temperature damage.

2.3.3.5 The locations of the regasification system arrangements are to be defined and evaluated in the risk assessment required in 4.1.1.5 of this Rules.

2.3.4 Accommodation spaces, service spaces and control stations

2.3.4.1 Cargo tanks and gas handling systems (if any) are to be separate from accommodation, service and machinery spaces. For gas handling systems (if fitted), such separation requires in general no accommodation space or combustion equipment installed in the defined hazardous areas. Where it is impracticable to separate appropriately accommodation spaces and life-saving appliances from cargo tanks and gas handling systems, special consideration may be given to the use of fire divisions and cofferdams.

2.3.4.2 Entrances, air inlets and openings to accommodations spaces are not to face the cargo area, and they are to comply with the arrangement requirements of Chapter 3, Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

2.3.4.3 Control stations are to be located in non-hazardous areas.

2.3.5 Gas handling systems

2.3.5.1 The outlets of gas handling systems, e.g. ventilation masts, flares, gas consumption units (GCUs), cold vents or pressure relief valves or from large engine exhausts are to be led to areas where radiation, heat or gases will not be a hazard to units, personnel or equipment.

2.3.5.2 In addition to the relevant requirements of CCS Rules for Offshore Oil and Gas Process System, flares and ventilation systems are to take into account the adverse effect of heat radiation upon heat sensitive systems, the heat sensitive materials, and electrical equipment and instrumentations, e.g. the heat radiation intensity of flares is not to exceed the rated temperature of machinery and electrical installations.

2.3.5.3 The concentration of gas is not to exceed 50% lower explosive limit (LEL) at any point on units where the gas plumes from vents could be ignited or personnel could come into contact with such gas.

2.3.6 Mooring equipment

2.3.6.1 Windlasses, chain lockers and spurling pipes are to be arranged in non-hazardous areas.

2.3.7 Access arrangements

2.3.7.1 Access for personnel and to cargo areas are to comply with the relevant requirements of Chapter 3, Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

Section 4 DESIGN LOADS

2.4.1 General requirements

2.4.1.1 The design loads and loading conditions defined in this Section apply to determination of structural scantlings and strength assessment. The loads used for fatigue strength assessment are specified in Section 6 of this Chapter.

2.4.2 Load combinations

2.4.2.1 When the finite element is used for strength assessment, calculations shall be carried out on the load combinations specified in this Section.

2.4.2.2 In each loading condition, the dynamic loads acting simultaneously are to be obtained by multiplying the envelope of the dynamic loads, required in Section 3, Chapter 6, Part 2 of CCS Rules for Classification of Offshore Floating Units, by the factor of combined dynamic loads.

2.4.2.3 The factors of combined dynamic loads in disconnect and transit conditions are to be selected according to 2.4.3 of this Chapter, and the factors of combined dynamic loads in on-site conditions are to be determined according to 2.4.4.

2.4.3 Load combinations in disconnect/transit conditions

2.4.3.1 The load due to external water pressure consists of hydrostatic pressure and hydrodynamic wave pressure.

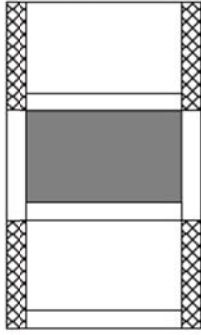
2.4.3.2 The loading patterns of units are shown in Figure 2.4.3.2(1) and Figure 2.4.3.2(2).

2.4.3.3 The dynamic loading conditions and the factors of combined dynamic loads are shown in Table 2.4.3.3.

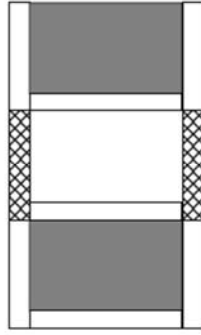
Dynamic Loading Conditions and Factors

Table 2.4.3.3

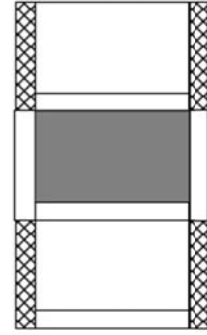
Wave heading angles			Head sea				Beam sea		Oblique sea	
Dynamic loading case			1	2	3	4	5S	5P	6S	6P
Hull girder loads	M_{wv}	f_{wv}	-1.0	1.0	-1.0	1.0	0.4	-0.4	-0.2	0.4
	Q_{wv}	f_{qv}	1.0	-1.0	1.0	-1.0	-0.2	0.2	0.2	0.0
	M_{wv-h}	f_{wv-h}	0.0	0.0	0.1	-0.1	0.2	-0.2	1.0	-1.0
Accelerations	a_v	f_v	0.6	-0.6	0.6	-0.6	1.0	-1.0	0.0	-0.1
	a_t	f_t	0.0	0.0	-0.1	0.1	0.2	-0.2	0.0	0.0
	a_{lng}	f_{lng}	-0.3	0.3	0.3	-0.3	-0.1	-0.1	0.4	0.5
Hydrodynamic wave pressure (port side)	P_{WL}	f_{WL}	-0.5	0.5	-0.5	0.5	-0.2	-0.7	0.1	0.3
	P_{blige}	f_{blige}	-0.2	0.2	-0.2	0.2	-0.5	-1.0	0.1	0.4
	P_{ctr}	f_{ctr}	-0.4	0.4	-0.4	0.4	-0.9	-1.0	-0.2	0.3
Hydrodynamic wave pressure (starboard side)	P_{WL}	f_{WL}	-0.5	0.5	-0.5	0.5	-0.7	-0.2	0.3	0.1
	P_{blige}	f_{blige}	-0.2	0.2	-0.2	0.2	-1.0	-0.5	0.4	0.1
	P_{ctr}	f_{ctr}	-0.4	0.4	-0.4	0.4	-1.0	-0.9	0.3	-0.2



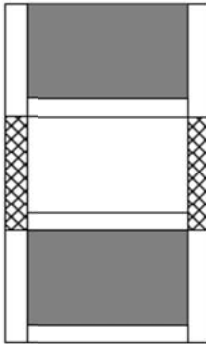
L.C. 1 & 3
Draft: 0.75 Tsc



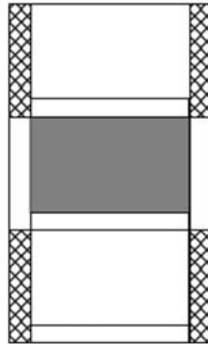
L.C. 5P
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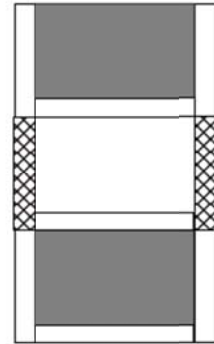
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L.C. 2 & 4
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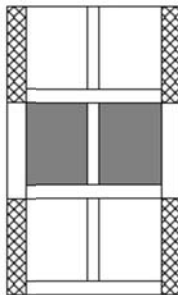


L.C. 5S
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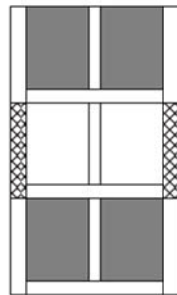


L.C. 6P
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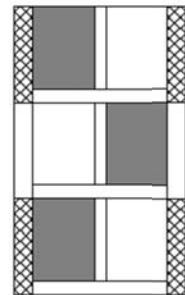
Figure 2.4.3.2(1) Loading pattern (Single-row tank)



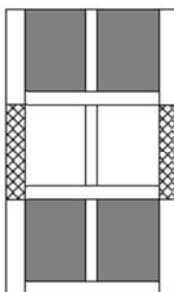
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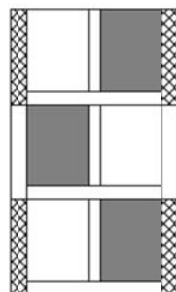
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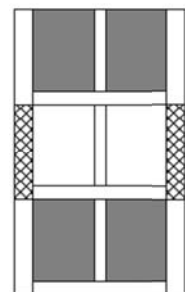
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L.C. 2 & 4
Draft: Tsc



L.C. 5S
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L.C. 6P
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Notes:  Carrying LNG  Carrying ballast water

Figure 2.4.3.2 (2) Loading pattern (Twin-row tanks)

2.4.4 Combined loading cases for on - site conditions

2.4.4.1 Factors of combined dynamic loads are to be confirmed according to the model test or the methods specified in 6.6.3, Chapter 6, Part 2 of CCS Rules for Classification of Offshore Floating Units, together with the following factors:

- (1) On - site loads;
- (2) Mooring system loads;
- (3) Wave heading and motion of units;
- (4) Loading status.

2.4.4.2 The longitudinal positions of structural members are to be considered in calculating the combined dynamic load factor. Details see Figure 2.4.4.2.

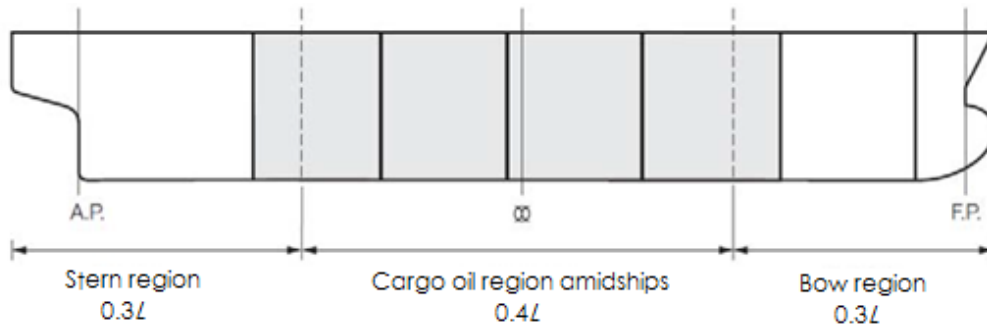


Figure 2.4.4.2 Diagram of structural area

2.4.5 Special loading cases for independent tanks

2.4.5.1 Strength assessment of independent tank and its supports is to be performed according to Table 2.4.5.1.

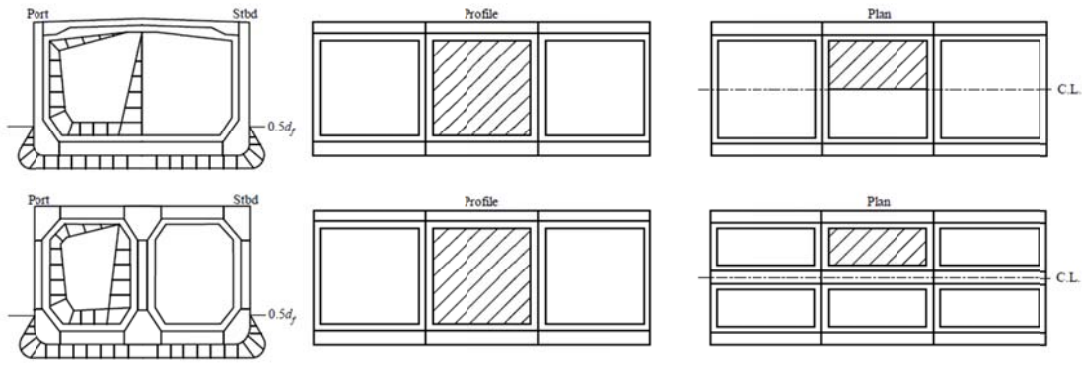
2.4.5.2 For special loading cases, the loading patterns are shown in Figure 2.4.5.2.

Special Loading Cases for Independent Tanks

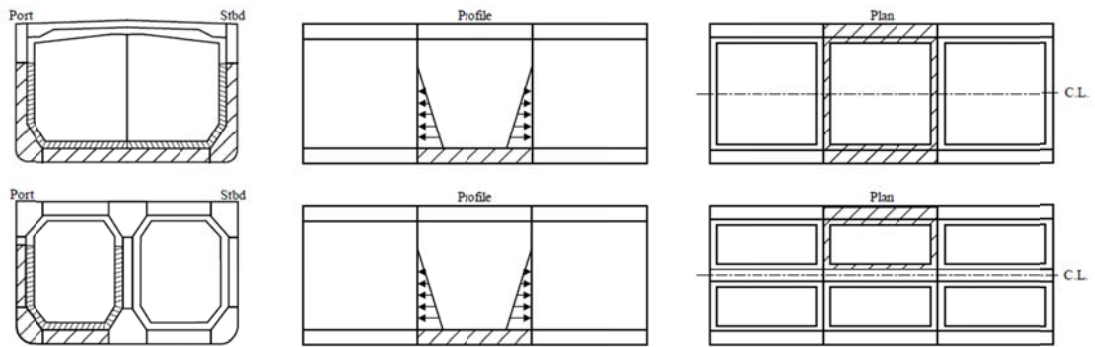
Table 2.4.5.1

Special loading case	SLC1	SLC2	SLC3	SLC4	SLC5
Descriptions	Single side loading	Flooded case in transverse bulkhead	Flooded case in anti-units	Collision	Static heel
Draft	$0.5 T_{sc}$	T_{flood}	T_{sc}	-	T_{sc}
Longitudinal inertial load	-	-	-	$-0.25g$	-
Vertical inertial load	$1.0g$	-	$1.0g$	$1.0g$	$g \cos 30^\circ$
Transverse inertial load	-	-	-	-	$g \sin 30^\circ$

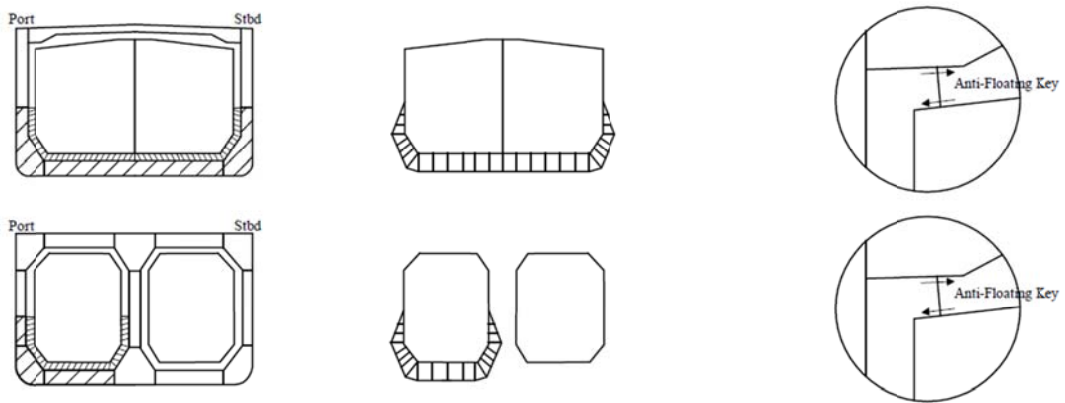
Note: T_{flood} means the maximum draft in the flooded condition.



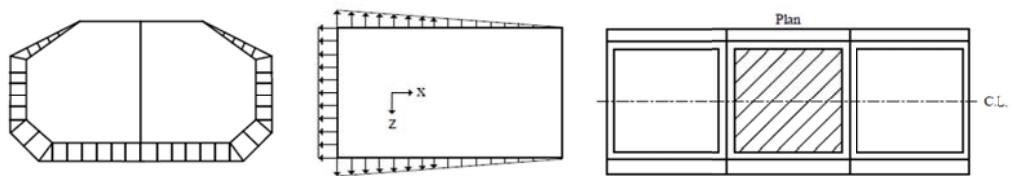
SLC 1



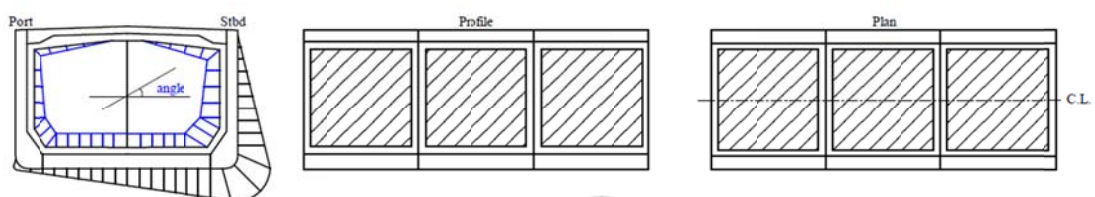
SLC 2

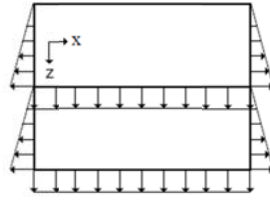


SLC 3



SLC 4





SLC5



Notes:  Carrying LNG  Carrying ballast water

Figure 2.4.5.2 Loading patterns (Special loading cases)

Section 5 STRENGTH ASSESSMENT

2.5.1 Loads and loading cases

2.5.1.1 Strength assessment is to be carried out based on the loads and loading cases specified in Section 4.

2.5.2 Finite element models

2.5.2.1 The finite element models of supporting and keying system of independent tank are also to comply with the relevant requirements specified in Section 4 of Appendix 1 and Section 4 of Appendix 2, Chapter A4, Part 2 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk and Section 4, Chapter 4 of CCS Guidelines for Survey of Membrane Tank LNG Carriers.

Section 6 FATIGUE

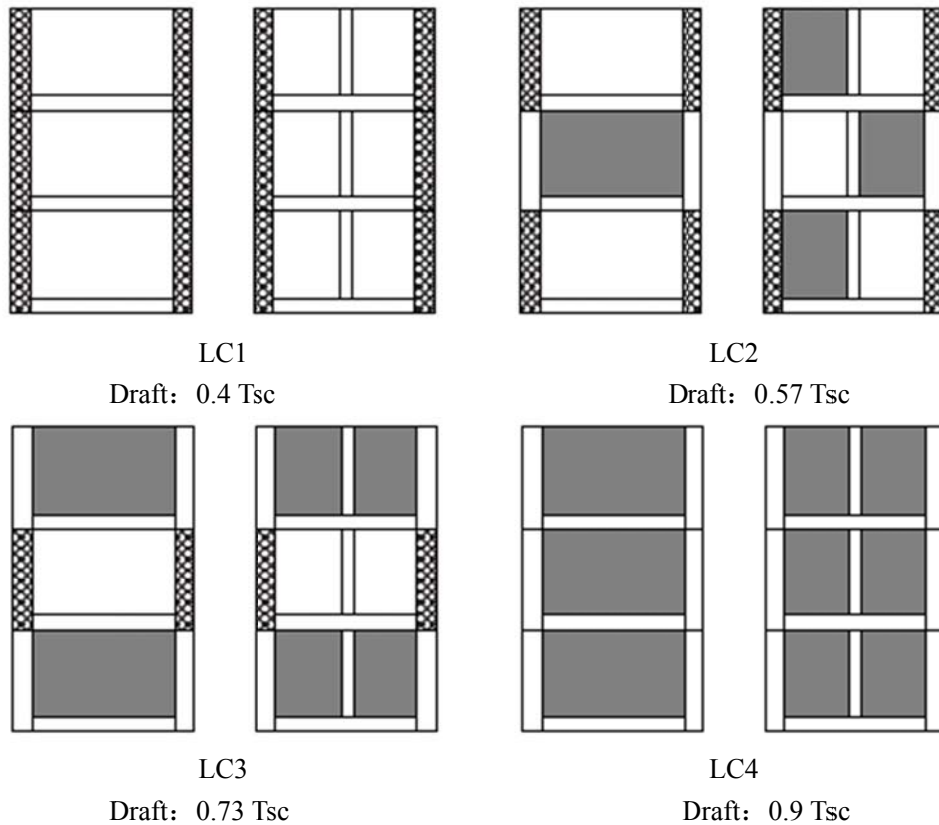
2.6.1 General requirements

2.6.1.1 Fatigue strength assessment is to be carried out for the following areas at least:

- (1) The areas required for fatigue strength assessment in Section 2, Chapter 10, Part 2 of CCS Rules for Classification of Offshore Floating Units;
- (2) Access openings, pipe penetrations and hatch corners of the opening for tank dome;
- (3) Tank supports and limit structures and seatings fitted to the hull and the cargo tank;
- (4) End bracket of transverse members, wash bulkheads and horizontal members;
- (5) Locations where the local calculated stress exceeds the minimum yield strength of the used steels.

2.6.2 Loading patterns

2.6.2.1 Sufficient number of loading patterns is to be considered to perform the fatigue assessment. The loading patterns shown in Figure 2.6.2.1 are to be considered for evaluation at least.



Notes: Carrying LNG Carrying ballast water

Figure 2.6.2.1 Loading patterns for fatigue strength assessment

2.6.2.2 If the actual minimum ballast draft under the operating environmental conditions is greater than $0.4T_{sc}$ for LC1, the actual draft is to be used, but not to exceed $0.6T_{sc}$.

2.6.2.3 If the actual maximum full draft under the operating environmental conditions is greater than $0.9T_{sc}$ for LC4, the actual draft is to be used.

2.6.2.4 Values equally divided between drafts of LC1 and LC4 are used as drafts of LC2 and LC3.

Section 7 FLOATING UNITS CONVERTED FROM LIQUEFIED NATURAL GAS CARRIERS

2.7.1 Acceptance criterias for hull structures

2.7.1.1 The hull structure where the regasification unit is fitted is to be strengthened if necessary, and to be assessed in accordance with the relevant requirements of Chapter 3, PART 2 of CCS Rules for Classification of Offshore Floating Units.

2.7.1.2 For the converted units, the hull, superstructure and deckhouse are to be evaluated according to the following criterias:

- (1) complying with the previous requirements of CCS Rules for Classification of Sea-going Steel Ships applicable at the time the ship was constructed; or
- (2) complying with the requirements in 3.1.4 of Chapter 3, Part 2 of CCS Rules for

Classification of Offshore Floating Units.

2.7.1.3 For the criteria specified in 2.7.1.2(1), the environmental severity factor based on the environmental conditions is not to be greater than 1.0.

CHAPTER 3 LNG TRANSFER SYSTEMS

Section 1 GENERAL PROVISIONS

3.1.1 General requirements

3.1.1.1 This Chapter applies to LNG transfer systems of units.

3.1.1.2 All piping, valves and accessories are to be suitable for the requirements of cargo handling and operating environmental conditions.

3.1.1.3 Units are to have sufficient capacity to manage the boil-off gas generated during LNG transferring, which is mainly generated by the heat entering through the transfer piping, LNG loading arm, cooling tanks and LNG pump, etc.

Section 2 LNG TRANSFER SYSTEMS

3.2.1 General requirements

3.2.1.1 An LNG transfer system generally means transfer lines, LNG vapor lines and other related systems onboard a unit for receiving LNG from LNG carriers or other offshore installations, and pipelines from LNG tanks of units to LNG shore connections (send-out), and other related systems, mainly including piping systems, LNG pumps, gas compressors and hose unloading systems of units. Where, the hose unloading system includes:

- (1) cargo hoses;
- (2) break-away couplings;
- (3) insulating flanges.

When applicable, this Section also applies to LNG loading arms installed on a unit.

3.2.1.2 The LNG transfer system is to be designed to avoid the release of gas or liquid into the air during normal transfer operation.

3.2.1.3 The LNG pipeline of the transfer system is to be subjected to stress analysis which is to take into accounts all the stresses due to the weight of pipes and frost, including acceleration loads, internal pressure, thermal contraction and loads induced by hog and sag of the ship for each branch of the piping system.

3.2.2 Piping systems

3.2.2.1 Flange connections of pipes are to be minimized to that required for installation and maintenance.

3.2.2.2 The pipes of LNG transfer systems, especially the transfer manifolds, are to be provided with enough strengthening and supporting structures to be subject to the possible loads and vibration during the operation.

3.2.2.3 Measures are to be provided for draining any LNG from the transfer pipes upon completion of transfer. LNG is to be discharged to the cargo tanks or other suitable locations.

3.2.2.4 LNG transfer lines are to be provided with installations for inerting and gas freeing so as to ensure that the pipelines are free of flammable gas when LNG transfer is not carried out.

3.2.2.5 All pipelines or components which may be isolated in the case of full of liquid in the pipes are to be protected with relief valves to avoid thermal expansion and evaporation.

3.2.2.6 LNG transfer manifolds are to be fitted with filters. Such filters may be permanent or temporary, and the standards of filtration are to be appropriate to the risk of debris, etc., entering the system. Measures are to be provided to indicate that filters are becoming blocked, and to isolate, depressurize and clean the filters safely.

3.2.2.7 Piping between the LNG tank and the transfer system is to be equipped with a manually operated stop valve for isolation and a remotely controlled emergency shutdown valve in series, or a combined manually and automatically operated valve. These valves are to be located as close to the tank as practicable.

3.2.2.8 Each transfer pipe is to be equipped with a manually operated stop valve for isolation and a remotely controlled emergency shutdown valve in series or a combined manually and automatically operated valve at the send-out manifold.

3.2.2.9 LNG vapour return connected to the gas phase space of the LNG carrier tank is to be provided.

3.2.2.10 Fixed or portable drip trays having a sufficient capacity of containing the volume which could escape are to be fitted where leakage of liquefied gas may occur, e.g. the connections of low temperature pipe, LNG transfer pipe manifolds. Drip trays are to be made of low temperature material and thermally insulated from the hull, and an overflow hole is to be provided near the top of the side wall of the drip tray through which LNG will be drained over the ship's side by a pipe that preferably leads down near the sea. The end of the pipe near the sea is to be far away from the ship berthing position in general, or, effective protective measures have been taken to avoid the effects on berthing of units/ship/offshore facility.

3.2.2.11 In order to avoid injury to personnel and low temperature damage to the hull structure on the deck due to LNG pressure injection, a splash guard and a drip tray or similar device are to be provided at the flange joint of any LNG piping having a pressure greater than 1.0 MPa.

3.2.2.12 Water supply system is to be installed to provide low pressure water curtain and additional protection for the hull steel and side structures near the discharge pipe of the drip tray. The system is to work during the LNG transfer.

3.2.3 Emergency shutdown (ESD) system

3.2.3.1 An emergency shutdown (ESD) system is to be installed for LNG transfer systems and equipment, which is to comply with the relevant requirements of Chapter 18, Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

3.2.3.2 The ESD system is to be activated by the manual and automatic inputs listed in Chapter 18, Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk. Any additional inputs are only to be included in the ESD system if it can be shown that their inclusion does not reduce the integrity and reliability of the system overall.

3.2.3.3 The ESD system is to return the LNG transfer system to a safe static condition, allowing remedial action to be taken. Due regard is to be given in the design of the ESD system to avoid the generation of surge pressures within the pipework.

3.2.3.4 The equipment to be shut down on ESD activation is to include manifold valves during loading or discharge, and pumps and compressors associated with transferring cargo in

either liquid or gaseous state.

3.2.3.5 The number and location of additional shutdown positions are to be determined by the type, number, location and position of the transfer systems and equipment.

3.2.4 LNG hoses

3.2.4.1 The Section applies to cargo hoses which carry LNG and LNG vapours between the unit and the ship or the shore.

3.2.4.2 Unless expressly specified in this Section, the hoses are to be designed and tested according to the relevant requirements of Chapter 5, Part 3 of CCS Rules for Construction and Equipment of Inland Waterways Ships Carrying Liquefied Gases in Bulk and the relevant standards⁴ accepted by CCS.

3.2.4.3 Hoses are strictly to comply with the manufacturer's instructions on test, storage, temperature and pressure operating cycles.

3.2.4.4 All materials are to be compatible with each other and with the fluid conveyed (LNG and LNG vapours).

3.2.4.5 The end fittings of hoses are to be suitable to the working pressure and working temperature.

3.2.4.6 The hoses are to be type approved by CCS. Type approval tests include temperature and pressure cycling tests, burst pressure tests, bending cycle fatigue tests, failure tests, impact tests, tensile tests, bending tests for minimum bend radius (MBR), maximum allowable applied torque (MAAT) test, electrical test and hydraulic test and so on.

3.2.4.7 Temperature and pressure cycling test

The hose assembly is to be subjected to a pressure cycling test at ambient temperature to demonstrate that the hose is capable of withstanding 200 pressure cycling tests from zero to at least twice the specified maximum working pressure.

3.2.4.8 Burst pressure test

After the pressure cycle test, the burst pressure test is to be carried out to demonstrate a bursting pressure of at least 5 times its specified maximum working pressure at the upper and lower extreme service temperature.

3.2.4.9 Bending fatigue test

The hose assembly is to be subjected to a bending fatigue test, at ambient and cryogenic temperature, with at least 400 000 cycles without failure.

The fatigue bend radius is to be in accordance with design recommendation.

3.2.4.10 Crushing test

The hose assembly is to be subjected to a crushing test at ambient temperature and cryogenic temperature without damage. The hose assembly is to be held between two rigid plates (an area equivalent to the diameter of the hose) and a force of 1000N is to be applied ten times at the same location in the middle of each flexible hose.

3.2.4.11 Impact test

The hose assembly is to be subjected to an impact test to ensure that the hose is capable of withstanding specified loads without damage at ambient and cryogenic temperature. The load specified during the test is the maximum impact pressure that the hose may withstand during

⁴ e.g. EN1474-2 Installation and equipment for liquefied natural gas -Design and testing of marine transfer systems Part 2: Design and testing of transfer hoses.

transfer operations.

3.2.4.12 Tensile test

The hose assembly is to be subjected to a tensile test at ambient and cryogenic temperature to ensure that the hose is capable of withstanding the maximum working load.

3.2.4.13 Bending test of MBR

The hose assembly is to be subjected to a bending test at ambient and cryogenic temperature to ensure that the hose is capable of withstanding the maximum working pressure at minimum working bend radius.

Hose is to be gradually bent to the MBR and then pressurized to the maximum working pressure. Hoses are to be examined for leaks whilst being held for 15 min at MBR and no damage is to be evident on return pre-test conditions.

3.2.4.14 MAAT test

The hose assembly is to be subjected to ambient and cryogenic twist test to ensure that the hose is capable of with- standing its maximum working load whilst at MAAT.

The hose assembly is to be gradually twisted to the MAAT and then pressurized to the maximum working pressure. The hose is to be examined for leaks whilst being held for 15 min at MAAT and no damage is to be evident on return pretest conditions.

3.2.4.15 Hydraulic pressure test

After the type approval test defined above, the hose assembly is to be subjected to a hydraulic pressure test to a pressure not less than 1.5 times the maximum working pressure, to demonstrate that the hose assembly is capable of withstanding the test without leaking.

3.2.4.16 Works testing

Each produced length of cargo hose completed with end-fittings is to be tested (hoses used for prototype testing are not to be used onboard), mainly include pressure test, leakage test and inspection of welds, etc.

(1) Pressure test

The hose assembly is to be subjected to hydraulic pressure tests at ambient temperature and cryogenic temperature, to a pressure not less than 1.5 times the maximum working pressure, but not more than two fifths of its bursting pressure, to demonstrate that the hose assembly is capable of withstanding its pressure without leaking.

(2) Leak test

The hose assembly is to be subjected to a pneumatic pressure test at ambient temperature, to a pressure not less than 1.1 times the design pressure, to demonstrate that the hose assembly is capable of withstanding its pressure without leaking.

(3) Inspection of welds

Welds of the hose assembly are to be subjected to non-destructive testing (NDT). When applicable, all butt welds of the hose assembly with connections systems are to be subjected to a 100% radiography examination.

3.2.5 Breakaway couplings

3.2.5.1 A breakaway coupling is capable of being released under the external force or by remote control, and its shutoff is to make LNG which may escape as few as possible without damage to the surrounding hull from low temperatures. The breakaway couplings can usually be separated into two predetermined sections, and the two sections after disconnection have a

self-sealing function.

3.2.5.2 Breakaway couplings can be activated:

- (1) by the predetermined maximal allowable forces applied to sections;
- (2) by manual or automatic control, in case of emergency.

3.2.5.3 The material of a breakaway coupling is to be appropriate to the working pressure and temperature, and the design pressure is not to be less than 2.0 MPa.

3.2.5.4 A calculation regarding the maximum impact force of the coupling which it would be subjected to when released is to be provided. A tensile strength calculation is to be provided for a bolt-type safety breakaway coupling, including the tensile forces at least in the directions of 0°, 45° and 90° to the axis of the coupling.

3.2.5.5 A breakaway coupling is to be so designed as to prevent a failure of release due to frosting of its cold surface.

3.2.5.6 A prototype test is to be carried out for each new type of bolt-type safety breakaway coupling, including the hydraulic test, axial released test, non-axial released test, medium impact test and drop test.

(1) Hydraulic test at ambient temperature: No significant leakage at a pressure of not less than 1.5 times design pressure;

(2) Hydraulic test at design temperature: No significant leakage at a pressure of not less than 1.5 times the maximum working pressure;

(3) Axial released test: The axial tensile force starts at zero and gradually increases to shutoff of the coupling, and record the tensile force value and leakage when released;

(4) Non-axial released test: Pull the coupling in the directions of 45° and 90° from its axis, the tensile force starts at zero and gradually increases to shutoff of the coupling, and record the tensile force value and leakage when released;

(5) Medium impact test: A medium impact test is to be carried out for the coupling inlet port at the maximum allowable flow specified in the design calculation after the shutoff of the coupling;

(6) Drop test: Each end of the coupling is to be dropped for four times from 2.5 m height after its shutoff, with no significant leakage after the shutoff of the coupling.

3.2.5.7 A bolt-type safety breakaway coupling used in the prototype test is not to be used for transferring LNG. However, each breakaway coupling is to be subjected to a hydraulic test at the ambient temperature before being put into service with a pressure not less than 1.5 times the required maximum working pressure, and a low temperature property test is also to be carried out at the design temperature with a pressure not less than 0.5 MPa.

3.2.5.8 The flow-rate and pressure-drop across each new type of breakaway coupling are to be measured and recorded. The tension range of a breakaway coupling forced to shut off is to be indicated in the certificate.

3.2.5.9 For breakaway couplings of novel design other than bolt-type safety breakaway couplings, the documents, such as the proof of successful application, operation instructions and technical specifications, are to be available and submitted to CCS for approval.

3.2.5.10 Break-away couplings are to be type approved by CCS, and the type test is:

(1) to confirm the values of axial and shear forces at which break-away couplings automatically separate. The tightness of the self-closing shut-off valves after separation is to be checked;

- (2) to confirm the release performance under icing condition;
- (3) to confirm the automatic release in case of activation (if applicable).

3.2.5.11 Works testing

The break-away couplings are to be subjected to a hydraulic pressure test, at ambient temperature, to a pressure not less than 1.5 times the design pressure, to demonstrate that the break-away couplings are capable of withstanding its pressure without leaking.

3.2.5.12 The design and arrangement of the LNG transfer pipeline are to be able to withstand the impact pressure caused by the detachment of break-away couplings. The manifold of the units to shore is to be appropriately strengthened.

3.2.6 Insulating flanges

3.2.6.1 The material of insulating flange is to satisfy the needs of LNG transfer and be capable of undertaking the design load during LNG transfer.

3.2.6.2 Each insulation flange is to be subjected to a test of electrical resistance in air and the resistance is to be not less than the following values:

Before hydrostatic testing: $\geq 10000\Omega$ above 1000 V;

After hydrostatic testing or when the arm is in service: $\geq 1000\Omega$ at 20V.

3.2.7 LNG loading arm

3.2.7.1 A loading arm is to be designed considering all factors and operating conditions that may be encountered in service, including ship's motions, changes in freeboard, weather and hydrographic conditions and LNG properties, to be adequate for the service which it is intended.

3.2.7.2 Unless expressly specified in this Section, the loading arm is to comply with the standards accepted by CCS or industry recognized standards⁵.

3.2.7.3 A loading arm is to be driven by a manual, pneumatic or hydraulic mechanical device. The control system of a loading arm is to be designed according to the relevant provisions of current standards of CCS or the nation⁶.

3.2.7.4 The range of the operating envelope of a loading arm is generally divided into a connection area, a working area, an alarm area and an emergency release area. The range of the operating envelope usually refers to the volume of space that can be reached by the end connector of the loading arm, which is determined by factors such as the ship's freeboard, movement of the ship, meteorological hydrology and tidal changes. The emergency release area is part of the range of the operating envelope and generally refers to the space volume range that the end connector of the loading arm can reach when the emergency release systems (ERSs) receives the emergency release signal until it is fully released.

3.2.7.5 The loading arm is to be provided with an active protection device (e.g. an emergency release system) to prevent damage. After separation of the emergency release system, the outboard end of the loading arm is to move upwards so that the LNG carrier will get safely away and the loading arm will be unattached completely without any connection or interference to

⁵ e.g. EN1474-2 Installation and equipment for liquefied natural gas -Design and testing of marine transfer systems Part 1: Design and testing of transfer arms, OCIMF: Design and Construction Specification For marine loading arms.

⁶ e.g. GB/T 7932 Pneumatic fluid power - General rules relating to systems; GB/T 3766 Hydraulic fluid power - General rules relating to systems; GB/T7935 Hydraulic fluid power - General requirements for hydraulic components; ISO 4413 Hydraulic fluid power - General rules and safety requirements for systems and their components.

the LNG carrier.

3.2.7.6 The triple swivel assembly is to be balanced for all arm attitudes so that the presentation flange remains in the range from the vertical plane to 3° to give first contact at the top of the manifold flange of the LNG carrier.

3.2.7.7 A loading arm is to be counterweight balanced in the empty condition, and the loading arm is to be balanced for any arm attitude in such case. The loading arm is to be safely fixed when not in use.

3.2.7.8 An insulating flange is to be fitted to the loading arm to electrically isolate between the units and the LNG carrier. The material of the flange is to satisfy the needs of 3.2.6 in this Chapter and be capable of undertaking the design load of the arm.

3.2.7.9 The end connector of the loading arm may be a flange or a QC/DC.

3.2.7.10 Design loads

(1) In general, the self weight of the loading arm is to include frost layers (at a density of 800 kg/m³, not cumulative) as follows:

Cold climate: 6 mm on all components;

For LNG: 25 mm on components carrying LNG;

Where a unit is located in an extremely cold region, the frost layers are to be taken into accounts against the local climate conditions.

(2) Wind velocities for loading arm in operation is generally not greater than 20 m/s, at reset status, be 55 m/s. Wind loads of the loading arm are to be calculated for the maximum projected area normal to wind and comply with the requirements for lifting appliances of CCS Rules for Lifting Appliances of Ships and Offshore Installations;

(3) The design of a loading arm is to include the loads caused by ship's inclining and motions, and the requirements for the loads are to be consistent with those for lifting appliances of CCS Rules for Lifting Appliances of Ships and Offshore Installations;

(4) A loading arm is to be calculated considering the thermal loads caused by material temperature differences;

(5) In addition, other loads which may be caused during the operation are to be taken into consideration;

(6) The manufacturer is to submit stress analysis of the loading arm with combined loads for all arm attitudes at the range of the operating envelope;

(7) The basic allowable design stress for structural components is to be the lower of either:

$$R_{eh}/1.5 \text{ or } R_m/2.35$$

Where, R_{eh} is the yield stress of material; R_m is the ultimate tensile stress of material; R_{eh} and R_m are to be the values specified in CCS Rules for Materials and Welding or other recognized standards⁷ for materials at design temperature.

(8) Wire ropes of a loading arm are to comply with the standards accepted by CCS or recognized standards, and the wire rope and fasteners have a safety factor of at least 5 times the breaking strength.

3.2.7.11 Materials

(1) The carbon content of the carbon steels for structural/mechanical loading arm components is to comply with the requirements of CCS Rules for Materials and Welding.

⁷ e.g. ASME B31.3 or ASME IID.

(2) The materials of all components in contact with LNG are to comply with the requirements of Chapter 6, Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, and aluminium is prohibited from being used as structural members and LNG carrying components.

(3) Hydraulic and lubricating components, such as pipes, fasteners, piston rods, connections and tanks, are to be made of stainless steel.

(4) The length of hoses used to provide articulation or electrical insulation is to be the minimum required for the duty and kept clear from the mechanical parts of emergency release systems.

(5) The electrical installations and materials of a loading arm are to satisfy the requirements for its operational environment and be in compliance with IEC 60079-0 or GB 3836.1 Explosive atmospheres - Part 1: Equipment - General requirements.

3.2.7.12 Welding and non-destructive testing

(1) Welding process is to be submitted for the Surveyor's approval, and all welds are to be found satisfactory by the Surveyor.

(2) All pressure welds are to be subjected to 100% radiographic inspection. Where it is impracticable to carry out radiographic inspection, the welds may be subjected to 100% defects inspections by other non-destructive testing methods, and the methods are to be submitted to the Surveyor for approval.

3.2.7.13 Emergency release systems (ERSs)

(1) An ERS is to comprise two shut-off valves in series and an emergency release coupling (ERC) between two of them, and, be so designed as to minimize spillage on release.

(2) The ERS is to be suggested to mount in the vertical leg of the triple swivel assembly.

(3) The ERS is to be capable of undertaking the maximum external load at the design pressure and design temperature of the load arm.

(4) The ERS is to permit a clean and safe separation of the loading arm from LNG carrier, following complete closure of the ERS valves and opening and releasing of the ERC, with frost layer of 25 mm.

(5) The ERS is to quickly activate on receiving a signal of release, and the time required for the operation of any ERS is to be 5s to 30s.

(6) Mechanical or hydraulic interlocks are to be provided to prevent ERS operation before complete closure of the shut-off valves.

(7) The ERS is not to leak, deform or fail at twice the maximum external load.

(8) ERS valves and hydraulic piping are to comply with the firefighting requirements of recognized standards⁸.

(9) An energy accumulator is to be provided for the ERS releasing mechanism to ensure real release and break of potential ice-block.

(10) In extremely cold weathers, the ERS is to be capable of being dismantled or installed.

(11) The leakage state and consequences after release of the ERS are to be approved by the Surveyor.

(12) The ERS is to be capable of initiating automatically when it reaches the emergency release area of the arm, and, means for preventing wrong operation is to be provided for its

⁸ e.g. SY/T 6960 Testing of valves - Fire type-testing requirements or ISO 10497 Testing of valves - Fire type-testing requirements.

manual start.

3.2.7.14 Swivels

(1) Swivels are to be subjected to a load test at the required design temperature and design pressure. Swivels are to have flexible rotation and no permanent deformations, and the leakage rate is not to exceed 10.0 cm³/min per centimeter of seal diameter at 0.6 MPa.

(2) The sealings of swivel are to satisfying the needs of LNG transfer at design temperature and design pressure. Seals are to prevent the ingress of moisture and impurities.

(3) Swivels are to accommodate temporary vacuum conditions at 0.05 MPa and reseal properly afterwards.

(4) A suitable lubrication system is to be provided for swivels to ensure good rotation capacity during transfer operation.

3.2.7.15 Drain devices

(1) A drain device is to be provided at the triple swivel assembly and at the base of the riser.

(2) If drain connections are fitted, consideration is to be given to that they allow complete drainage of the residual liquid in the arm before disconnection. The size of the drain connections may be based on the size of the loading arm.

(3) Threaded fittings are to be prohibited to the drain device.

3.2.7.16 Alarm and monitoring systems

(1) The arm is to be fitted with single state alarm system for luffing and slewing, to monitor the excessive drift of LNG carrier.

(2) The first stage alarm will initiate the closure of transfer operation and automatic shut down of LNG transfer pumps, booster equipment of the LNG tanks and vapour return lines.

(3) The second stage alarm will initiate automatic shut down of the stop valves of emergency release couplings and start of the ERS.

(4) When a pre-alarm is provided in addition to the first and second stage alarms, it will not initiate any function, other than manually intervention.

(5) The alarm system (other than those to activate an automatic shutdown system) is to activate the visual and audible signals at the control station.

(6) A failure of the hydraulic, electrical or any other function of loading arms is not to result in false activation of the ERS.

3.2.7.17 Testing

(1) A loading arm is to be subjected to the relevant testing after the completion of assembly and installation on board, including a pressure test, tightness test, low temperature swivel test, QC/DC test, low temperature ERS test and overall performance test.

(2) Pressure tests

The loading arm is to be subjected to a pressure test upon completion of pre-assembly, and the test medium is to be suggested to be volatile mediums (e.g. methyl alcohol), may be water provided that blowing off is done.

The test pressure is not less than 1.5 times design pressure.

During the test, the pressure is gradually to be increased up to the test pressure with pressure maintaining for 10 min, and then down to the design pressure with pressure maintaining for 30 min. The arm is to be deemed as qualified if no pressure drop or no leakage.

In case of negative pressure, the loading arm is to be subjected to a vacuum tightness test after passing the pressure test, with a negative pressure of 0.08 MPa.

(3) Tightness tests

The loading arm is to be subjected to tightness test after passing the pressure test. The test medium may be air, halogen, helium, ammonia gas or other gas that can be used for tightening test. The test pressure is to be 0.6 MPa.

The test pressure is to be kept for 10 min after reaching it, and the gasket is to be checked by liquid soap, foamer, color developing agent, gas molecular sensing instrument or other special means. The arm is to be deemed as qualified if no leakage.

(4) Swivel tightness tests

The swivel tightness test is to be carried out at the minimum design temperature with a load of twice design pressure of the loading arm. The swivel is to be deemed as qualified if no deformation and the leakage in compliance with 3.2.7.14(1) after pressure maintaining of 30 min.

(5) Quick connector tightness tests

The quick connector tightness test is to be carried out at the minimum design temperature with a load of twice design pressure of the loading arm. The quick connector is to be deemed as qualified if no deformation and no leakage.

(6) ERS tests

① Before assembly, the valve body is to be subjected to a strength test with a pressure of 1.5 times the design pressure and maintain the pressure for 30 min. The valve body is to be deemed as qualified if no leakage.

② After assembly, the ERS is to be subjected to a strength test at 1.5 times the design pressure and maintain the pressure for 30 min. The ERS is to be deemed as qualified if no leakage.

③ After passing the strength test, the ERS is to be tested for the valve closure and shroud ring open by connecting the electrical and hydraulic systems five times in succession, and the ERS is to be deemed as qualified if having reliable closure of the valves up and down, smooth open of the shroud ring, no abnormal sound and no jamming.

After passing the strength test, the ERS is to be subjected to a tightness test at the design pressure, and the pressure is to be kept for 10 min. The gasket is to be checked by liquid soap, foamer, color developing agent, gas molecular sensing instrument or other special means. The ERS is to be deemed as qualified if no leakage.

④ After passing the strength test and tightness test, the ERS is to be subjected to a low temperature test at the minimum design temperature, and ice layer of 25 mm is to be formed on its surface by water spraying. The ERS is to be deemed as qualified if having reliable closure of the valves fore and aft, smooth open of the shroud ring, no abnormal sound and no jamming, provided that the internal pressure is not below the design pressure.

(7) Overall performance testing of loading arms

A loading arm is to be subjected to an overall performance test after assembly and installation on board. The test is to include:

- ① Balance testing of inboard and outboard arms;
- ② Inspection of the working envelop;
- ③ Testing of the control system and limit alarm;
- ④ Emergency release testing: the arm is to be subjected to five releasing tests in succession in the empty condition, an overall low temperature test, a releasing test at the low temperature and an ERS test using the standby power;
- ⑤ Function test of nitrogen purge system of swivels joint.

3.2.8 Tests of LNG transfer system

3.2.8.1 The LNG transfer system is to be subjected to a hydraulic pressure test at ambient temperature with a pressure not less than 1.5 times the working pressure, to demonstrate that the system is capable of withstanding the pressure without leakage.

3.2.8.2 The LNG transfer system is to carry out a functional test to verify the integrity of its various functions.

3.2.9 LNG transfer rate

3.2.9.1 The maximum LNG transfer rate is to be justified, taking into consideration:

- (1) management of the BOG generated during transfer operation;
- (2) temperature of LNG;
- (3) characteristics of LNG carriers/units;
- (4) maximum allowable flow of the hose/loading arm.

3.2.9.2 The LNG transfer velocity in the piping system is not to exceed 10m/s in order to avoid the generation of static electricity and to limit the heat transfer due to friction inside the pipes.

3.2.10 Water curtain systems

3.2.10.1 Water curtain systems are to be provided on the sides of liquid phase pipe joints with unit to transmit LNG to and from the outside. The installation range of water curtain system is to be effective to prevent the hull structure from being damaged at low temperature.

3.2.10.2 Installation of water curtain sprinklers is not to affect the mooring and gasification operations of unit.

3.2.10.3 Control installations for water curtain systems are to be arranged in an appropriate location away from the connecting equipment.

CHAPTER 4 REGASIFICATION SYSTEMS

Section 1 GENERAL PROVISIONS

4.1.1 General requirements

4.1.1.1 In addition to this Chapter, the regasification systems are to comply with the applicable requirements of Chapter 7 of CCS Rules for Offshore Oil and Gas Process System and Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

4.1.1.2 The design, arrangement and equipment of regasification systems is to minimize the risk of fire and explosion.

4.1.1.3 Regasification systems are to be so designed that any single failure is not to result in a hazard that affects safety.

4.1.1.4 The pipe clamps and brackets on LNG piping of high-pressure pumps and in the manifold areas are to be constructed of low temperature materials. The adjacent hull structures are to be suitably insulated.

4.1.1.5 A risk assessment is to be conducted for regasification systems in accordance with the requirements of Appendix 1 of the Rules and to be submitted to CCS for information.

Section 2 VAPORIZERS

4.2.1 General requirements

4.2.1.1 All LNG high pressure pumps outlet pipeline in closed circuit are to be designed to be capable of withstanding the maximum pressure which may occur in the pump unless relief valves are provided.

4.2.1.2 Vaporizers are to be designed to avoid the effects of icing and corrosion.

4.2.1.3 All piping materials used in vaporizers are to take into account the physical and chemical properties of the medium in the pipeline.

4.2.1.4 Where potential risk of failure of a tube or passage could result in gas entering the sea-water or other heating medium side:

(1) The sea-water or other heating medium side is to be designed to accept the probable maximum gas pressure of the gas side; or;

(2) The sea-water or other heating medium side is to be protected with relief valves in readily visible positions; the discharge from these relief valves is to be taken to a suitable high-pressure venting arrangement and the number and position of valves are to be adequate to relieve the flow occurring due to failure of a single tube.

4.2.1.5 An expansion drum or an equivalent facility is to be fitted for the pipes containing heating mediums. If an expansion tank/drum is fitted, it is to comply with following conditions:

- (1) Expansion drums are to be fitted with level gauges, thermometers and air vents;
- (2) Expansion drums are to be fitted with high and low level alarm;
- (3) Expansion drums are to be fitted with combustible gas detectors;

(4) The vents of gas heating circuit expansion tank are to lead to the open area.

4.2.1.6 If propane or other hydrocarbons are used as the heating medium in a heat exchanger or vaporizer, its storage tank is to be located in the cargo area and the condensate is not to be passed directly back to the engine room. For heating mediums other than non-hydrocarbons, the condensate may be passed back to the engine room unless it has passed through a degassing tank located in the gas-dangerous area. The vent outlet of the degassing tank is to be routed to a safe location and be fitted with a flame screen. The degassing tank is to be covered by two independent gas detectors which are located close to each other. If the gas detectors are of self-monitoring type the installation of a single gas detector can be permitted.

4.2.1.7 If the unit is to operate in regions where insufficient natural sources of heat are available for vaporization, e.g. low sea water temperature, the design gas output conditions are to be maintained utilizing alternative means.

4.2.1.8 Commissioning and testing of vaporizers are to be undertaken by the manufacturer prior to units being installed on board.

4.2.1.9 Water supply pumps are to be fitted with suitable inlet filters. It is to be possible to remove and clean the filters whilst the regasification system remains operational.

Section 3 GAS DETECTION

4.3.1 General requirements

4.3.1.1 In addition to the gas detection system fitted to allow compliance with CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, a permanently installed system of gas detection is to be fitted:

(1) in all enclosed spaces containing gas piping, gas equipment, gas consumers or regasification equipment;

(2) in other enclosed or semi-enclosed spaces where gas vapors may accumulate;

(3) in air-locks;

(4) in heat transfer fluid expansion tanks;

(5) in the condensate degassing tank;

(6) at the ship-to-shore connection of gas and liquid pipelines.

4.3.1.2 If propane or other combustibles are used as the heating medium, the appropriate combustible gas detectors are to be fitted.

4.3.1.3 The number and the positions of detection heads are to be determined with due regard to the size and layout of the compartment, the air flow from compartment purging or ventilation and risk assessment results, and the manufacturer's recommendations.

4.3.1.4 The gas detection system serving the regasification system may be either independent or combined with the gas detection system required in CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

Section 4 EMERGENCY SHUTDOWN (ESD) SYSTEMS

4.4.1 General requirements

4.4.1.1 An emergency shutdown (ESD) system serving the regasification systems and equipment is to be fitted and comply with the applicable requirements of Section 10, Chapter 18, Part 3 of the Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

4.4.1.2 For a unit converted from an LNG carrier, any additional ESD system is to be coordinated with the existing ESD system. If necessary, coordination analysis or cause and effect analysis is to be carried out.

4.4.1.3 Multi-party communication lines or equivalent facilities are to be provided to the unit for automatic and manual ESD communication to the LNG carrier / shore.

4.4.1.4 The ESD system is to return the regasification system to a safe static condition. Due regard is to be given in the design of the ESD system to avoid the generation of surge pressures within the pipework.

4.4.1.5 The number and location of additional ESD positions are to be determined by the type, number, location and position of the regasification systems and equipment.

4.4.1.6 The ESD system is to have a data logging function. It is to be capable of automatically recording a certain amount of the latest operational data of regasification systems and equipment and store abnormalities such as alarms and faults during operation. Records of abnormalities can only be cleared manually.

Section 5 PROCESS SHUTDOWN (PSD) SYSTEMS

4.5.1 General requirements

4.5.1.1 The activation of the PSD is to stop the supply of LNG to the LNG suction drum, high pressure LNG pumps and gas discharge valve. Where the installation comprises a number of separate regasification systems the PSD may be system-specific as well as full shutdown. A PSD function arrangement matrix is to be designed and arranged in accordance with the requirements of Table 18.1, Chapter 18, Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

4.5.1.2 Manual PSD points are to be arranged at the regasification system control station and at locations as determined by the type, number, location and position of the regasification systems and equipment. The process shutdown points are to be clearly visible.

4.5.1.3 Process shutdown valves in liquid piping are to close fully under all service conditions within 30 seconds of activation. Information about the closing time of the valves and their operating characteristics are to be available on board and the closing time is to be verifiable and reproducible.

4.5.1.4 The closure time of 30 seconds for the shutdown valve referred to above is to be measured from the time of manual or automatic initiation to final closure. This is called the total shutdown time and is made up of a signal response time and a valve closure time. The valve closure time is to be such as to avoid surge pressure in pipelines. Valves are to close fully and smoothly.

Section 6 DEPRESSURIZATION AND BLOWDOWN SYSTEMS

4.6.1 General requirements

4.6.1.1 A depressurization and blowdown system is to be provided for depressurizing the pumps, compressors, pressure vessels and pipeworks containing high pressure liquid and gas.

4.6.1.2 Where a liquid depressurization system is provided, adequate provision is to be made in the design and installation for the effects of back pressure in the system and vapour flash-off when the pressures of liquids in the blowdown system are reduced.

4.6.1.3 Manual and automatic activation of the depressurization system is to be provided.

4.6.1.4 Manual activation is to be possible from the regasification control station, at the send-out manifold, and from other locations as determined by the type, number, location and position of the regasification systems and equipment.

4.6.1.5 Automatic activation is to be part of the emergency shutdown (ESD) system.

Section 7 PRESSURE RELIEF AND VENTING SYSTEMS

4.7.1 General requirements

4.7.1.1 Each regasification unit is to be provided with dedicated high pressure safety relief valves and venting arrangements. The arrangements are to be independent from the venting arrangements serving the cargo tanks. High pressure safety relief valves, headers, knock-out/drain drum and vent masts are to be located within the cargo deck area.

4.7.1.2 High pressure safety relief valves and venting arrangements for liquid and gas phases are to be provided for each regasification system. The safety relief valve support arrangements are to withstand the maximum loads imposed by discharges.

4.7.1.3 Where multiple regasification systems are installed, the design of pressure safety relief and venting arrangements is to consider the maximum combined release rate.

4.7.1.4 The gaseous phase safety relief valves are to be led to the dedicated high pressure vent mast for the regasification system. The high pressure vent mast is to be sized to handle the maximum regasification capacity and to ensure safe dispersal of the gas.

4.7.1.5 The liquid phase safety relief valves are to be led to a knock-out/drain drum (if applicable) having adequate capacity for the maximum LNG inflow anticipated within the design of the regasification unit. The knock-out drum is to be fitted with a high-level alarm and a high-level switch to stop all high pressure LNG pumps. Any LNG from the vent knock-out drum is to be safely drained or be allowed to boil off and vapour to be returned to the ship's vapour header.

Section 8 FIRE PROTECTION AND FIRE EXTINCTION

4.8.1 General requirements

4.8.1.1 The regasification system is to be protected with both a water spray deluge system plus a dry chemical powder system and a fire detection system. The systems are to comply with

the requirements of Chapter 11, Part 3 of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

4.8.1.2 Protection from fire and heat is to be provided as necessary for the safe escape of personnel in case of emergency.

4.8.1.3 Fire protection arrangements are to be such as to prevent possible jet fires propagating from the regasification unit to the adjacent cargo tank areas. Proposed arrangements should be submitted to CCS and be evaluated in the risk required in 4.1.1.5 of this Rules.

4.8.1.4 The regasification system is to be covered by at least two jets of water not emanating from the same hydrant, and the pressure at the hydrant is not to be less than 0.5MPa.

4.8.2 Water spray systems

4.8.2.1 A water spray system for cooling, fire prevention and crew protection is to be installed on an unit to provide coverage for the deck areas where the regasification system (such as evaporators, connecting equipment, liquid lines, high pressure gas lines, natural gas containers and associated valves) is located, in addition to the areas required in CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk. It may determine whether protection for the above coverage can be exempted or replaced by equivalent protective measures, and the risk assessment results are to be submitted to CCS for approval.

4.8.2.2 For the coverage described in 4.8.2.1, a water sprinkler system may be used to replace the water spray systems if they are unable to provide reliable coverage due to environmental conditions.

4.8.2.3 The water spray system is to have a separate section serving the area where the regasification system is located.

4.8.2.4 The capacity of the supply pumps of water-spray systems is to be sufficient to deliver the required amount of water to all areas simultaneously or where the system is divided into sections, the arrangements and capacity are to be such as to supply water simultaneously to the regasification equipment areas and areas specified in CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

4.8.3 Dry chemical powder systems

4.8.3.1 The unit is to be fitted with fixed dry chemical powder systems complying with the requirements of CCS Rules for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk providing the coverage for the regasification system.

4.8.3.2 At least 2 portable dry powder extinguishers of 5 kg are to be provided in the area where the regasification system is arranged.

Section 9 PIPING

4.9.1 General requirements

4.9.1.1 All high pressure or low temperature (-110°C and below) LNG pipes serving the regasification system are to be subjected to a stress analysis⁹, taking into account all the stresses due to the acceleration loads, internal pressure, thermal stress and additional loads induced by hog

⁹ Refer to the CCS Guidelines for LNG Low Temperature Pipeline Stress Analysis.

and sag for each branch of the piping system.

4.9.1.2 Piping between the LNG cargo containment system and the regasification system is to be equipped in series with a manually operated stop valve and a remote operated shutdown valve, or a combined manually operated and remote valve. These valves are to be located as close to the LNG cargo tank as practicable. Where the regasification unit is located forward of the unit, these valves are to be as near as possible to the boundary of the forwardmost cargo tank and within the cargo area.

4.9.1.3 A manually operated stop valve and a remote operated shutdown valve, or a combined manually operated and remote valve are to be provided at the send-out manifold.

4.9.1.4 Each gas outlet pipeline (send-out) and shore connecting manifold are to be provided with support structures of adequate strength to withstand the loads during gas send-out operations.

4.9.1.5 All manually operated valves serving for cargo operations are to be located in a readily accessible location.

4.9.1.6 The spool piece, reducers, valves and other fittings to which the cargo system or the send-out system is directly connected are to be made of CCS approved material. They are to be of robust construction, adequately supported and suitable for the stated design conditions and manifold forces

4.9.1.7 Means of purging, inerting and gas-freeing the pipe lines used for the regasification system is to be provided.

4.9.1.8 Means for mechanical separation is to be provided between the regasification piping system and the inert gas and nitrogen systems.

4.9.1.9 All pipes are to be properly supported, and provisions are to be incorporated in the design to minimize the number of their flanged connections.

4.9.1.10 Drip trays or diversion trenches are to be provided where liquid piping is dismantled regularly, or where liquid leakage may be anticipated to collect LNG leakage and to transport LNG to a safe place. Drip trays or diversion trenches are to be made of low temperature materials.

4.9.1.11 In order to protect personnel from cryogenic burns and prevent ship structures on deck from being exposed to brittle fracture due to LNG pressure jet, spray shield arrangements and drip trays or similar protective devices are to be fitted to any flanged connection of piping containing LNG at a pressure above 1.0MPa.

4.9.1.12 All LNG pipes serving the regasification system are to be suitably insulated.

Section 10 INSTRUMENTATIONS AND AUTOMATION SYSTEMS

4.10.1 General requirements

4.10.1.1 The regasification system is to be provided with monitoring, alarm and safety systems. These systems are to comply with the applicable requirements of Chapter 7 of CCS Rules for Classification of Offshore Floating Units.

4.10.1.2 The sensors of safety systems are to be independent of the sensors used for

monitoring and alarm systems.

4.10.1.3 Instrumentations and automation systems are to be provided with automatic and/or remote controls to ensure the system operates within its design parameters.

4.10.2 Control stations

4.10.2.1 A control station for the regasification system is to be arranged within a non-hazardous area. Emergency procedures are to be capable of being performed from the station

4.10.3 Communications

4.10.3.1 At least two means of communication are to be provided between the control station and the receiving terminal. Means of communication should use specialized communication equipment and at least one of these systems is to be independent of the main electrical supply. The systems are to be dedicated and permanently fixed on the operating console.

4.10.4 Alarms, shutdowns and safeguards

4.10.4.1 Suitable interlocks are to be provided to prevent start-up of the regasification system under conditions which could hazard the system or its equipment and components.

4.10.4.2 The manufacturer is to identify the required alarms, shutdowns and safeguards for all vaporizers; the minimum required shutdowns are indicated in Table 4.10.4.2.

4.10.4.3 The manufacturer is to identify the required alarms, shutdowns and safeguards for the suction drum; the minimum required shutdowns are indicated in Table 4.10.4.3.

Alarms, Shutdowns and Safeguards for Vaporizers Table 4.10.4.2

Item	Alarm	Note
Gas discharge temperature	Low low	Automatic shutdown
Sea-water (and heating medium) supply pressure	Low low	Automatic shutdown
Gas leak detected		ESD operation (programmed)
Notes: 1. The Table contains the minimum list of alarms and shutdowns for vaporizers; additional alarms and shutdowns may be determined through risk assessment as required by Appendix 1 - Risk Assessment in this Rule. 2. If certain alarms and shutdowns are not applicable for the regasification system, sufficient evidence is to be produced and is to form part of the risk assessment as required by Appendix 1 - Risk Assessment in this Rule.		

Alarms, Shutdown and Safeguards for Suction Drums Table 4.10.4.3

Item	Alarm	Note
Suction drum pressure	Low	Automatic shutdown
Suction drum level	Low low	Automatic shutdown
Suction drum level	High high	Automatic shutdown

Note: 1. The Table contains the minimum list of alarms and shutdowns for suction drums; additional alarms and shutdowns may be determined through risk assessment as required by Appendix 1 - Risk Assessment.

2. If certain alarms and shutdowns are not applicable for the regasification system, sufficient evidence is to be produced and is to form part of the risk assessment as required by Appendix 1 - Risk Assessment.

CHAPTER 5 POSITION MOORING SYSTEMS

Section 1 GENERAL PROVISIONS

5.1.1 General requirements

5.1.1.1 The positioning of units is mainly of mooring position type, and this Chapter is applicable to the position mooring system for the mooring positioning of units, including single point mooring systems, jetty mooring systems, spread mooring systems and thruster assisted mooring systems, etc.

Section 2 ENVIRONMENTAL CONDITIONS

5.2.1 Design Environmental Conditions

5.2.1.1 Maximum design condition

(1) The maximum design condition is defined as the extreme condition with a specific combination of wind, waves and current for which the system is to be designed.

(2) A minimum return period of 5 years for the maximum design condition is required for mobile mooring system. If the design life of the mooring system is relatively low, it is more reasonable to choose a shorter return period, and the return period is to be determined by a risk analysis taking into account the consequence of mooring failure, but not less than 1 year.

5.2.1.2 Maximum operation condition

(1) The maximum operation condition is defined as the limiting environmental condition of the mooring system during the normal operation of the units. When the condition is exceeded, the normal operation of the units is to be suspended.

(2) The return period associated with the maximum operation condition of the mobile mooring system is determined by the owner/designer, but not less than 1 year.

5.2.2 Heading angles of wind, current and wave

5.2.2.1 In the design and analysis of the position mooring system, a sufficient number of angular separation of wind, current and waves, and the most serious possible combinations of wind, current and waves are to be considered.

5.2.2.2 For position mooring system for mooring in fixed direction, such as jetty mooring, it is assumed that wind, current and waves are collinear.

5.2.2.3 For single point mooring system, which allow the terminal to weathervane, the combination of angular separation of wind, current and waves are to be determined based on sea state data of the specific operation site. When this data is not available, the following combinations for non-collinear of wave, wind and current is to be considered as a minimum:

- (1) Wind and current are collinear and both at 30 degrees to waves;
- (2) Wind at 30 degrees to waves and current at 90 degrees to waves;
- (3) Wind at 90 degrees to waves and current at 30 degrees to waves;

- (4) Wind at 30 degrees to waves and current at 45 degrees to waves;
- (5) Wind at 45 degrees to waves and current at 30 degrees to waves.

Section 3 MOORING ANALYSIS AND DESIGN CRITERIAS

5.3.1 Mooring analysis

5.3.1.1 The mooring analysis of units can use both quasi-static analysis or dynamic analysis method, the specific recommended analysis methods and conditions are shown in table 5.3.1.1.

Recommended Analysis Methods and Conditions **Table 5.3.1.1**

Type of Mooring		Analysis Method	Conditions to be Analyzed
Permanent Mooring	Strength Design	Dynamic	Intact/Damaged
	Fatigue Design	Dynamic	Intact
Mobile Mooring	Strength Design	Quasi-static or dynamic	Intact/damaged/transient
	Fatigue Design	Not required	Not required
<p>Note: 1. Permanent mooring system: Refer to mooring system used for permanent mooring operations, when strong storm is coming, the units can not be removed from the operation area.</p> <p>2. Mobile mooring system: Refer to mooring system used for a relatively short time of mooring operations, when strong storm is coming, the mooring system can be disconnected, the units can be removed from the operation area.</p>			

5.3.1.2 For the mobile mooring system, when unit is moored in the vicinity of another structure, the transient analysis is to be performed to check units offset (check for tension is not required).

5.3.1.3 When time history response analysis is used, duration time of a calculation is to be at least three hours. The standard built-up time at start of the calculation is not to be less than 10% of calculation duration time to prevent excessive numerical motion at start time of calculation.

5.3.1.4 In the mooring analysis, loading conditions approved in the loading manual and the possible loading conditions in the actual operation, are to be considered.

5.3.1.5 When one or more liquid tanks in the units are in a non-full or non-empty loaded condition, and the wave direction is transverse, the effect of sloshing in liquid tank on units and mooring system is to be considered.

5.3.1.6 In order to assess the motion of units in waves in relatively shallow water, shallow water effects are to be taken into account. In cases where the changes in tidal levels in shallow waters are relatively large, the tidal difference affecting on units and mooring system is to be considered.

5.3.2 Design Criteria

5.3.2.1 In the case of jetty mooring system, the allowable offset is to satisfy the specified value of table 5.3.2.1.

The Allowable Offset-Jetty Mooring

Table 5.3.2.1

The allowable offset					
Surge (m)	Sway (m)	Heave (m)	Roll (°)	Pitch (°)	Yaw (°)
2.0	2.0	-	2.0	2.0	2.0

5.3.2.2 When quasi-static analysis or dynamic analysis method is adopted in mooring analysis, the tension safety factor of chains or wire ropes, synthetic fibre ropes is not to be less than the specified value in table 5.3.2.2, safety factors for mooring cable of other materials are to be approved by CCS.

5.3.2.3 In the analysis of the one broken mooring line condition, in the case of a unit which is moored in the proximity of other units, the safety factors for any mooring lines arranged on the opposite side of the other units are to be taken as 1.5 times those indicated in Table 5.3.2.2.

Safety Factors for Mooring Lines

Table 5.3.2.2

	Safety factors	
	Chains or wire ropes	Synthetic fibre ropes
Intact		
Quasi-static analysis	2.00	3.00
Dynamic analysis	1.67	2.50
One broken mooring line (at new equilibrium position)		
Quasi-static analysis	1.43	2.15
Dynamic analysis	1.25	1.88
One broken mooring line (transient condition)		
Quasi-static analysis	1.18	1.77
Dynamic analysis	1.05	1.58

Section 4 MOORING EQUIPMENT

5.4.1 General requirements

5.4.1.1 Where jetty mooring systems are used by units, units are to be ensured to moored to the jetty to prevent its over offset at the mooring position.

5.4.2 Mooring lines

5.4.2.1 For the jetty mooring system, the mooring lines is to be made of low elastic modulus material, in order to limit the movement of units, or made of high modulus synthetic fibre material.

5.4.3 Bollards and bitts

5.4.3.1 The safe working load (SWL) of the bollard is not less than the minimum breaking load (MBL) of mooring lines. In general, the SWL of the bollard is 2 times the MBL of the mooring lines.

5.4.3.2 Bollards are to be equipped for the mooring capacity as required by the units size, and to be evenly fitted on each side of the ship.

5.4.3.3 All bollards/bitts are to be welded to the deck on each side of the units in way of the

location required.

5.4.3.4 Mooring bits fitted onboard, including that used for emergency towing-off wires, are to be double bollards. The diameter of double bollards is normally not to be less than 10 times that of mooring lines, and at least greater than 300 mm.

5.4.3.5 Line stoppers are to be fitted in the vicinity of each set of double bollards and each cruciform bollard. The stoppers are to be provided with deck rings or lugs, the SWL of which is to be compatible with the working load of mooring lines.

5.4.4 Fairleads

5.4.4.1 All fairleads fitted onboard are to be of closed type, only one line is allowed to pass through each closed fairlead in order to ensure safe mooring.

5.4.4.2 The working load of fairleads is in no case to be less than the minimum breaking load (MBL) of the line passing through the fairlead.

5.4.5 Winches

5.4.5.1 The Safe Working Load (SWL) of the winches is to be greater than the mooring line's minimum breaking load (MBL).

5.4.5.2 Winches are to be provided with brakes which are normally divided into hydraulic brakes and manual brakes. The winch's brakeing capacity is not less than the 80% of the line's minimum breaking load (MBL).

5.4.5.3 The minimum distance between a winch drum and the nearest fairlead or chock is to be such that the fleet angle does not exceed 1.5° .

5.4.5.4 Mooring winches and bollards are normally bolted to foundations that are welded to the deck.

5.4.5.5 The means specified below are to be provided for controlling catenary mooring systems:

(1) Each windlass is to be capable of being controlled from a position which provides a good view of the operation;

(2) Means are to be provided at the windlass control position to monitor mooring line tension and windlass power load as well as to indicate the amount of mooring line paid out;

(3) Means of communication are to be provided between essential places for mooring operations (for example, operating position, wheel house, control room, etc.).

5.4.6 Chain/Cable Stoppers

5.4.6.1 According to the configuration of the windlasses/winches, the chain/cable stopper can be required to set up.

5.4.6.2 Chain stopper and its supporting structure used for mooring systems are to have sufficient strength against the breaking strength of the mooring lines.

CHAPTER 6 ELECTRICAL INSTALLATIONS

Section 1 GENERAL PROVISIONS

6.1.1 General requirements

6.1.1.1 Electrical installations are to be such that:

(1) all electrical auxiliary services necessary for maintaining the ship in normal operational and habitable conditions will be ensured without recourse to the emergency source of electrical power;

(2) electrical services essential for safety will be ensured under various emergency conditions and;

(3) the safety of passengers, crew and ship from electrical hazards will be ensured.

Section 2 MAIN SOURCE OF ELECTRICAL POWER

6.2.1 General requirements

6.2.1.1 A main source of electrical power of sufficient capacity is to be provided. This main source of electrical power is to consist of at least two generating sets.

6.2.1.2 The capacity of generating sets mentioned in 6.2.1.1 is to be such that in the event of any one generating set being stopped it will still be possible to supply those services mentioned in 6.1.1.1.

6.2.1.3 A main source of electrical power may be provided as necessary for non-self-propelled and long-term berth at the dock units. Where the main source of electrical power is the generator, the requirements of 6.2.1.1 and 6.2.1.2 need not be complied with.

6.2.1.4 Where arrangements are made for the supply of electricity from a source on shore or other external source of electrical power, the requirements of shore power and external source of electrical power of CCS Rules need to be complied with.

Section 3 EMERGENCY SOURCE OF ELECTRICAL POWER

6.3.1 General requirements

6.3.1.1 Units are to be provided with self-contained emergency source of electrical power.

6.3.2 Scope and period of supply of the emergency source

6.3.2.1 The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified hereinafter, if they depend upon an electrical source for their operation:

- (1) for a period of 18 h, the control and monitor system for tank and regasification system and their pipes;
- (2) for a period of 18 h, the ESD system;
- (3) for a period of 18 h, the other system for recover the system to a safe state;
- (4) the requirement of 2.2.2, Chapter 2, Part 6 of CCS Rules for Classification of Offshore Floating Units.

Section 4 POWER SUPPLY AND DISTRIBUTION

6.4.1 Power supply and distribution systems

6.4.1.1 The following systems of distribution may be used:

- (1) DC two-wire insulated system;
- (2) AC two-wire insulated system;
- (3) AC three-wire insulated system;
- (4) The hull of floating unit is not to be used for neutral earthed (including direct, high resistance and low resistance earthing) three-wire system.

Other distribution systems other than those mentioned above are to be subject to special approval by CCS.

6.4.1.2 Earthed systems with hull return are not permitted, except:

- (1) impressed current cathodic protective systems;
- (2) insulation level monitoring devices, provided that the circulation current of the device does not exceed 30 mA under the most unfavourable conditions;
- (3) components used for the suppression of interference in radio circuits;
- (4) limited and locally earthed systems, such as starting and ignition systems of internal combustion engines, provided that any possible resulting current does not flow directly through any hazardous area.

6.4.1.3 Earthed distribution systems are not permitted, except:

- (1) earthed intrinsically safe circuits, to the satisfaction of the Society;
- (2) power supplies, control circuits and instrumentation circuits in non-hazardous areas where technical or safety reasons preclude the use of a system with no connection to earth, provided the current in the hull is limited to not more than 5 A in both normal and fault conditions;
- (3) limited and locally earthed systems, such as power distribution systems in galleys and laundries to be fed through isolating transformers with the secondary windings earthed, provided that any possible resulting hull current does not flow directly through any hazardous area;
- (4) alternating current power networks of 1000 V root mean square (line to line) and over, provided that any possible resulting current does not flow directly through any hazardous area; to this end, if the distribution system is extended to areas remote from the machinery space, isolating transformers or other adequate means are to be provided.

6.4.2 Earth detection

6.4.2.1 The insulated distribution systems for power, heating and lighting circuits, whether primary or secondary, are to be provided with a device capable of continuously monitoring the insulation level to earth and of giving an audible or visual indication to locations with personnel,

such as navigation bridge, master control room or control station, in case of abnormally low insulation values.

Section 5 EXPLOSION PROTECTION

6.5.1 General requirements

6.5.1.1 Hazardous area classification and choice of electrical equipment are to comply with the requirements of CCS Rules for Classification of Offshore Floating Units.

6.5.1.2 The manufacturing, testing, marking and installation of electrical equipments are to be in accordance with the requirement of publication IEC 60079 or or similar standard.

6.5.1.3 Equipment within a hazardous area are to be assessed and certificated or registered by the authorities approved by CCS. Automatic isolation of non-conforming flammable gas detection equipment is not to be used in place of approved equipment.

6.5.1.4 The explosion group and temperature class of electrical equipment are to be selected in accordance with the category, class and ignition temperature of the gas (mixture) or vapour (mixture) which may occur around the equipment. The explosion group and temperature class of explosion proof equipment appropriate to a hazardous area which may contain natural gas are not to be lower than II A T2, those of explosion proof equipment of a storage battery room are not to be lower than II C T1.

6.5.1.5 Appropriate measures are to be taken to prevent gas (mixture) or vapors from reaching the other locations via the cables or their ducts from the hazardous area.

6.5.1.6 Portable two-way radios necessary for the operation are to be of a certified safe type.

Section 6 COMMUNICATION SYSTEM

6.6.1 General requirements

6.6.1.1 In addition to the requirements of this Chapter, communication systems are to be complied with the relevant requirements of Chapter 7, Part 7 of CCS Rules for Classification of Offshore Floating Units.

6.6.1.2 Whenever possible, adequate intercommunication is to be provided in all possible places to transmit and receive information in the emergency situation. The intercommunication systems are to comply with relevant requirements of Section 6, Chapter 7, Part 7 of CCS Rules for Classification of Offshore Floating Units.

ANNEX 1 RISK ASSESSMENT

Section 1 GENERAL PROVISIONS

1.1.1 General requirements

1.1.1.1 This Annex applies to loading, unloading, storage, regasification and supply of LNG.

1.1.1.2 Risk assessment may be a quantitative, semi-quantitative or quantitative approach, and the approached adopted are to be approved by CCS.

Section 2 RISK ASSESSMENT ELEMENTS

1.2.1 Risk assessment - Objective

1.2.1.1 The objective or goal of the risk assessment is to eliminate or mitigate risk that could harm individuals, the environment or the units, and propose mitigate measures if nessasary.

1.2.2 Risk assessment - Approach

1.2.2.1 Qualitative risk assessment (QualRA)

(1) The approachs of QualRA include “what-if” analysis, Hazard Identification(HAZID), hazard operability (HAZOP) analysis, failure modes and effects analysis (FMEA), fault tree analysis (FTA) and event tree analysis (ETA).

(2) Guidewords and phrases for QualRA see Appendix 1.

(3) Risk matrix for QualRA see Appendix 2.

1.2.2.2 Quantitative risk assessment (QRA)

(1) A quantitative risk assessment is a formalized statistical risk assessment method for calculating a numerical risk level for comparison with defined regulatory risk criteria.

(2) The following data sources may be used for failure frequency analysis:

- ① failure database in appendix 3;
- ② failure database applied to the LNG industry;
- ③ historical statistics of enterprises;
- ④ failure probability models based on reliability;
- ⑤ other data sources.

The failure database used is to be approved by CCS.

(3) An analytical model or software approved by CCS (CFD is recommended) is to be used to calculate the impact of consequences, including at least the following categories of hazards and extents of damage in general:

- ① intensity of thermal radiation from a fire;
- ② concentration of vapour cloud diffusion;
- ③ shock wave pressure from explosion.

1.2.3 Steps of risk assessment

1.2.3.1 The risk assessment is to include the following steps at least:

- (1) preparation;
- (2) collection of data;
- (3) hazard identification;
- (4) definitions of leakage scenarios;
- (5) failure frequency analysis;
- (6) impact analysis;
- (7) risk calculation;
- (8) risk assessment;
- (9) risk reducing measures.

1.2.4 Risk assessment - Reporting

1.2.4.1 A written report documenting the risk assessment is to be produced and referred to CCS for approval.

1.2.4.2 The specific contents of the report and its structure are dependent upon design and assessment specifics, and reporting preferences. However, the report is to provide:

- (1) an overview of the design and arrangement;
- (2) an explanation of the risk assessment process;
- (3) information on the relevant qualifications and expertise of the team;
- (4) the time taken to complete the assessment and whether SMEs (subject matter experts) were present to provide their expert input;
- (5) risk results and conclusions;
- (6) recommendations and actions.

Section 3 DISASTER ACCEPTANCE CRITERIA

1.3.1 Vapour cloud diffusion

1.3.1.1 The acceptance criteria of volumetric concentration of vapour cloud diffusion are to comply with the provisions in Table 1.3.1.1.

The Acceptance Criteria of Volumetric Concentration of Vapour Cloud Diffusion

Table 1.3.1.1

Vapour cloud	Volumetric concentration	Remarks
diffusion	2.5%	50% of lower flammable limit of methane

1.3.2 Thermal radiation

1.3.2.1 Damage to personnel and device caused by fire depend on intensity of thermal radiation and exposure time in fire.

1.3.2.2 The acceptance criteria of thermal flux and thermal dose of thermal radiation is to comply with the provisions in Table 1.3.2.2.

The Acceptance Criteria of Thermal Radiation Table 1.3.2.2

Fire	Maximum intensity of	Maximum thermal	Remarks
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	thermal radiation (kW/m ²)	dose of thermal radiation [kW/m ²] ^{4/3} t	
	5.0	500	In the event of not less than 10% of skin exposure to a fire for 30 seconds, second-degree burns to at least 10 persons
	5.0	300	In the event of not less than 10% of skin exposure to a fire for 30 seconds, second-degree burns to at least one person in the building
	32	Not applicable	Loss of strength (significantly decreased loading capacity) of steel structures exposure to a fire during sustained burning

1.3.2.3 LNG fire on unit could cause deaths of person and damage of device and structure (include hull structure).

1.3.3 Shock wave pressure from explosion

1.3.3.1 Damage to personnel, structure and device cause by explosion depend on shock wave pressure and propagation velocity from explosion.

1.3.3.2 The acceptance criteria of shock wave pressure from explosion are to comply with the provisions in Table 1.3.3.2.

The Acceptance Criteria of Shock Wave Pressure from Explosion Table1.3.3.2

	Overpressure corresponding to damage (Pa)		Categories of overpressure damage
	Lower limit	Upper limit	
Explosion	250	4000	Damage at window panes
	5000	10000	Damage at doors and covers and personal injury
	15000	20000	Serious structural damage
	25000	50000	Serious casualties

1.3.3.3 Explosion caused by gasified LNG on unit could lead to deaths of person and damage of device and structure (include hull structure).

Section 4 RISK ACCEPTANCE CRITERIAS

1.4.1 General requirements

1.4.1.1 Prior to the commencement of the risk assessment, risk criteria are to be agreed with CCS.

1.4.1.2 Risk criteria in quantitative risk assessments commonly refer to individual risk and societal risk (or group risk). In general, the individual risk is to be assessed, and the societal risk is also to be assessed when this might be exposure of ten or more people.

1.4.2 Definitions

1.4.2.1 An individual risk is a probability that an individual is exposed to hazards during a defined period of time, in generally means the probability that an individual will become a fatality each year.

1.4.2.2 1.4.2.2 A social risk is a probability that a group of persons (including employees and the public) is exposed to hazards during a defined period of time, in generally means the accident accumulation frequency that greater than or equal to N persons will become a fatality each year, which is shown in a curve of accumulation frequency and number of death (a F-N curve).

1.4.3 Individual risk acceptance criteria

1.4.3.1 The individual risk acceptance criteria are to comply with the provisions in Table 1.4.3.1.

The Individual Risk (IR) Acceptance Criteria **Table 1.4.3.1**

	Value-at-risk (frequency of death/unit/year)	
	Existing unit	Existing unit
Maximum risk acceptable to crew	1.0E-3	1.0E-4
Maximum risk acceptable to passengers on board or persons on shore	1.0E-4	1.0E-5
Widely accepted risk	1.0E-6	1.0E-6

1.4.4 Social risk acceptance criteria

1.4.4.1 The acceptance criteria of social risk are to comply with the provisions in Figure 1.4.4.1.

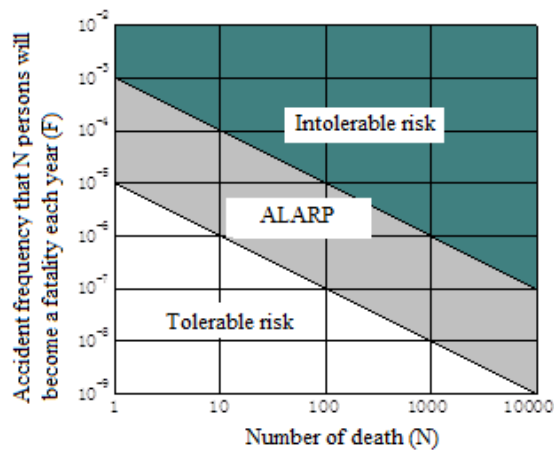


Figure 1.4.4.1 The Social Risk (SR) Acceptance Criteria

Section 5 RISK REDUCING MEASURES

1.5.1 General requirements

1.5.1.1 Where the risk calculated is just on the border of the area of intolerable risk or

ALARP, additional mitigation actions are to be carried out to reduce the risk to be tolerate.

1.5.1.2 The mitigation actions include but do not limited to new technologies and instruments combined in the design, optimized design of installation arrangement, upgrades of equipment, improving leakage alarm devices, emergency response procedures and operation procedures.

1.5.1.3 The mitigation actions used are to be approved by CCS.

Appendix 1

Prompts - guidewords and phrases

Example prompts for use in QualRA

Failure of cargo containing equipment* – a hole/crack leading to release of cargo	
Wear and tear	vibration, loading, cycling, prolonged use
Erosion	cargo contaminants, high stream velocity, prolonged use
Stress and strain	vibration, loading, cycling, unit movement, prolonged use
Fatigue	vibration, loading, cycling, unit movement, prolonged use
Corrosion	exposure to weather, exposure to sea water, humidity, loss of dry air supply, contact with corrosive materials
Collision	unit collides with another vessel, unit hits rocks, unit strikes the harbour wall or jetty
Grounding	unit runs aground
Impact	dropped object (e.g. during maintenance or cargo loading), collapse of supporting structure, maloperation during loading/maintenance
Fire	ignition of flammable materials, fire in adjacent spaces/areas
* plus equipment containing gases or other substances that could release into spaces resulting in harm (e.g. asphyxiation, burns)	
Failure of process control – operation outside of design conditions leading to subsequent release of cargo	
Temperature high	loss of insulation, instrument failure, software failure, actuator failure, maloperation by operator, external fire, exposure to extreme weather, decomposition
Temperature low	loss of heating medium circulation, heating medium contamination, instrument failure, software failure, actuator failure, maloperation by operator, exposure to extreme weather
Pressure high	maloperation by operator (e.g. closed valve), loss of utilities (e.g. instrument air), external fire, loss of power supply, rollover, excess generation of boil-off gas, actuator failure
Pressure low (vacuum)	maloperation by operator, loss of utilities (e.g. instrument air), loss of power supply (electricity), actuator failure
Flow high	instrument failure, software failure, maloperation by operator, actuator failure, exposure to extreme sea conditions
Flow low	instrument failure, software failure, maloperation by operator, actuator failure, exposure to extreme sea conditions
Flow reversed	instrument failure, software failure, maloperation by operator (e.g. closed valve), exposure to extreme sea conditions
No Flow	instrument failure, software failure, maloperation by operator (e.g. closed valve), actuator failure

Level high	instrument failure, software failure, maloperation by operator, actuator failure, exposure to extreme sea conditions
Level low	instrument failure, software failure, maloperation by operator, actuator failure, exposure to extreme sea conditions
Cargo left in pipe/line	maloperation by operator, closed valves, no inert/purge supply, limited inert/purge supply
No cargo in pipe/line	instrument failure, software failure, maloperation by operator, closed valves
Loss of power	loss of electrical signals, blackout, loss of instrument air, loss of hydraulic fluid

The risk is unacceptable and is not 'mitigated as necessary'. Additional or alternative mitigation measures must be identified and implemented before operation, and these must reduce the risk to medium or low.

Risk Matrix Example – environment

Consequence (Severity)	Catastrophic D_E					
	Major C_E					
	Localised B_E					
	Minor A_E					
		$10^{-6}/y$	$10^{-5}/y$	$10^{-4}/y$	$10^{-3}/y$	
	1	$10^{-7}/y$	$10^{-7}/y$	$10^{-4}/y$	$10^{-3}/y$	
	Remote	Ext. Unlikely	V. Unlikely	Unlikely	Likely	
	Likelihood (Chance per year)					

HIGH

MEDIUM

LOW

Consequence Category Examples

- A_E Minor - limited and reversible damage to sensitive areas/species in the immediate vicinity
- B_E Localised - significant but reversible damage to sensitive areas/species in the immediate vicinity
- C_E Major - extensive or persistent damage to sensitive areas/species
- D_E Catastrophic - irreversible or chronic damage to sensitive areas/species

Likelihood Category Examples

1. Remote - 1 in a million or less per year
2. Extremely Unlikely - between 1 in a million and 1 in 100,000 per year
3. Very Unlikely - between 1 in 100,000 and 1 in 10,000 per year
4. Unlikely - between 1 in 10,000 and 1 in 1,000 per year
5. Likely - between 1 in 1,000 and 1 in 100 per year

The likelihood categories can be related to a unit life. For example, assuming a unit lifetime is 25 years, then for a scenario with an annual likelihood of 1 in a million (i.e. rating 1 Remote) the probability of occurrence in the unit's lifetime is 1 in 40,000 (i.e. 25×10^{-6}).

Risk Rating and Risk Criteria Examples

Low Risk – $A_E1, A_E2, A_E3, A_E4, B_E1, B_E2, B_E3$ & C_E1

The risk can be accepted as 'mitigated as necessary'. Where practical and cost-effective it is good practice to implement mitigation measures that would further reduce the risk.

Medium Risk – $A_E5, B_E4, B_E5, C_E2, C_E3, C_E4, D_E1, D_E2$ & D_E3

The risk is tolerable and considered 'mitigated as necessary'. This assumes that all reasonably practicable mitigation measures have been implemented. That is, additional or alternative mitigation measures have been identified and implemented unless judged impractical or the cost of implementation would be disproportionate to the reduction in risk.

High Risk – C_E5, D_E4 & D_E5

The risk is unacceptable and is not 'mitigated as necessary'. Additional or alternative mitigation measures must be identified and implemented before operation, and these must reduce the risk to medium or low.

Risk Matrix Example – unit assets (equipment, spaces and structure)

Consequence (Severity)	Extensive Damage C _A									<div style="background-color: #808080; width: 100%; height: 20px; margin-bottom: 5px;"></div> <div style="background-color: #d3d3d3; width: 100%; height: 20px; margin-bottom: 5px;"></div> <div style="background-color: #ffffff; width: 100%; height: 20px;"></div>	
	Major Damage B _A										MEDIUM
	Localised Damage A _A										LOW
		10 ⁻⁶ /y	10 ⁻⁵ /y	10 ⁻⁴ /y	10 ⁻³ /y						
		1 Remote	2 Ext. Unlikely	3 V. Unlikely	4 Unlikely	5 Likely					
		Likelihood (Chance per year)									

Consequence Category Examples

- A_A Localised damage - an event halting operation for more than x days
- B_A Major damage - an event halting operation for more than y days
- C_A Extensive damage - loss of unit, an event halting operation for more than z days

Likelihood Category Examples

1. Remote - 1 in a million or less per year
2. Extremely Unlikely - between 1 in a million and 1 in 100,000 per year
3. Very Unlikely - between 1 in 100,000 and 1 in 10,000 per year
4. Unlikely - between 1 in 10,000 and 1 in 1,000 per year
5. Likely - between 1 in 1,000 and 1 in 100 per year

The likelihood categories can be related to a unit life. For example, assuming a unit lifetime is 25 years, then for a scenario with an annual likelihood of 1 in a million (i.e. rating 1 Remote) the probability of occurrence in the unit's lifetime is 1 in 40,000 (i.e. 25×10^{-6}).

Risk Rating and Risk Criteria Examples

Low Risk – A_A1, A_A2, A_A3 & B_A1

The risk can be accepted as 'mitigated as necessary'. Where practical and cost-effective it is good practice to implement mitigation measures that would further reduce the risk.

Medium Risk – A_A4, A_A5, B_A2, B_A3, B_A4, C_A1, C_A2 & C_A3

The risk is tolerable and considered 'mitigated as necessary'. This assumes that all reasonably practicable mitigation measures have been implemented. That is, additional or alternative mitigation measures have been identified and implemented unless judged impractical or the cost of implementation would be disproportionate to the reduction in risk.

High Risk – B_A5, C_A4 & C_A5

The risk is unacceptable and is not 'mitigated as necessary'. Additional or alternative mitigation measures must be identified and implemented before operation, and these must reduce the risk to medium or low.

Appendix 3

Likelihood of releases

Indicative Likelihood Values by Likelihood Category

1. Remote - 1 in a million or less per year ($10^{-6}/y$ or less)			
Type C Cargo Tank	<1 x 10^{-6}		
2. Extremely Unlikely - between 1 in a million and 1 in 100,000 per year ($10^{-6}/y$ to $10^{-5}/y$)			
Leak \geq 10 mm \varnothing	50 mm or less \varnothing	51-150 mm \varnothing	151-300 mm \varnothing
Pipework / per metre	7 x 10^{-6}	3 x 10^{-6}	3 x 10^{-6}
Flange	4 x 10^{-6}	5 x 10^{-6}	7 x 10^{-6}
Manual Valve	---	7 x 10^{-6}	9 x 10^{-6}
3. Very Unlikely - between 1 in 100,000 and 1 in 10,000 per year ($10^{-5}/y$ to $10^{-4}/y$)			
	50 mm or less \varnothing	51-150 mm \varnothing	151-300 mm \varnothing
Pipework / per metre	8 x 10^{-5}	4 x 10^{-5}	3 x 10^{-5}
Flange	4 x 10^{-5}	5 x 10^{-5}	8 x 10^{-5}
Manual Valve	3 x 10^{-5}	5 x 10^{-5}	7 x 10^{-5}
4. Unlikely - between 1 in 10,000 and 1 in 1,000 per year ($10^{-4}/y$ to $10^{-3}/y$)			
	50 mm or less \varnothing	51-150 mm \varnothing	151-300 mm \varnothing
Actuated Valve	3 x 10^{-4}	3 x 10^{-4}	3 x 10^{-4}
Instrument Connection	3 x 10^{-4}	includes flange	
Process Vessel	7 x 10^{-4}	pressurised vessel	
5. Likely - between 1 in 1,000 and 1 in 100 per year ($10^{-3}/y$ to $10^{-2}/y$)			
	50-150 mm \varnothing	>151 mm \varnothing	
Heat Exchanger / Evaporator / Heater	2 x 10^{-3}	2 x 10^{-3}	
Pumps (centrifugal or reciprocating)	5 x 10^{-3}	1 x 10^{-3}	