CHINA CLASSIFICATION SOCIETY

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

AMENDMENTS

2020

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Beijing

CONTENTS

PART TWO CLASSIFICATION SURVEY AND ADDITIONAL REQUIREMENTS FOR HULL STRUCTURE

Chapter A2 CLASSIFICATION AND SURVEYS

Section 2 CHARACTERS OF CLASSIFICATION AND CLASS NOTATIONS

A2.2.2.4 Class notations of ships carrying liquefied gases in bulk are as follows:

(1) Type notation: Liquefied Gas Carrier

(2) Other class notations

① In accordance with the degree of protection against cargo leakage and the requirement for the distance between cargo tanks and shell plating, the following class notations will be appended to the type notation "Liquefied Gas Carrier" respectively:

Type 1G
Type 2G
Type 2PG
Type 3G

② For the ships carrying liquefied gases in bulk which were built before 1 July 1986, and complying with IMO resolution A.328(IX) Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (hereinafter referred to as GC code), in accordance with the degree of protection against cargo leakage and the requirement for the distance between cargo tanks and shell plating, the following class notations will be appended to the type notation "Liquefied Gas Carrier" respectively:

Type IG
Type IIG
Type IIPG
Type IIIG

③ Where the scantlings of structural members of cargo tanks are determined according to the maximum vapour pressure, the class notation for the maximum permissible pressure is to be appended, e.g.:

Max. Vapour Pressure XXXMPa

④ For cargo tanks carrying cargo at the certified design temperature, the class notation for the cargo minimum temperature is to be appended:

Min. <u>Cargo</u> Temperature XXX℃

⑤ The scantling of cargo tank structural members are to be determined according to the maximum design cargo density. The class notation for the maximum cargo density is to be appended, e.g.:

Max. Cargo Density XXX t/m^3

Note: For liquefied natural gas carriers, the maximum design cargo density is normally taken as $0.5t/m^3$, therefore the maximum cargo density is not indicated.

⑥ In accordance with the type of cargo containment system, the following class notations are to be appended respectively:

Type A Independent Tank

Type B Independent Tank
Type C Independent Tank
Integral Tank
Membrane Tank
Semi-membrane Tank
~~Internal Insulation Tank~~

⑦ For ships mainly carrying one or more of the products listed in Chapter 19 of PART THREE of the Rules, the words “for+ product name” may be appended after notation “Carrier”. The product name is to be in accordance with column “a” of the table of minimum requirements in chapter 19 of PART THREE of the Rules, e.g.:

Class notation of ships carrying liquefied ethane: Liquefied Gas Carrier for Ethane
Class notation of ships carrying liquefied butane, butane/propane mixture: Liquefied Gas Carrier for Butane, Butane and Propane mixture

Section 3 SURVEYS

A2.3.2 Surveys after construction

A2.3.2.2 Annual surveys

(1) The applicable requirements of 5.4.2, 5.6.2, 5.9.2, 5.10.2 and 5.16.2 in Chapter 5 of PART ONE of CCS Rules for Classification of Sea-Going Steel Ships are to be complied with.

(2) To confirm that any special arrangements to survive condition of damage are in order.

(3) To examine, where applicable, the alternative design and arrangements for the segregation of the cargo area, in accordance with the test and inspection requirements, if any, specified in the approved documentation.

(~~3~~4) ~~To confirm that doors, sidescuttles and windows in wheelhouse superstructure and deckhouse ends facing the cargo area are in a satisfactory condition.~~ To confirm that wheelhouse doors and windows, sidescuttles and windows in superstructure and deckhouse ends in the cargo area are in a satisfactory condition.

(~~4~~5) To examine the ~~cargo pump rooms~~ cargo machinery spaces and cargo compressor rooms, including their escape routes.

(~~5~~6) To confirm that the manually operated ESD (emergency shutdown system) together with the automatic shutdown of the cargo pumps and compressors are satisfactory.

(~~7~~8) To examine the gas detection arrangements for cargo control rooms and the measures taken to exclude ignition sources where such spaces are ~~not gas-safe~~ classified as hazardous areas.

(~~13~~14) To examine the cargo and process piping, including the expansion arrangements, insulation from the hull structure, pressure relief and drainage arrangements, and water curtain protection as appropriate.

(~~16~~17) To examine the arrangements for the cargo pressure/temperature control including, when fitted, the thermal oxidation systems and any refrigeration system and to confirm that any associated safety measures and alarms are satisfactory.

(~~17~~18) To examine the cargo, bunker, ballast and vent piping systems, including PRVs, vacuum relief valves, vent masts and protective screens, as far as practicable.

(~~21~~22) To confirm that electrical equipment in ~~gas-dangerous~~ hazardous areas is in a satisfactory condition and is being properly maintained.

(~~23~~24) To examine the fixed fire-fighting system for the enclosed cargo machinery spaces, and the enclosed cargo motor room within the cargo area ~~the cargo pump room~~ and confirming that its means of operation is clearly marked.

(~~26~~27) To examine the appropriate fire-extinguishing system for the enclosed cargo machinery spaces for ships that are dedicated to the carriage of a restricted number of cargoes and the internal water spray system for the turret compartments ~~the fixed installation for the gas-dangerous spaces~~ and to confirm their ~~its~~ means of operation is clearly marked.

A2.3.2.3 Intermediate surveys

(1) The applicable provisions of 5.4.3, 5.6.3, 5.9.3, 5.10.3 and 5.16.3 in Chapter 5 of PART ONE of CCS Rules for Classification of Sea-Going Steel Ships.

(2) The provisions of A2.3.2.2(2) to (38) of the Rules.

(3) To confirm, where applicable, that pipelines and independent cargo tanks are electrically bonded to the hull.

(4) To generally examine the electrical equipment and cables in ~~dangerous zones such as cargo pump rooms~~ hazardous areas and zones such as cargo machinery spaces and areas adjacent to cargo tanks to check for defective equipment, fixtures and wiring~~.~~; ~~The~~ the insulation resistance of the circuits should be tested and in cases where a proper record of testing is maintained consideration should be given to accepting recent readings.

(5) To confirm blown through testing with dry air to the distribution piping of the dry chemical powder fire-extinguishing systems.

Chapter A3 APPROVAL OF PLANS AND DOCUMENTS OF SHIPS

The entire contents of A3.1 are replaced by the following:

A3.1 Plans and documents required for classification certificate

A3.1.1 For ships carrying liquefied gases in bulk that are intended to be classed with CCS, in addition to the plans and documents as required in Section 1 of Chapter 2 and Chapter 20 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships, the plans and documents as listed in A.3.1.2 and A.3.1.3 of this Chapter and in other chapters and sections (if any) of the Rules are to be submitted for examination in accordance with the requirements of the Rules.

A.3.1.2 The plans and documents as listed in A.3.1.2.1 and A.3.1.2.2 are to be submitted to CCS for approval.

A3.1.2.1 Hull structures:

(1) Liquefied gas carriers with Type A and Type B independent cargo tanks:

① Cargo tank structure drawing;

② Support structure (support block, anti-pitch chocks and anti-roll chocks) (reinforcement) drawing (may also be included in cargo tank structure drawing) ;

③ Emergency towing and single point mooring arrangement (applicable to liquefied gas carriers with deadweight not less than 20,000 t);

(2) Liquefied gas carriers with Type C independent cargo tanks:

① Type C tank structure drawing;

② Emergency towing and single point mooring arrangement (applicable to liquefied gas carriers with deadweight not less than 20,000 t).

(3) Liquefied gas carriers with membrane tanks:

① Basic structure drawing of pump tower;

② Emergency towing and single point mooring arrangement (applicable to liquefied gas carriers with deadweight not less than 20,000 t).

A3.1.2.2 Machinery, electricity and other specialties

(1) Schematic diagram of cargo piping system;

(2) Arrangement of low-temperature piping for cargo and treatment (if applicable);

(3) Remote control system drawing of cargo pipeline valve;

(4) Schematic diagram and arrangement of pressure relief system;

(5) Schematic diagram of vent and drainage for cargo system;

(6) Schematic diagram of vacuum protection system (if applicable);

(7) Schematic diagram of cargo reliquefaction system (if applicable);

(8) Schematic diagram of cargo cooling system (if applicable);

(9) Schematic diagram of cargo heating system (if applicable);

(10) Schematic diagram of cargo vapour combustion system (if applicable);

(11) Arrangement of cargo vapor combustion unit room (if applicable);

(12) Ventilation plan of cargo vapor combustion unit room (if applicable);

(13) Ventilation system plan of cargo vapour combustion unit (if applicable);

(14) Schematic diagram and arrangement of gas fuel system (if applicable);

(15) Ventilation system plan of gas valve sets and double wall pipes (if applicable);

(16) Schematic diagram of inert gas and dry air system;

(17) Arrangement of inert gas generator room (if applicable);

(18) Plan of nitrogen production system (if applicable);

(19) Schematic diagram and arrangement of degassing and scavenging pipings of cargo tanks;

(20) Gas sampling detection system;

(21) Cofferdam heating system (if applicable);

(22) Schematic diagram and arrangement of water-spray system on deck;

(23) Arrangement of dry chemical powder station/room;

(24) Schematic diagram and arrangement of dry chemical powder fire-extinguishing system;

(25) Schematic diagram and arrangement of water curtain system (if applicable);

(26) Schematic diagram and arrangement of fixed fire extinguishing system in cargo machinery enclosed space (if applicable);

(27) Bilge and ballast system in cargo area;

(28) Cargo operations manuals;

(29) Technical documents on pipeline installation process (approved on site);

(30) Technical documents on leakage test and performance test (type test) of valves (if applicable) (approved on site);

(31) Technical documents of type tests of expansion parts in cargo piping system (approved on site);

(32) Technical documents of the materials, welding, post-welding heat treatment and non-destructive testing of cargo piping (approved on site);

(33) Technical documents of pressure tests (structural and tightness tests) for cargo and processing piping (approved on site);

(34) Functional test program for all piping systems, including valves, fittings and equipment associated with loading and unloading of cargo (liquid or vapor) (approved on site);

(35) Cargo gas test procedure (approved on site);

(36) Electrical system diagram of cargo emergency stop device;

(37) Technical documents on tank welding procedure (approved on site);

(38) Stress relief procedure for type C independent cargo tank (approved on site);

(39) Arrangement and technical documents of secondary barriers including methods for periodic inspection of tightness (approved on site);

(40) Technical documents on the main and secondary barriers model tests of membrane type cargo tank (approved on site);

(41) Electrical system diagram of air lock alarm equipment;

(42) Electrical system diagram of inert gas generation plants;

(43) Electrical system diagram and arrangement of monitoring and alarms related to liquid cargo;

(44) Electrical system plan and arrangement of combustible gas detection device;

(45) Division of hazardous areas;

(46) Arrangement of electrical equipment layout in hazardous area;

(47) Document on verification of intrinsically safe circuit;

(48) Arrangement of emergency towing device (if applicable);

(49) Other plans and documents as deemed necessary by CCS.

A3.1.3 The plans and documents listed in A3.1.3.1 and A3.1.3.2 are to be submitted to CCS for information.

A3.1.3.1 Hull structure

(1) Liquefied gas carriers with Type A and type B independent cargo tanks:

① Hold yield strength analysis report;

② Hold buckling strength analysis report;

③ Support structure strength analysis report;

④ Configuration and arrangement of insulations and details of their connection;

⑤ Temperature field calculation report;

⑥ Sloshing load and hull structural strength calculation report;

⑦ Fatigue strength analysis report;

⑧ Fatigue crack propagation evaluation and leakage analysis report of Type B independent tank.

(2) Liquefied gas carriers with Type C independent cargo tanks:

① Hold yield strength analysis report (if applicable);

② Hold buckling strength analysis report (if applicable);

③ Fatigue strength analysis report for Type C tank (if applicable);

④ Structural strength analysis report of Type C tank support and associated supporting members;

⑤ Instructions for Type C tanks;

⑥ Strength calculations of Type C tanks (including finite element analysis, if applicable);

⑦ Sloshing load and hull structural strength calculation report (if applicable);

⑧ Arrangement of fixture of Type C independent cargo tanks;

⑨ Insulation and configuration of Type C independent cargo tanks.

(3) Liquefied gas carriers with membrane tanks:

① Hold yield strength analysis report;

② Hold buckling strength analysis report;

③ Direct calculation report of pump tower structure strength;

④ Basic structure of cargo containment system;

⑤ Arrangement of pump tower;

⑥ Construction of insulation box;

⑦ Insulation box arrangement and connection details;

⑧ Calculation report of thermal analysis and temperature field forecast;

⑨ Thermal stress calculation report;

⑩ Direct strength assessment report for whole ship;

⑪ Fatigue assessment report based on spectral analysis;

⑫ Sloshing load and hull structural strength calculation report;

⑬ Fatigue strength analysis report.

A3.1.3.2 Machinery, electricity and other specialties

(1) Arrangement of cargo machinery space;

(2) Arrangement of cargo loading/unloading station;

(3) List of valves of cargo piping;

(4) List of equipment of cargo system;

(5) List of materials of cargo system;

(6) Cargo system specifications;

(7) Cargo processing flow chart;

(8) Calculations of wall thickness of cargo and cargo processing piping;

(9) Specification of cargo pipeline (including pipes, bends, flanges, supports, etc.);

(10) Technical specification of expansion joints (if applicable);

(11) Technical specification of low-temperature pipeline insulation;

(12) Complete stress analysis report of low-temperature piping for cargo and treatment (if applicable);

(13) Specification of emergency stop valves;

(14) List of pressure relief valves;

(15) Sizing calculations of pressure relief valves;

(16) Technical specification of pressure relief valves;

(17) Technical documents on procedures to be used for changing pressure setting of pressure relief valves in cargo tanks (if applicable);

(18) Arrangement of Cargo tank tubulars;

(19) Level, temperature and pressure measurement and sensor arrangement in cargo tanks;

(20) Locations of sampling points in cargo tanks;

(21) Cargo tank spray system (if applicable);

(22) Vent mast details;

(23) Vent mast cowl;

(24) Installation of cargo vapour burner (if applicable);

(25) Gas balance calculations (if applicable);

(26) Arrangement of room of gas valve sets (if applicable);

(27) Calculations of deck water spray system;

(28) Calculations of dry chemical powder fire-extinguishing system;

(29) Electric distribution system failure mode analysis (FMEA) report;

(30) Other plans and documents as deemed necessary by CCS.

The complete text of A3.2 is replaced by the following:

A3.2 Plans and documents for Certificate of Fitness

A3.2.1 When a Certificate of Fitness is to be issued by CCS, the plans and documents as listed in A3.2.2 and A3.2.3 are to be submitted for approval and information.

A3.2.2 The following plans and documents are to be submitted for approval for the issuance of the Certificate of Fitness (Note: The IGC Code referred to below in this paragraph is equivalent to PART THREE of the Rules):

(1) Plans for the ship arrangements (Chapter 3 of IGC Code).

(2) Plans for the process pressure vessels and liquid, vapour and pressure piping systems (Chapter 5 of IGC Code).

(3) Plans for the Cargo pressure/temperature control (Chapter 7 of IGC Code).

(4) Plans for the cargo tank vent systems (Chapter 8 of IGC Code).

(5) Plans for the electrical installations (Chapter 10 of IGC Code).

(6) Plans for the fire protection and fire extinction (Chapter 11 of IGC Code);

(7) Plans for the instrumentation (gauging, gas detection) (Chapter 13 of IGC Code).

(8) Plans of piping for use of cargo as fuel, where applicable (Chapter 16 of IGC Code).

(9) Cargo operations manuals (Chapter 18 of IGC Code).

A3.2.3 The following plans and documents are to be submitted for information for the issuance of the Certificate of Fitness (Note: the IGC Code referred to below in this paragraph is equivalent to PART THREE of the Rules)

(1) List of products intended to be carried by the ship and noting the corresponding minimum special requirements (Chapter 19 of IGC Code).

(2) Plans for the ship type, cargo containment, control of vapor space within cargo tanks, vapour detection, gauging, personnel protection, filling limits for cargo tanks and other special requirements (Chapters 2, 4, 6, 13, 14, 15 and 17 of IGC Code).

(3) Plans for freeboard and intact stability, discharges below the bulkhead deck and survival capability (Chapter 2 of IGC Code).

(4) Plans for the environmental control (Chapter 9 of IGC Code).

Chapter A4 HULL AND CARGO TANK STRUCTURE

A4.1 General requirements

A4.1.4 Steel grade selection for hull structures is to comply with relevant requirements of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships, requirements of 4.19 of Chapter 4 and Chapter 6 of PART THREE of the Rules and relevant requirements of CCS Rules for Materials and Welding. Low temperature steel grade is to be selected on the basis of the ambient temperatures of the area in operation. Temperature distribution is generally obtained through heat transferring analysis and the ambient temperature is given in Table A4.1.4 (For specific application, see relevant requirements of 5.3.8 5.3.7 of Section 5 of Appendix 1 or 6.3 of Section 6 of Appendix 2 to this Chapter). The steel grades of members in the same temperature field are to be the same, such as strakes, stiffeners and brackets, etc.

A4.1.5 Except specified otherwise, the following symbols apply to appendixes to this PART:

L — ship length, in m; see Section 1 of Chapter 1 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships;

B — ship breadth, in m; see Section 1 of Chapter 1 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships;

D — molded depth, in m; see Section 1 of Chapter 1 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships;

R_{eH} — yield stress of material, in N/mm^2;

K — material factor; for carbon-manganese steels and aluminum alloys, see 1.3.1.7 and 1.3.5 of Section 3 of Chapter 1 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships; for nickel steels, carbon-manganese steels, austenitic steels and aluminum alloys of independent tank structure: $K = \frac{235}{min(R_m/2.66, R_e/1.33)}$; for nickel steels, $K = \frac{235}{R_e}$; for austenitic steels, $K = \frac{235}{\min(R_{p0.2}, 0.7R_m)}$;

$R_{p0.2}$ — specified non-proportional tensile strength of austenitic steels, in N/mm^2, as provided in Section 8 of Chapter 3 of PART ONE of CCS Rules for Materials and Welding;

R_m, R_e — see 4.18.1.3 of Chapter 4 of PART THREE of the Rules;

ρ — density of liquid cargo or seawater, in t/m^3, where density of seawater is taken as 1.025 t/m^3;

T — cargo design temperature, in ℃, taken as the minimum temperature of cargoes designed to be carried in cargo tanks.

A 4.4.1 Ships carrying liquefied gases in bulk which are of 150 m in length or over and of various cargo tank types are to be subject to fatigue strength assessment according to the requirements of the Rules and relevant guidelines. The requirements for fatigue strength of hull structures and cargo tank structures of various tank types are as follows:

(1) for hull structures, cargo tanks and their support structures of independent tank liquefied gas carriers, see Appendix 3 to this PART;

~~(2) for hull structures and the pump tower structures of membrane tank liquefied gas carriers, see CCS Guidelines for Fatigue Strength of Ship Structure.~~

Ships of 150 m in length or above carrying liquefied gases in bulk of each cargo tank type are to be subject to fatigue strength assessment according to the requirements of the Rules and relevant guidelines, of which, for hull structures and the pump tower structures of membrane tank liquefied gas carriers, see Chapter 20 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships and CCS Guidelines for Fatigue Strength of Ship Structure; for hull, independent tanks and their supporting structures of independent tank liquefied gas carriers, see Appendix 3 of this PART.

Appendix 1 ADDITIONAL REQUIREMENTS FOR CARRIERS WITH INDEPENDENT TYPE A AND TYPE B PRISMATIC TANKS

Section 1 GENERAL PROVISIONS

1.1 General requirements

Figure 1.1.1(1) is revised as follows:

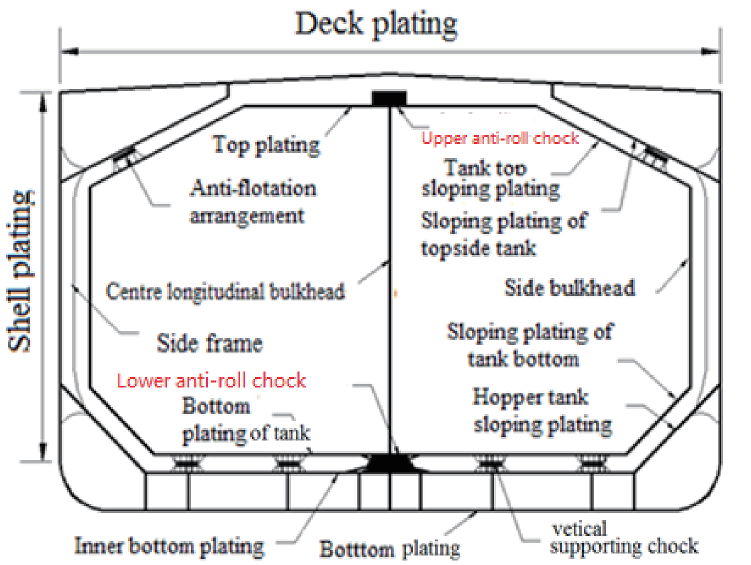


Figure 1.1.1(1) Transverse Section of Typical Independent Type A Tank

Figure 1.1.1(2) is revised as follows:

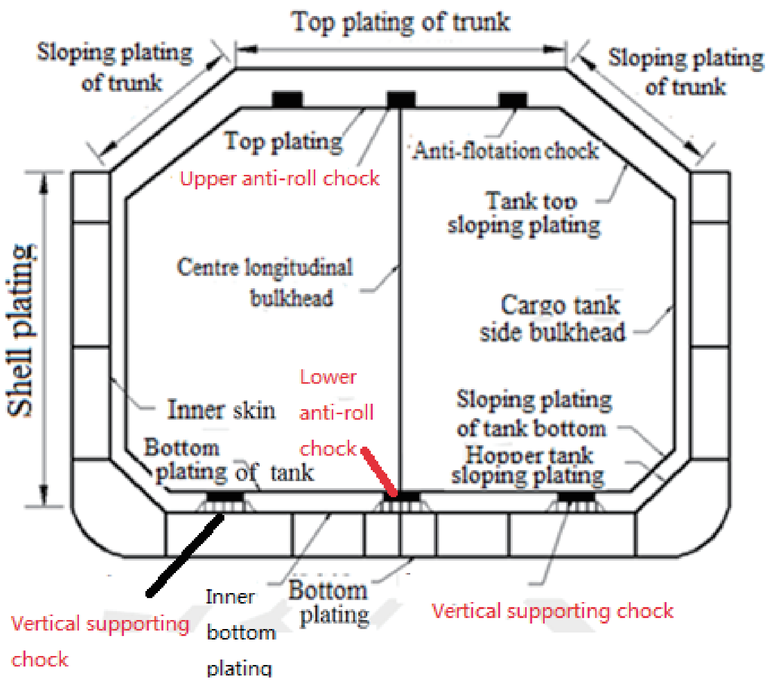


Figure 1.1.1(2) Transverse Section of Typical Independent Type B Tank

A new paragraph 1.2 is added as follows:

1.2 Structural design details

1.2.1 Where a knuckle is arranged on the structure such as shell plate, longitudinal bulkhead etc., webs, brackets or rolled sections are to be provided at the knuckle to transmit the transverse load/shear.

For longitudinal small knuckles (e.g. about 10°), closely spaced carlings may be fitted across the knuckle, between longitudinal members above and below the knuckle. Strengthening is not necessary in way of shallow knuckles that are not subject to high lateral loads or high in-plane loads across the knuckle, such as deck camber knuckles. In general, the distance between knuckle and stiffener supporting knuckle is not more than 50 mm.

1.2.2 The symmetrical section is recommended to be adopted as far as applicable for side longitudinals and inner hull longitudinals between 2 m below the ballast waterline and 2 m above the full-loaded waterline. The symmetrical section is also recommended for longitudinals within the above-mentioned extent of longitudinal bulkheads to avoid additional torsional stress. Where higher tensile steel is adopted for side longitudinals and vertical stiffeners or brackets on primary transverse structural webs are connected directly to side longitudinals, the toes of stiffeners or brackets within the above-mentioned extent are generally to be well radiused.

1.2.3 Where side longitudinals of higher tensile steel pass through watertight bulkheads in the cargo tank region, radiused brackets of the same material are to be fitted on both the fore and aft sides of the connection between the upper edge of bilge and 0.8D above the draft line, and attention is to be given to ensure the alignment of the brackets.

Section 2 SCANTLINGS OF HULL STRUCTURES IN WAY OF CARGO TANK AREAS OF LIQUEFIED GAS CARRIERS WITH INDEPENDENT PRISMATIC TANKS

2.4 Transverse bulkheads

2.4.1 The scantlings of bulkhead plates and stiffeners are to comply with the requirements for watertight bulkheads in Chapter 2 of PART TWO of CCS Rules for Classification of Sea- Going Steel Ships and the design head h is to be determined in accordance with the following requirements:

(1) For watertight transverse bulkhead platings, the design head h is to be determined in accordance with the following requirements (whichever is the greatest):

① vertical distance measured from the lower edge of the plate in a strake to the deepest equilibrium waterline obtained from the applicable damage stability calculations;

② vertical distance measured from the lower edge of the plate in a strake to the assumed freeboard deck;

③ 2.5 m.

(2) For stiffeners, the design head h is to be determined in accordance with the following requirements (whichever is the greatest):

① vertical distance measured from the mid-span of stiffeners to the deepest equilibrium waterline obtained from the applicable damage stability calculations;

② vertical distance measured from the mid-span of stiffeners to the assumed freeboard deck;

③ 2 m.

~~Where bulkhead plates and stiffeners are within ballast tank, the scantlings are to comply with the requirements for deep tanks in Chapter 2 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships.~~ Where the transverse bulkhead forms boundary of ballast tank, the scantlings are to comply with the requirements for deep tank bulkhead in Section 13, Chapter 2, PART TWO of CCS Rules for Classification of Sea-Going Steel Ships. The minimum web thickness of bulkhead stiffener is to meet following requirements:

For rolled or combined stiffeners with flange or face plate: $t \geq \frac{d_w}{\left(75\sqrt{K}\right)} + t_c$ mm

For flat bar stiffeners: $t \geq \frac{d_w}{\left(22\sqrt{K}\right)} + t_c$ mm

where: d_w — depth of stiffener webs, in mm;

K — material factor;

t_c — refer to paragraph 1.6.5, Chapter 1, PART TWO of CCS Rules for Classification of Sea-Going Steel Ships.

A new paragraph 2.4.2 is added as follows:

2.4.2 Except as otherwise provided in this paragraph, the end connection of transverse bulkhead stiffeners is to comply with the requirements of paragraph 1.2.6, Chapter 1, PART TWO of CCS Rules for Classification of Sea-Going Steel Ships. The requirements for bracket thickness and face plate width are as follows:

(1) Bracket thickness: $t \geq \left(2 + f_{bkt}\sqrt{W}\right)\sqrt{\frac{R_{eH\_s}}{R_{eH\_b}}} + 1.5$ mm, and need not be greater than 13.5mm

where: $f_{bkt} = 0.2$, for bracket with face plate or flange;

$f_{bkt} = 0.3$, for bracket without face plate or flange;

W — section modulus of transverse bulkhead stiffener required by the Rules, in cm^3;

R_{eH_s} — yield stress of material of transverse bulkhead stiffener, in N/mm^2;

R_{eH_b} — yield stress of material of bracket, in N/mm^2.

(2) When the section modulus W of transverse bulkhead stiffener required by the Rules is not less than $500cm^3$ or the length of free edge of bracket is more than 50 times of bracket thickness, the bracket is to be with flange or face plate. The flange or face plate width is not to be less than that obtained from the following formula:

$$b = 45\left(1 + \frac{W}{2000}\right) \text{ mm, and not less than 50mm}$$

where: W— section modulus of transverse bulkhead stiffener required by the Rules, in cm^3.

~~2.4.2~~2.4.3 The scantlings of vertical girders supporting horizontal stringers of transverse bulkheads are to be determined by direct calculation based on the assumptions that their both ends are rigidly fixed and that they are subject to concentrated loads transferred by horizontal stringers, the considered design head being taken the vertical distance from the mid-span of horizontal stringers to the deepest equilibrium waterline of adjacent tanks or the assumed freeboard deck, whichever is the greater, in m, and is not to be less than 2.5 m, with the permissible bending stress being taken as 0.67 R_{eH} N/mm^2 and the allowable shear stress taken as 0.39 R_{eH} N/mm^2.

2.5 Topside tanks and side structures

2.5.1 Topside tanks and side structures are generally to comply with 8.3.3 to 8.3.6 and 8.6.2 to ~~8.6.5~~8.6.7 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships. When applying 8.6.2 to 8.6.7, the heeling angle θ is to be obtained from the following formula:

$$\theta = (27.8 - 0.0415L) + 2.361(L/B - 4.2) \quad (°)$$

2.5.2 The main frames within the cargo area are generally to be integral with their upper and lower brackets. The connecting bracket as shown in Figure 2.5.2 is to be provided in top side tank and bottom side tank to ensure continuity of upper and lower structure of main frame. The scantlings of the connecting bracket are to comply with detailed requirements for directly calculating main frame bracket toe end.

A new Figure 2.5.2 is added as follows:

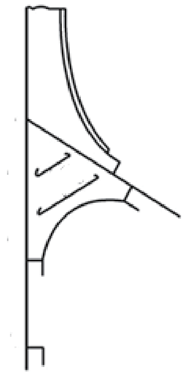


Figure 2.5.2 Diagram of Connecting Bracket

2.5.6 The section modulus *W* of shell longitudinals (excluding longitudinals of topside tanks, refers to 2.5.1) is generally to comply with the requirements of Section 7, Chapter 2 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships. Where shell longitudinals are within deep tanks, the section module *W* is also not to be less than that obtained from the following formula:

$$W = 8s\rho h_1 l^2 K \quad cm^3$$

where: s — spacing of longitudinals, in m;

l — span of longitudinals, in m;

ρ — density of liquefied cargo, in t/m^3, to be taken not less than 1.025;

h_1 — obtained from the following formula:

$$h_1 = Z/d + h_0 - 0.35d \quad \text{for } Z < 0.35d$$

$$h_1 = h_0 \quad \text{for } Z \geq 0.35d$$

where: h_0 — vertical distance, in m, measured from the lower edge of bulkhead plating (calculation of plating) or mid- span of stiffeners (calculation of stiffeners) to the ~~tank top in way of center longitudinal bulkhead~~ tank top, or half the distance to the top of overflow, whichever is the greater, in m;

Z — vertical distance from the baseline to the calculation point, in m;

d — draught, in m.

2.6 Inner hull structures

2.6.1 The thickness t of inner skin plating (if any) forming periphery of tanks is not to be less than that obtained from the following formula:

$$t = 3.95s\sqrt{K\rho h_0} + 2.5 \quad mm$$

where: s — spacing of inner hull longitudinals, in m;

ρ — density of liquefied cargo or seawater, in t/m^3, taken as not less than 1.025 ~~t/m^3~~;

h_0 — vertical distance, in m, measured from the lower edge of bulkhead plating (calculation of plating) or mid- span of stiffeners (calculation of stiffeners) to the top of deep tank or half the distance to the top of overflow, whichever is the greater, in m;

2.6.2 The section modulus W of inner hull longitudinals (if any) forming periphery of tanks is not to be less than that obtained from the following formula:

$$W = 8K\rho s h_0 l^2 \quad \text{cm}^3$$

where: s — spacing of inner hull longitudinals, in m;

l — span of inner hull longitudinals, in m;

ρ — density of liquefied cargo or seawater, in t/m^3, taken as not less than 1.025 t/m^3;

h_0 —vertical distance, in m, measured from the lower edge of bulkhead plating (calculation of plating) or mid- span of stiffeners (calculation of stiffeners) to the top of deep tank or half the distance to the top of overflow, whichever is the greater, in m;

2.7 Double bottoms

2.7.1 The extension and height of double bottoms are not to be less than that required by chapter 2 of PART THREE of the Rules. Structural scantlings and arrangements are to comply with the relevant requirements for double bottoms in Section 6, Chapter 2 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships. However, requirements of 1.12.8 of Chapter 1 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships may not be required. For requirements for web stiffener of main structural members, refer to paragraph 5.12.2.5, Chapter 5, PART TWO of CCS Rules for Classification of Sea-Going Steel Ships.

2.7.2 The section modulus W of bottom longitudinals is not to be less than that obtained from the following formula:

$$W = 8sph_1l^2K \quad \text{cm}^3$$

Symbols in the formula are the same as those in 2.5.6.

2.7.2 The section modulus W of bottom longitudinals is not to be less than that obtained from the following formula:

$$W_1 = \frac{8.5}{1.73 - F_b}(d+h)sl^2K \quad \text{cm}^3$$

$$W_2 = 8s\rho h_1 l^2 K \quad \text{cm}^3$$

where: s — spacing of longitudinals, in m;

l — span of longitudinal, in m;

ρ — density of liquid, in t/m^3, to be taken not less than 1.025 t/m^3;

h — 0.26C, to be taken not more than 0.2d;

d — draught, in m;

C — coefficient, refer to paragraph 2.2.3.1, Section 2, Chapter 2, PART TWO of CCS Rules for Classification of Sea-Going Steel Ships;

F_b — reduction factor, refer to paragraph 2.2.5.6, Section 2, Chapter 2, PART TWO of CCS Rules for Classification of Sea-Going Steel Ships;

h_1 — to be calculated according to the following formula:

$$h_1 = Z/d + h_0 - 0.35d \quad \text{if } Z < 0.35d$$

$$h_1 = h_0 \quad \text{if } Z \geq 0.35d$$

where: h_0 — vertical distance, in m, measured from the mid-span of the stiffener to the top of the tank, or half the distance to the top of overflow, whichever is the greater;
For bottom longitudinals in way of pipe tunnel, only above requirements of section modulus W_1 are to be complied with.

2.7.3 Where double bottoms are also used as ballast tanks, the requirements for the inner bottom plating (including hopper tank sloping plate) and inner bottom longitudinals (including hopper tank sloping plate longitudinals) is not to be lower than that required for deep tanks in Section 13, Chapter 2 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships. As the watertight floor forms the ballast tank periphery, thickness t is not to be less than that obtained from the following formula:

$$t = 3.95sf\sqrt{\rho hK} + 2.5 \quad \text{mm}$$

where: s — spacing of stiffeners, in m;

$f = 1.2 - s/(2.1b)$, and not more than 1, where b is length of longer side of plate panel, in m;

h —vertical distance, in m, measured from the lower edge of the bulkhead strake to the top of deep tank, or half the distance to the top of overflow, whichever is the greater;

ρ — density of liquid, in t/m^3, to be taken not less than 1.025 t/m^3;

K — material factor.

Plate thickness is not to be less than 8mm if $L \geq 90m$; 7mm if $60m \leq L < 90m$; 6mm if $L < 60m$.

Section 3 SCANTLINGS OF INDEPENDENT PRISMATIC TANKS

3.1 General requirements

3.1.2 Structural scantling of cargo tank structure is to comply with the requirements of 4.21 and 4.22 of Chapter 4 of PART THREE of the Rules, including design basis, structural analysis, ultimate design condition, accident design condition and testing requirements.

3.1.3 For partly loaded cargo tanks, strength evaluation is to be carried out on tank structure under sloshing loads according to CCS Guidelines for Assessment of Sloshing Loads and Structural Scantling of Tanks.

3.2 ~~Boundary~~ Structure of cargo tanks

3.2.1 Plate thickness of cargo tank periphery and its internal structure is to comply with following requirements:

(1) Requirements for minimum plate thickness: thickness of all plates forming cargo tank periphery and its internal structure is not to be less than 7.5mm.

(2) The thickness t of plating forming periphery of cargo tanks is not to be less than that obtained from the following formula:

$$t = 39.5s\sqrt{KP_{eq}} + 2.5 \quad \text{mm}$$

where: s — spacing of ~~frames or~~ stiffener, in m;

P_{eq} — internal pressure of liquid obtained in accordance with 4.28.1.1 and 4.28.1.2 of Chapter 4 of PART THREE of the Rules, in MPa, the considered point is to be measured from the lower edge of strake;

~~Where the cargo is non-corrosive, the plating thickness t obtained from the above formula may be reduced by 3 mm. However, when the thickness of plate obtained in accordance with the requirements for deep tank in section 13 of Chapter 2 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships is less than 12.5 mm, it may be reduced by an amount not greater than 20%.~~

Where the cargo is non-corrosive, the plating thickness t obtained from the above formula may be reduced by 3 mm if it is not less than 12.5 mm. The plating thickness t obtained from the above formula is to be reduced by not more than 0.2 t if it is less than 12.5mm.

~~Thickness of plate is in no case to be taken less than 7.5 mm.~~

3.2.3 Section module W of stiffeners of cargo tank periphery is not to be less than that obtained from the following formula:

$$W = 800 s P_{eq} l^2 \xi \qquad \text{cm}^3$$

where: s — spacing of ~~frames or~~ stiffener, in m;

P_{eq} — internal pressure of liquid obtained in accordance with 4.28.1.1 and 4.28.1.2 of Chapter 4 of PART THREE of the Rules, in MPa, the considered point is to be measured from the mid-span of stiffeners;

l — span of ~~frames or~~ stiffeners, in m;

ξ — coefficient, to be taken in accordance with table 3.2.3.

Coefficient ξ **Table 3.2.3**

	~~Nickel steels, carbon manganese steels, Austenitic steels and aluminium alloys~~
Independent type A and B prismatic tanks	$\frac{235\eta}{min(R_m/2.66, R_e/1.33)}$, for nickel steels, carbon manganese steels, Austenitic stainless steels and aluminum alloys
~~Independent type B prismatic tanks~~	~~$\frac{235\eta}{min(R_m/2, R_e/1.2)}$, for nickel steels and carbon manganese steels;~~ ~~$\frac{235\eta}{min(R_m/2.5, R_e/1.2)}$, for Austenitic steels;~~ ~~$\frac{235\eta}{min(R_m/2.5, R_e/1.2)}$, for aluminium alloys;~~
Note: R_m, R_e — see 4.18.1.3 of Chapter 4, PART THREE of the Rules; η — taken as 0.435	

3.2.4 The above section modulus requirements for cargo tank inner structures in way of anti-pitch chocks and anti-roll chocks and vertical supporting blocks and stiffeners of bulkhead/frame in way of anti-roll chocks are to be increased by 25% on the basis of the calculated value of 3.2.3.

3.2.5 Section module W of members of cargo tank transverse web frame (Figure 3.2.5(1) and (2)) ~~is generally not to be less than that obtained in accordance with table 3.2.5, but the final scantling is to be determined based on the result of strength checks through direct calculation~~ and scantlings of cargo tank transverse web frame are to be determined based on direct calculation analysis. During initial design, section module W of members (Figures 3.2.5(1) and (2)) can be obtained from Table 3.2.5. Internal pressure of liquid and structural testing condition as defined in 4.28.1.1 and 4.28.1.2 of Chapter 4, PART THREE of the Rules are to be taken into account during structural analysis and the arrangement of structures is generally to comply with the requirements of Figure 3.2.5 (1).

Requirements for Section Modules of Cargo Tank Transverse Web Frame   Table 3.2.5

Structural member	Section module W, cm^3	Relevant coefficient
Top transverse	~~$W = 1170\eta_1\eta_2 P_{eq} S l^2 K$~~ $W = 1170\eta_1\eta_2\eta_3 P_{eq} S l^2 K$	$\eta_1 = 0.34$, $\eta_2 = 1.81$, $l = l_t$
Slope transverse		$\eta_1 = 0.25$, $\eta_2 = 1.78$, $l = l_t$
Side vertical web		$\eta_1 = 0.34$, $\eta_2 = 1.41$, $l = l_s$
Bottom transverse		$\eta_1 = 0.48$, $\eta_2 = 1.00$, $l = l_b$
Center vertical webs and horizontal stringers		$\eta_1 = 0.34$, $\eta_2 = 1.00$, $l = l_c$
Vertical webs and horizontal webs in way of fore and aft ends of bulkhead		$\eta_1 = 0.34$, $\eta_2 = 2.13$, $l = l_c$
where: η_1 — reduction factor, difference between the actual situation of structure arrangement (such as nonlinear or multiple supports beam) and single span model is to be mainly considered, to be taken appropriately for different members; η_2 — impact effect coefficient of liquid cargo loads under sloshing condition or collision condition (fore and aft ends of bulkhead), differing from positions and to be taken appropriately for different members in calculation; η_3 — for aluminum alloy and austenitic stainless steel, $\eta_3 = 0.66$; for nickel steel and carbon manganese steel, $\eta_3 = 1$; l — span of primary supporting members or transverse web frames, in m, to be taken as l_t, l_s, l_b and l_c for different members in calculation; S — spacing of primary supporting members or transverse web frames, of the width of the supporting area of girders, in m; P_{eq}, — see 3.2.3		

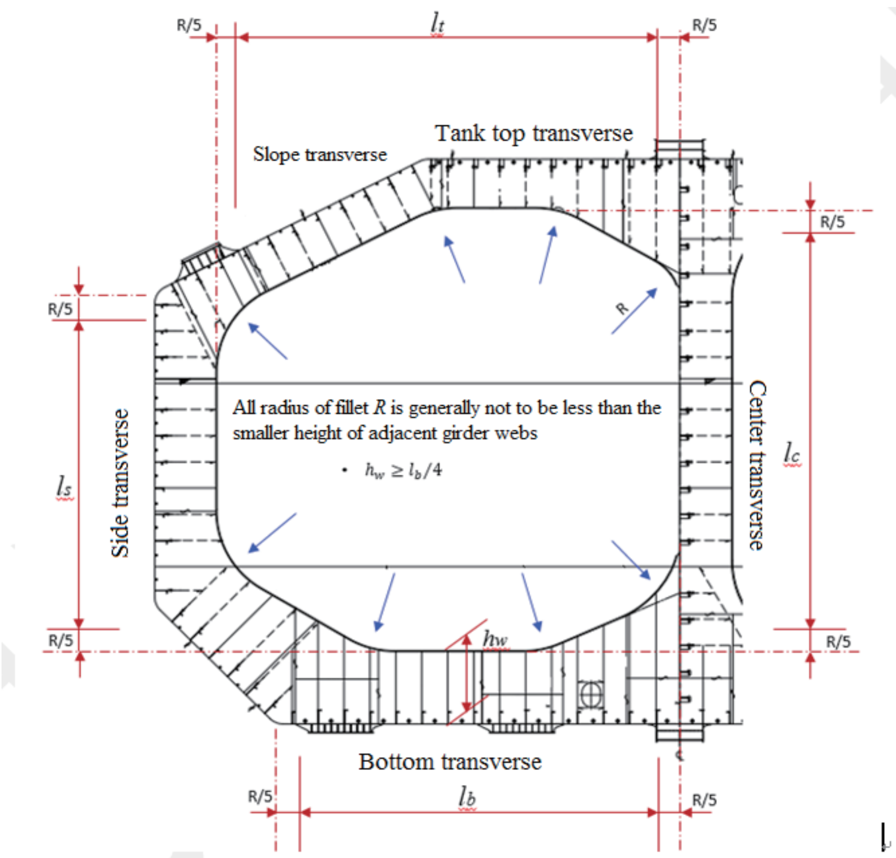


Figure 3.2.5(1) Cargo Tank Transverses

Figure 3.2.5(2) is revised as follows:

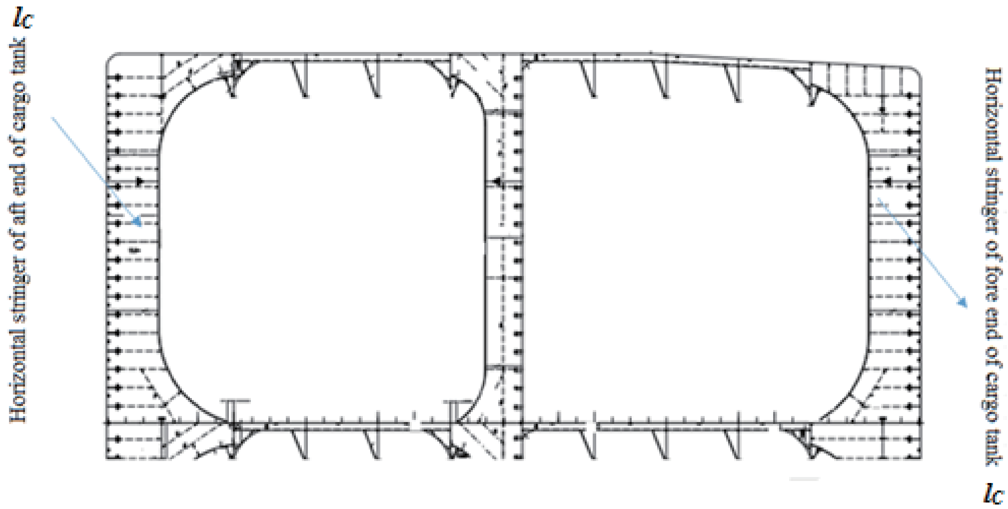


Figure 3.2.5(2) Horizontal Stringers of Cargo Tank

3.2.8 Where the watertight bulkhead may be subjected to internal hydrostatic pressure P_{eq} on only one side, the bulkhead plating and stiffening and primary supporting members are to comply with requirements of 3.2.1 to 3.2.6. If not affected by the above mentioned loads, ~~scantlings of members may be determined in accordance with the following provisions:~~ thickness of plating is not to be less than the considered height and spacing of frames as required by the periphery of the corresponding tank, and another 0.5 mm is then to be reduced. Section modules of stiffeners and transverse web frames are to comply with requirements of ~~3.2.1 and 3.2.2~~3.2.3 to 3.2.6 respectively, but the value of P_{eg} need not to exceed that obtained from the following formula:

$$\max\left\{(0.1P_1+\frac{\rho h}{10^5}),(\frac{t-1.0}{126.5s\sqrt{K}})^2\right\} \quad \text{MPa}$$

$$\max\left\{(P_1+\frac{\rho h}{10^5}),0.1(\frac{t-1.0}{126.5s\sqrt{K}})^2\right\} \quad \text{MPa}$$

where: P_1 — setting value of vacuum relief valves. in MPa;
ρ — density of liquid, in t/m^3;
h — considered height of tank, in m;
t — obtained in accordance with 3.2.1, in mm;
s — spacing of stiffeners, primary supporting members or transverse web frames, in m.

3.2.9 For tank dome structure, where the minimum thickness of 7.5 mm is taken for tank periphery by dome skin plate, the stiffeners and transverse web frames are to comply with requirements of ~~3.2.2~~3.2.3 to 3.2.8, however, the value of P_{eg} is not to be less than the value of the pressure according to the obtained ~~with~~ minimum thickness, i.e.:

$$P_{eq\_min}=\left(\frac{6.5}{126.5s\sqrt{K}}\right)^2 \quad \text{MPa}$$

for symbols in the formula, see 3.2.8.

The strength of plating and stiffeners of cargo tank dome structure is also to be adapted to able to withstand the greater hydraulic pressure obtained according to the following provisions:

pressure of port pressure relief valves, or; air pressure when cargo tank is to be subject to hydrostatic pressure pneumatic compartment test tank testing is to be carried out through compressed water/air method.

3.2.10 In order to check the accidental collision condition, the following load conditions are to be considered without deformation likely to endanger the tank structure:

(1) Periphery in way of support of cargo tank and the support are to be capable of sustaining the forward collision force equal to a half of the weight of cargo tank and cargo, and one fourth for the backward;

(2) Periphery at fore and aft ends of cargo tank and transverse wash bulkhead are is to be capable of sustaining forward collision force equal to a half of the weight of cargo, and one fourth for the backward. When considering the loads on the fore and aft ends, effects of transverse wash bulkhead in constraining translation of cargo are not considered. Distribution of the loads on transverse wash bulkheads may be determined by interpolation based on longitudinal position with an inertial force corresponding to 0.5 g in the forward direction and 0.25 g in the aft direction.

The strength check for (1) may be carried out through direct calculation; for (2), the scantlings of plating and stiffeners are generally to comply with the following requirements:

For bulkhead plating: $t = 0.0158\alpha_p b\sqrt{\frac{|P_{collision}|}{C_a R_{eH}}} + 2.5$ mm

For vertical/horizontal stiffeners: $W = \frac{1000 f |P_{collision}| s l^2}{f_{end} C_s R_{eH}}$ cm^3

where: α_p — obtained by the following formula:

$\alpha_p = 1.2 - \frac{b}{2.1a}$, where a is the length of panel, in mm; b is the breadth of panel, in mm;

C_a — taken as 1.0;

$P_{collision}$ — during the simulation the collision of ships, the pressure acting on the transverse bulkhead ahead corresponding to one half the weight of cargo, in KN/m^2, to be obtained by the following formula:

$P_{collision} = 0.5\rho g l$

$P_{collision} = 0.5\rho g l_{tank}$ (forward bulkhead)

$P_{collision} = 0.25\rho g l_{tank}$ (after bulkhead)

where: l_{tank} — the calculated distance from transverse bulkhead to adjacent (fore/aft) transverse bulkhead, in m;

ρ — density of liquid, in t/m^3;

s — spacing of stiffeners, in m;

l — span of stiffeners, in m;

f_{end} — bending end factor, obtained according to the following provisions:

(1) for continuous stiffeners with fixed ends, not to be less than:

12, for the upper end of horizontal and vertical stiffeners;
10, for lower end of vertical stiffeners;

(2) for vertical stiffeners with one or two end supported by hinges, taken as 7.5;

(3) for other end conditions, may be determined through direct calculation;

C_s — taken as 0.9;
f — factor, taken as 1.1, reflecting relationship between construction scantling and net scantling.

3.2.12 The arrangement for intersection of continuous secondary members and primary supporting members is to comply with the relevant requirements of 1.2.6 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships. ~~Where dome structure is used, the section module W of the primary supporting member made of steel and aluminum alloy such as girders and web frames and attached plating is not to be less than that obtained by the following formula:~~

$$W = 1170 b P_{eq} l^2 K \quad \text{cm}^3$$

~~where: b — breadth of the supporting area of girders, in m;~~
~~P_{eq} — internal pressure of liquid obtained in accordance with 4.28.1.1 and 4.28.1.2 of Chapter 4, PART THREE of the Rules, in MPa, measured from the mid-span of girder;~~
~~other symbols — see 3.2.3.~~

~~Where the cargo is non-corrosive, the thickness obtained from above may be reduced by the corrosion allowance (CA) as specified in 3.2.1.~~

Section 5 CALCULATION OF TEMPERATURE FIELD ~~AND THERMAL STRESS~~ AND SELECTION OF STEEL GRADE

5.1 General requirements

5.1.1 The requirements of this Section apply to the prediction and analysis of temperature field ~~and the calculation of thermal stress~~ for ships carrying liquefied gases with independent type A and type B prismatic tanks under the low temperature of cargo and the selection of steel grades under low temperature. Where other calculation methods are used, they are to be agreed by CCS.

5.1.2 Calculation of temperature field is carried out for ~~3~~ the following purposes:

(1) selection of steel grades for hull plating;

~~(2) calculation of thermal stress of hull;~~

~~(3)~~(2) calculation of low-cycle fatigue strength (applicable to type B tank only).

5.1.3 Where the temperature of the carried cargo falls below -10℃, the temperature field of hull is generally to be analyzed. ~~Where the temperature of the carried cargo falls below -55℃, the thermal stress of hull is generally to be analyzed.~~

5.1.5 For analysis and calculation required by this Section, the following plans and calculation documents are to be submitted for information:

(1) configuration and arrangement of insulations and details of their connection;

(2) thermal coefficient;

(3) reports in relation to~~ thermal analysis and prediction and~~ calculation of temperature field;

(4) hull structural plans related to the calculation and FE structural analysis above;

~~For type B tank, the above plans and documents are to be submitted during AIP and type approval.~~

5.2.3 The insulations, supporting blocks and stopp~~er~~ing blocks of cargo tanks are ~~to be~~ generally modeled by ~~solid elements, generally~~ hexahedral elements. Solid elements of supporting blocks and stopp~~er~~ing blocks are only used for temperature field calculation~~ but not for stress calculation~~.

~~5.3.6 Where temperature field of hull is used for calculation of thermal stress of hull, the situation that the primary barrier is intact and cargoes only exist within the primary barrier is to be taken into account and the tank is to be fully loaded.~~

~~5.3.7~~5.3.6 Where temperature field of hull is used for calculation of low-cycle fatigue of tanks of independent type B LNG carrier, the situation that the primary barrier is intact and cargoes only exist within the cargo tank is to be taken into account and the loading conditions are as specified in 5.4.2 (1).

~~5.3.8~~5.3.7 Where temperature field of hull is used for selection of steel grades ~~and calculation of thermal stress~~, the external ambient conditions are to be selected based on the following principles:

(1) for ships engaged in world-wide services, IGC ambient condition is generally to be used;

(2) for ships navigating in US waters (except for Alaska), USCG (except for Alaska) condition is to be used; USCG (Alaska) condition is to be used when navigating in Alaska area;

(3) for ships navigating in other cold regions and/or complying with the requirements for PC class (Polar class), other calculation conditions given in accordance with relevant provisions of port State Administration or flag State/Polar rules and requirements for ice class and design temperature (if any) are to be used;

(4) for parameters of external ambient conditions, refer to Table ~~5.3.8~~5.3.7.

Ambient conditions **Table ~~5.3.8~~5.3.7**

	IGC	USCG (except for Alaska)	USCG (Alaska)	Maximum design ~~ambient~~ temperature environment (see 7.2 of Chapter 7 of PART THREE of the Rules)
Air temperature(℃)	5	-18	-29	45
Sea temperature(℃)	0	0	-2	32
Wind speed(kn)	0	5	5	0

~~5.3.9~~5.3.8 Where temperature field of hull is used for calculation of low-cycle fatigue of type B prismatic tanks, the highest temperature in normal services is to be taken as the ambient condition and the maximum design ~~ambient~~ temperature environment in Table ~~5.3.8~~5.3.7 is to be selected as ambient condition. Where the ambient temperatures in extreme hot or cold regions where the ship is in service are beyond the scope in Table ~~5.3.8~~5.3.7, the design ~~ambient~~ temperature is to be adjusted as appropriate.

~~5.3.10~~5.3.9 For calculation of temperature field, external waterline is to be taken as the minimum draught in loading condition to determine the applying areas for convective boundary conditions of sea water and external air.

~~5.3.11~~5.3.10 Requirements for ambient conditions for calculation of hull temperature field with various application purposes and scopes are indicated in Table ~~5.3.11~~5.3.10.

Table 5.3.11 is revises as:

Requirements for ambient conditions for calculation of hull temperature field   Table ~~5.3.11~~5.3.10

Application purpose	Scope	Whether the primary barrier leaks	Loading condition of tank	External environment	Position of waterline
Selection of steel grades	Type A, B	Yes	Fully loaded	IGC, USCG(except for Alaska), USCG(Alaska), maximum design ~~ambient~~ temperature environment, self-defined	minimum draught in loading condition
~~Calculation of thermal stress of hull~~	~~Type A, B~~	~~No~~			
calculation of low-cycle fatigue of tank	Type B	No	Surface of liquid cargo is close to tank top (1)	Maximum design ~~ambient~~ temperature environment	
(1): see requirements in 5.4.2 (1)					

~~5.3.12~~5.3.11 The boundary condition of convective heat exchange is used between plates of hull structure and air, and between plates of hull structure and sea water. The convective heat exchange coefficient is to be selected as appropriate. Where specific values are unavailable, it ~~may be~~ is generally determined by using recognized empirical formulae of thermodynamics.

~~5.3.13~~5.3.12 During calculation of convective heat exchange coefficient between plates of hull structure and air, the effect of hull framing on the attached shell plating needs to be considered. In general the hull framing is considered as cooling rib.

~~5.3.14~~5.3.13 Radiation heat transfer between plates of hull structure and external environment is to be considered.

~~5.3.15~~5.3.14 Where the tank is fully loaded, the temperature boundary condition is to be applied on internal surface of tank.

~~5.3.16~~5.3.15 Where the tank is not fully loaded, the temperature boundary condition is to be applied on the internal surface of tanks below the liquid surface and convective steam boundary condition is to be applied on internal surface of tanks above the liquid surface.

New paragraphs 5.3.16 and 5.3.17 are added as follows:

5.3.16 When temperature of fore and aft hull structure within cargo area is calculated, ambient temperature within fore and engine area is taken as 5^{o}C.

5.3.17 Design temperature of complete or partial secondary barrier is taken as cargo temperature.

5.4 Calculation of tank temperature field for low-cycle fatigue analysis

5.4.2 Different filling levels include:

(1) highest filling level, the surface of liquid cargo is just close to the ~~inner~~ top of tank;

(2) lowest filling level, the liquid cargo just covers the ~~inner~~ bottom of tank;

(3) filling levels up to each horizontal girder.

5.6 Selection of steel grades

5.6.1 Selection of the material for cargo tank is to comply with relevant provisions of Tables 6.1, 6.2 and ~~6.4~~6.3 of Chapter 6 of PART THREE of the Rules and Section 7 of Chapter 3 of PART ONE of CCS Rules for Materials and Welding.

5.6.3 Hull material complying with 4.19.1.4 of Chapter 4 of PART THREE of the Rules is also to comply with relevant requirements of Table ~~6.5~~6.2 of Chapter 6 of PART THREE of the Rules and Section 7 of Chapter 3 of PART ONE of CCS Rules for Materials and Welding.

Table 5.6.4 is revised as follows:

Scope of application of selected steel grade Table 5.6.4

	IGC	USCG (except for Alaska)	USCG (Alaska)	Maximum design ~~ambient~~ temperature environment (see 7.2 of Chapter 7of PART THREE of the Rules)
Scope of application of selected steel grade	The whole cargo tank region	Inner shell of cargo tank region and its connected members	Inner shell of cargo tank region and its connected members	N/A

New paragraphs 5.6.5 and 5.6.6 and new Figure 5.6.5 are added as follows:

5.6.5 When selecting steel grades of longitudinal continuous plates such as deck, inner bottom plate and inner shell, low temperature steel is to be extended to a range of S = 500 mm beyond the position required by secondary barrier, as shown in Figure 5.6.5. Steel grade E or DH is to be selected for the plates adjacent to low temperature steel.

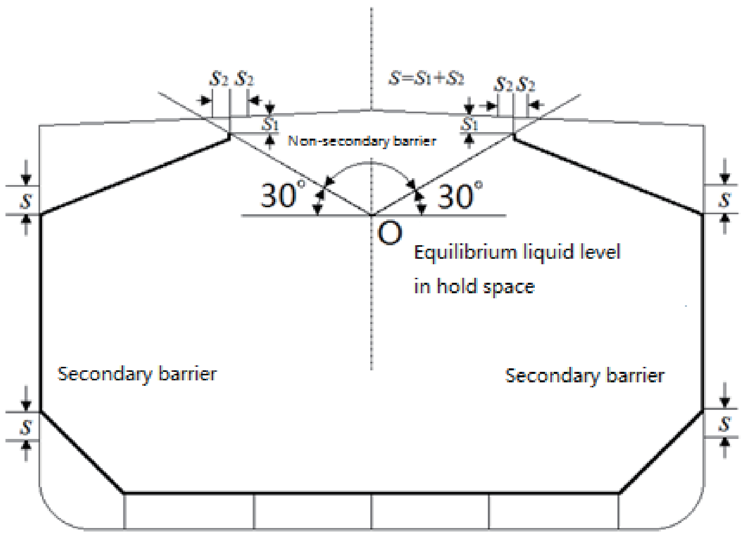


Figure 5.6.5 Extent of low temperature steel

5.6.6 When selecting steel grade of stiffeners and brackets, the steel grade is to be the same as that of the plates to which they are attached.

Appendix 2 ADDITIONAL REQUIREMENTS FOR CARRIERS WITH TYPE C INDEPENDENT TANK

Section 2 SCANTLINGS OF HULL STRUCTURE OF CARRIERS WITH TYPE C INDEPENDENT TANK

2.1 General requirements

2.1.1 This section specifies the additional requirements for scantlings of hull structure of carriers with type C independent tanks. For those not covered in this Section, the scantlings and arrangement of hull structures and other requirements are to comply with relevant provisions of Chapter A4 of the Rules and Chapter 2 and Chapter 8 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships.

~~2.1.2 For single-bottom ships, the bottom framing may be in accordance with the relevant requirements of Chapter 6 of PART TWO of CCS Rules for Classification of Sea-Going Steel Ships, and strength may be checked through direct calculation according to Section 5 of this Appendix.~~

A new sub-section 2.5 is added as follows:

2.5 Longitudinally framed single bottom

2.5.1 This sub-section applies to the longitudinally framed single bottom, in which the outer edges are formed with the hopper tank bottom side girders or side girders below longitudinal bulkheads. The continuous center keelson is to be provided in way of the central longitudinal section of the ship. Where the breadth of ship is more than 9 m, one side keelson at least is to be fitted on each side of the center keelson, and generally be fitted at the midpoint between the center keelson and hopper tank bottom side girder.

2.5.2 The spacing of bottom longitudinals is not to be greater than 1 m.

2.5.3 The section modulus W of bottom longitudinals is not to be less than that obtained from the following formula:

$$W = \frac{8.5}{1.73 - F_b}(d + h_1)sl^2K \quad \text{cm}^3$$

where: F_b — reduction factor, see 2.2.5.6, Chapter 2, PART TWO of CCS Rules for Classification of Seagoing Steel Ships;
d — draught, in m;
h_1 — see 2.3.1.2, Chapter 2, PART TWO of CCS Rules for Classification of Seagoing Steel Ships;
s — spacing of longitudinals, in m;
l — span of longitudinal, in m, but not less than 1.5 m;
K — material factor.

2.5.4 The spacing of the plate floors is not to be greater than 3 m.

2.5.5 Web height h of plate floor at the centerline is not to be less than:

$$h = 42(B + d) - 70 \quad \text{mm}$$

where: B — breadth of ship, in m;
d — draught, in m.

Web height of center keelson and side keelsons is not to be less than that of plate floor.

2.5.6 Thickness of web and face plate of plate floor and center keelson is not to be less than:

$$t = (0.01h + 3)\sqrt{K}$$ mm, but not less than 6 mm and need not be greater than 14 mm

where: h — calculated web height of plate floor, in mm, see 2.5.5 of this Section;
K — material factor.

Thickness of web and face plate of side keelson is not to be less than the value calculated according to above formula minus 2 mm, but not less than 6mm.

2.5.7 The sectional area A of web of the plate floor is not to be less than:

$$A = C_2 S d l_F K \quad \text{cm}^2$$

where: S — spacing of the plate floors, in m;
d — draught, in m;
l_F — full span of the plate floor, in m, measured from port hopper tank bottom side girder to starboard hopper tank bottom side girder;

$$C_2 = 0.56(1 - R_0 - 2R_1)$$

where: $R_0 = \dfrac{\varphi}{77\gamma}$;

$R_1 = f_{gd}\beta\dfrac{\varphi}{\gamma}$;

$\beta = -0.03 f_y + 0.0167$;

$f_y = \dfrac{Y_{G1}}{l_F}$;

Y_{G1} — transverse distance from side keelson to hull centerline, in m;

$\varphi = 0.295u^3 - 1.332u^2 + 1.22u + 0.67$, and not more than 1.0;

$u = u_1$, and not more than 2.4;

$$u_1 = 0.353 l_G \sqrt[4]{\frac{I_F}{I_G}\frac{1}{\gamma l_F^3 S}};$$

l_G — span of the center keelson, in m, measured from aft transverse bulkhead to fore transverse bulkhead;

$\gamma = 0.02 + (0.05 - 0.12 f_y) f_{gd}$;

$f_{gd} = \dfrac{I_{G1}}{I_G}$;

I_F — inertia moment of plate floor, in cm^4;

I_G — inertia moment of center keelson, in cm^4;

I_{G1} — inertia moment of side keelson, in cm^4;

K — material factor.

2.5.8 The section modulus W of the plate floor is not to be less than that obtained from the following formula:

$$W = C_1 S d l_F^{\,2} K \quad \text{cm}^3$$

where: S — spacing of the plate floors, in m;

d — draught, in m;

l_F — full span of the plate floor, in m, measured from port hopper tank bottom side girder to starboard hopper tank bottom side girder;

C_1 — taken as the greatest value obtained from the following formulae:

$$C_1 = 12\left|2f_y^{\,2} - 2Rf_y + (R - 0.5)\right|$$

$$C_1 = 6\left|2R - R_0^{\,2} - 8R_1 f_y - 1\right|$$

$$C_1 = 6\left|2R - 8R_1 f_y - 1\right|$$

where: $R = R_0 + 2R_1$

R_0, R_1, f_y — see 2.5.7 of this Section;

K — material factor.

2.5.9 The sectional area A of web of the center keelson, within the scope from transverse bulkhead to the nearest first floor, is not to be less than that obtained from the following formula:

$$A = C_{02} S d l_F K \quad \text{cm}^2$$

where: S — spacing of the plate floors, in m;

d — draught, in m;

l_F — full span of the plate floor, in m, measured from port hopper tank bottom side girder to starboard hopper tank bottom side girder;

$$C_{02} = \frac{1}{139\gamma} f_N \eta\,;$$

$$f_N = \begin{cases} \dfrac{l_G}{S} & \text{if plate floors number} < 1.1 \times \left(\dfrac{l_G}{S} - 1.0\right) \\ 0.95\dfrac{l_G}{S} & \text{if plate floors number} \geq 1.1 \times \left(\dfrac{l_G}{S} - 1.0\right) \end{cases};$$

$$\eta = 0.0083u^5 - 0.1214u^4 + 0.663u^3 - 1.598u^2 + 1.327u + 0.65\,;$$

$u = u_1$, and not more than 4.5;

u_1, γ — see 2.5.7 of this Section;

l_G — span of the center keelson, in m, measured from aft transverse bulkhead to fore transverse bulkhead;

K — material factor.

2.5.10 The section modulus W of the center keelson, within the scope from transverse bulkhead to the nearest first floor, is not to be less than that obtained from the following formula:

$$W = C_{01} S d l_F l_G K \quad \text{cm}^3$$

where: s — spacing of the plate floors, in m;

d — draught, in m;

l_F — full span of the plate floor, in m, measured from port hopper tank bottom side girder to starboard hopper tank bottom side girder;

l_G — span of the center keelson, in m, measured from aft transverse bulkhead to fore transverse bulkhead;

$$C_{01} = \frac{1}{15\gamma} f_N \lambda ;$$

$$\lambda = 0.2057u^3 - 0.9384u^2 + 0.8733u + 0.7565 \quad u \le 2.1$$
$$\lambda = -0.0244u^3 + 0.2944u^2 - 1.2303u + 1.865 \quad u > 2.1 ;$$

f_N, u — see 2.5.9 of this Section;

γ — see 2.5.7 of this Section;

K — material factor.

2.5.11 The sectional area A of web of the side keelson, within the scope from transverse bulkhead to the nearest first floor, is not to be less than that obtained from the following formula:

$$A = C_{12} S d l_F K \quad \text{cm}^2$$

where: s — spacing of the plate floors, in m;

d — draught, in m;

l_F — full span of the plate floor, in m, measured from port hopper tank bottom side girder to starboard hopper tank bottom side girder;

$$C_{12} = 85\beta f_{gd} C_{02} \frac{l_{G1}}{l_G} ;$$

C_{02} — see 2.5.9 of this Section;

β, f_{gd} — see 2.5.7 of this Section;

l_G — span of the center keelson, in m, measured from aft transverse bulkhead to fore transverse bulkhead;

l_{G1} —span of the side keelson, in m, measured from aft transverse bulkhead to fore transverse bulkhead;

K — material factor.

2.5.12 The section modulus W of the side keelson, within the scope from transverse bulkhead to the nearest first floor, is not to be less than that obtained from the following formula:

$$W = C_{11} S d l_F l_G K \quad \text{cm}^3$$

where: s — spacing of the plate floors, in m;

d — draught, in m;

l_F —full span of the plate floor, in m, measured from port hopper tank bottom side girder to starboard hopper tank bottom side girder;

$$C_{11} = 85\beta f_{gd} C_{01} \frac{l_{G1}}{l_G} ;$$

C_{01} — see 2.5.10 of this Section;

β, f_{gd} — see 2.5.7 of this Section;

l_G — span of the center keelson, in m, measured from aft transverse bulkhead to fore transverse bulkhead;

l_{G1} —span of the side keelson, in m, measured from aft transverse bulkhead to fore transverse bulkhead;

K — material factor.

2.5.13 If the number of side keelsons in the single bottom frame is four and above, scantling of the primary structural members are to be verified by direct calculation, as well as comply with the requirements of 2.5.5 to 2.5.6 of this Section.

(1) Model scope: Along length direction is to cover from aft transverse bulkhead to fore transverse bulkhead, along breadth direction is to cover ship breadth, and along height direction is to cover from shell to double side stringer;

(2) Meshing: Webs of floor and keelson are to be modelled by plate elements, with not less than 3 elements along the web height direction, and face plates are to be modelled by beam elements. Plate element meshes are to be shaped square as far as practicable, with aspect ratio not more than 2;

(3) Boundary condition: The displacement in longitudinal, transverse and vertical directions of the nodes in way of the transverse bulkhead, together with the rotation around longitudinal, transverse and vertical directions, are to be restrained, i.e. $\delta_x=\delta_y=\delta_z=\theta_x=\theta_y=\theta_z=0$;

(4) Load application: seawater pressure is to be calculated according to following formula and applied on the shell plate:

$$p = 10(d - z) \quad \text{kN/m}^2$$

where: d — draught, in m;

z — vertical position of the point considered, in m.

(5) Assessment criteria: The maximum shear stress in web of primary structural members, to be taken as the average value along web height, is not to exceed 90/K N/mm^2. The maximum normal stress of primary structural member (including face plate) is not to exceed 156/K N/mm^2, in which K is the material factor.

Section 3 SCANTLINGS OF TYPE C INDEPENDENT TANK

3.3 Fittings to cargo tank

3.3.1 The thickness t of the watertight longitudinal bulkhead plating of cargo tanks is to be determined in accordance with the following requirements:

$$~~t \geq \frac{2p_{eq}\times e}{20\sigma_m\phi - p_{eq}} + c~~ \qquad t \geq \frac{2p_{eq}\times e}{2\sigma_m\phi - p_{eq}} + c \quad \text{mm}$$

where: e — distance of axes of twin hull tank, in mm;

other symbols — see 3.2.2.

The check of the watertight longitudinal bulkhead plate of the tri-lobe tank may be carried out according to above assumptions and provisions.

For the non-watertight longitudinal bulkhead plate of the tri-lobe tank, the thickness requirements may be in accordance with relevant provisions in 3.3.6 of this Section.

3.3.2 The loading conditions of stiffeners of cargo tank watertight longitudinal bulkheads are as follows:

(1) Loading condition 1 — starboard and port tanks are fully loaded, see Figure 3.3.2(1), where the calculation method for P_{gd} is specified in 4.28.1and CCS4.28.1.2.a~CCS4.28.1.2.d of Chapter 4 of PART THREE of the Rules.

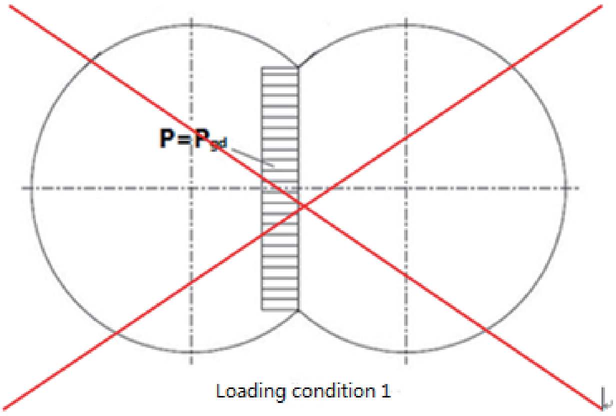
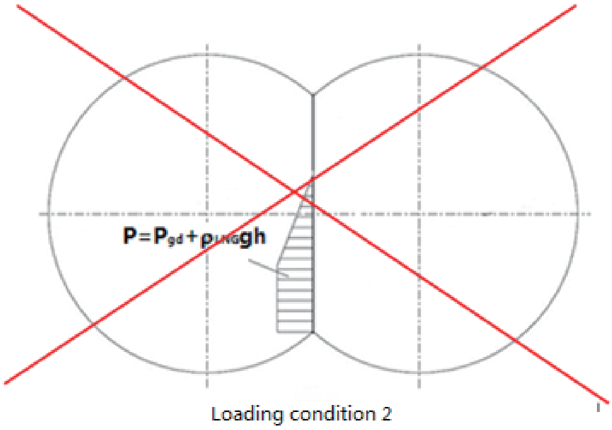


Figure 3.3.2(1) Loading condition — starboard and port tanks are fully loaded

(2) Loading condition 2 — starboard and port tanks are 50% loaded, see Figure 3.3.2 (2), where the calculation method for P_{gd} is shown in the above (1).



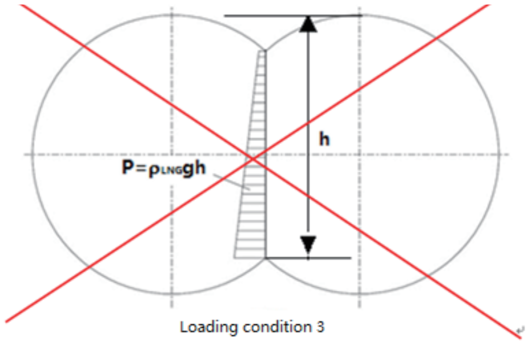
(Note: relevant values of α_{β}, Z_{β} and h are to be determined based on the actual situation during the calculation in accordance with 4.28.1.2 as well as CCS4.28.1.2.a~CCS4.28.1.2.d of Chapter 4 of PART THREE of the Rules.)

Figure 3.3.2(2) Loading condition — starboard and port tanks are 50% loaded

(3) Loading condition 3 — one side of tank is fully loaded and the other one is empty (the words "One side fully load and the other side empty is not allowed" are to be indicated in the Loading Manual)., see Figure 3.3.2 (3), If maximum pressure differential of starboard and port side tanks can be determined, loading condition with maximum pressure differential of starboard and port side tanks given in the Loading Manual may be considered, but the words "One side fully load and the other side empty is not allowed" are to be indicated in the Loading Manual the inhomogeneous loading condition is to be listed in the Loading Manual as operation limit.

The check of the watertight longitudinal bulkhead plate of the tri-lobe tank may be carried out according to the above assumptions and provisions.

For the non-watertight longitudinal bulkhead plate of the tri-lobe tank, the thickness requirements may be in accordance with the relevant provisions in 3.3.6 of this Section.



~~Figure 3.3.2(3) Loading condition — one side of tank is fully loaded and the other one is empty~~

3.3. 3 The bending stress σ_b of stiffeners of cargo tank watertight longitudinal bulkheads is to be determined in accordance with the following formula:

$$\sigma_b \le [\sigma_b]$$

where: $\sigma_b = \frac{M}{W} \times 10^3$ MPa;

M — bending moment of stiffeners of longitudinal bulkhead, in kN·m; during calculation, load P_{eq} is to be based on the loading mode in 3.3.2 and calculated according to actual ~~the~~ boundary conditions and Table 3.3.3 ~~are to be simulated based on actual situations~~;

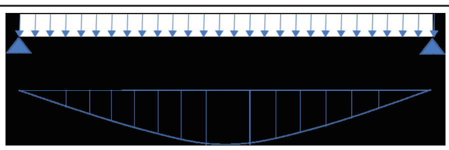
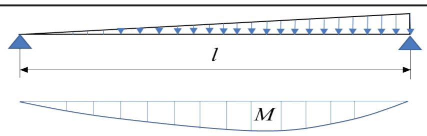
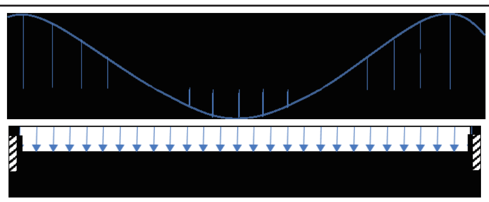
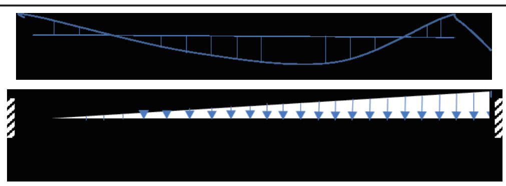
W — section modules of stiffeners of longitudinal bulkhead, in cm^3;

$[\sigma_b]$ — permissible bending stress, in MPa, to be taken as 0.57 R_{eH}.

The check of stiffeners of watertight longitudinal bulkhead of the tri-lobe tank may be carried out according to the above methods.

A new Table 3.3.3 is added as follows:

Calculation formula of maximum bending moment within span of stiffeners Table 3.3.3

Schematic diagram of mechanical model	Formula of bending moment	Explanation
	$M = 0.125 s p_{eq} l^2 \times 10^3$	Both ends are simply supported and the loads are distributed evenly across the span
	$M = 0.064 s p_{eq} l^2 \times 10^3$	Both ends are simply supported and the loads are distributed in triangle across the span
	$M = 0.042 s p_{eq} l^2 \times 10^3$	Both ends are fixed rigidly and the loads are distributed evenly across the span
	$M = 0.022 s p_{eq} l^2 \times 10^3$	Both ends are fixed rigidly and the loads are distributed in triangle across the span

Notes: ① P_{eq} — internal pressure, in MPa; see 3.2.2 of this Section, and for calculation of P_{gd}, see ②;
② When P_{gd} is calculated according to 4.28.1.2, Chapter 4, PART THREE of the Rules and CCS4.28.1.2.a~CCS4.28.1.2.d, relevant values of α_β, Z_β and h are to be determined according to actual condition;
③ s, l — stiffener interval and calculation span, in m.

Section 4 DIRECT CALCULATION OF STRUCTURAL STRENGTH OF TYPE C INDEPENDENT TANK AND SUPPORTING STRUCTURES OF SADDLE

4.4 Boundary conditions

4.4.2 Boundary conditions for local loads are given in Table 4.4.2 and Figure 4.4.2.

Boundary conditions for local loads **Table 4.4.2**

Position	Boundary conditions	Remarks
Forward end plane	$\delta_x = 0, \theta_y = 0, \theta_z = 0$	
Aftward end plane	$\delta_x = 0, \theta_y = 0, \theta_z = 0$	
Lines AA', BB', CC', DD'	Vertical spring element	Including vertical shear force bearing components such as topside tank sloping plating and hopper tank sloping plating
Lines AB, A'B', CD, C'D'	Horizontal spring element	Only applicable to asymmetric conditions: LC3, LC4, LC5, LC10
Point E ~~(intersection point of longitudinal centerline of bulkheads forward and aft cargo holds amidships and bottom plating)~~	$\delta_y = 0$	

Note: spring stiffness is to be obtained by the following formula:

$$K = \frac{5GA}{6l_H n} \qquad \text{N/mm}^2$$

where: G — shearing modulus of elasticity, in N/mm^2, $G = 0.792\times10^5$ N/mm^2 for steel;
A — the effective shear area of side plating, topside tank sloping plating and hopper tank sloping plating, etc., in mm^2;
l_H — length of cargo holds amidships, in mm;
n — number of spring constraints.

Figure 4.4.2 is replaced by the following:

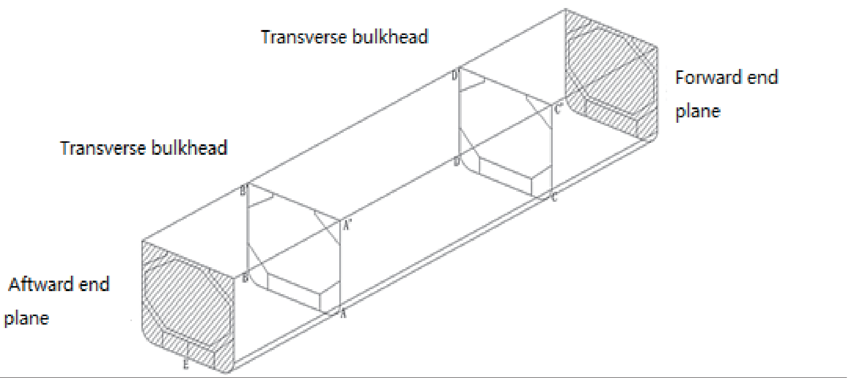


Figure 4.4.2 Positions for applying boundary conditions

4.6 Structural models of saddles of type C independent tank

4.6.2 The scope of a local model is to be centered on the object of investigation (saddle), with an extent of at least two frames being taken fore (+X) and aft (–X) respectively along the ship's length; in the direction of moulded depth (+Z) the model is to extend from the baseline to at least the first platform deck above the lowest platform deck of the hopper tank. Where primary supporting members of the structure are not covered at the model boundary taken by the above method, the boundary is to be further extended to reach the primary members, see Figure 4.6.2. For saddles structures which are not symmetrical to port and starboard, full width structural model is adopted.

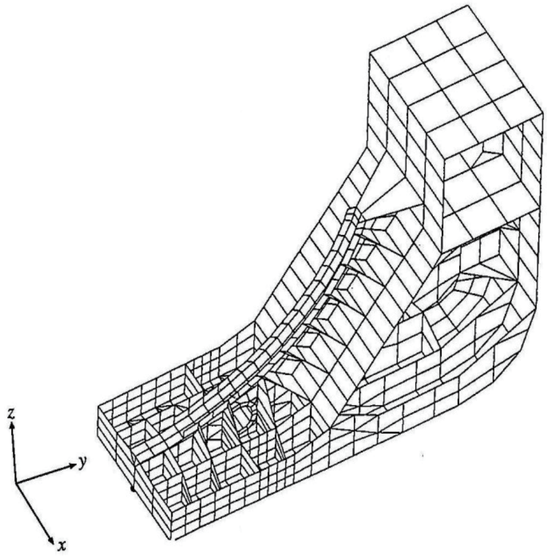


Figure 4.6.2 3-dimensional local structural model of "saddles/supporting members + adjacent hull structure"

4.6.4 It is recommended that the boundary conditions of the local model be set according to Table 4.6.4:

Boundary Conditions of the Local Model **Table 4.6.4**

Supporting point location \ Degree of freedom	X	Y	Z	θ_x	θ_y	θ_z
Longitudinal centerline[1]	free	fixed	free	fixed	free	fixed
fore end plane	fixed	fixed	fixed	free	fixed	fixed
aft end plane	free	fixed	fixed	free	free	free
Note 1: When full width saddles model is adopted, boundary condition is not used in way of longitudinal centerline section.						

4.9 Type C deck tank base

4.9.1 For type C tank saddles installed on the deck, strength assessment can be carried out with reference to 4.6 to 4.8.

Section 5 DIRECT STRENGTH CALCULATIONS FOR TYPE C INDEPENDENT TANK AND CONNECTED SUPPORTING STRUCTURES

5.2 Design load

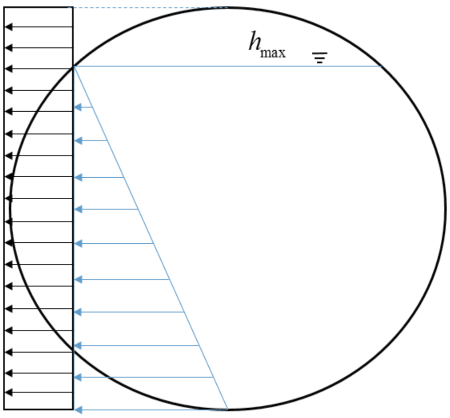
5.2.3 Where partial loading of 20% to 90% filling height occurs for type C independent tank, the sloshing load not less than that obtained from the calculation formula is to be taken into account and the requirements are as follow:

(1) The sloshing load is to be calculated from the relevant formulae in Section 2 of CCS Guidelines for Assessment of Sloshing Loads and Structural Scantling of Tanks.

(2) The sloshing pressure is to be taken as the maximum sloshing dynamic load P_{smax} of each filling height at "level II", evenly distributed in the whole range of the tank height, and is applied to the cargo tank with the combination of the maximum static load P_{0max} (see Figure 5.2.3 and Table 5.2.3).

Type C independent tank sloshing load and application **Table 5.2.3**

Sloshing load	Load and combination	Applied position	Applied method and scope (Only application of one side is required)
Transverse sloshing load	$P_{s\,max} + P_0$	Inner side of tank (left half side or right half side)	$P_{s\,max}$ is applied to the height of whole tank depth; P_0 is applied to the height of h_{max}.
Longitudinal sloshing load	$P_{s\,max} + P_0$	Stiffening ring and tank head (front half side or after half side)	$P_{s\,max}$ is applied to the height of whole tank depth; P_0 is applied to the height of h_{max}.
	$P_{s\,max}$	Swash bulkhead	$P_{s\,max}$ is applied to the height of whole swash bulkhead.



$P_{s\,max}$ $P_{0\,max}$

Figure 5.2.3 Distribution assumption of sloshing pressure

(3) During sloshing analysis, for single and bi-lobe tanks, the calculation dimensions of cargo tanks are to be taken as the dimensions of the single tank; for tri-lobe tanks, the calculation dimensions of cargo tanks are to be taken as the combined space of one tank at top and two tanks at bottom.

(4) The sloshing analysis of type C independent tank needs not consider the sloshing motion effect of "level III".

5.6 Strength criteria

5.6.1 The purpose is to check the shell in way of the connection between the cargo tank and its supporting structure, local structural area with high stress level (~~e.g.~~ in way of Y-shape connection of bi-lobe and tri-lobe tanks, not considering compound plate in way of dome and its opening) and fittings of cargo tank (~~e.g.~~ stiffening ring, bulkhead, supporting members of saddle, but not considering swash bulkhead) and chock of saddle.

Section 6 SIMPLIFIED CALCULATION OF TEMPERATURE FIELD AND THERMAL STRESS AND SELECTION OF STEEL GRADE FOR TYPE C INDEPENDENT TANK

6.1.2 Calculation of temperature field is carried out for ~~two~~ the following purposes:

(1) selection of steel grades for hull plating;

(2) calculation of thermal stress of hull.

6.3 External temperature for calculation of temperature field

6.3.1 Generally, the external ambient conditions are to be selected based on the following principles:

(1) for ships engaged in world-wide services, IGC ambient condition is generally to be used;

(2) for ships navigating in US waters (except for Alaska), USCG (except for Alaska) condition is to be used; USCG (Alaska) condition is to be used when navigating in Alaska area;

(32) for ships navigating in other cold regions and/or complying with the requirements for PC class (Polar class), other calculation conditions given in accordance with relevant provisions of port State Administration or flag State/Polar rules and requirements for ice class and design temperature (if any) are to be used;

(43) for parameters of external ambient conditions, refer to Table 6.3.1.

Ambient conditions **Table 6.3.1**

	IGC	USCG (except for Alaska)	USCG (Alaska)	Maximum design ambient temperature environment (see 7.2 of chapter 7 of PART THREE of the Rules)
Air temperature(℃)	5	-18	-29	45
Sea temperature(℃)	0	0	-2	32
Wind speed(kn)	0	5	5	0

6.3.2 Where the ambient temperatures in extreme hot or cold regions where the ship is in service are beyond the scope in Table 6.3.1, the design ambient temperature is to be adjusted determined as appropriate.

Appendix 3 ADDITIONAL REQUIREMENTS FOR FATIGUE STRENGTH ASSESSMENT OF CARRIERS WITH INDEPENDENT TANKS

Section 1 GENERAL PROVISIONS

1.1 General requirements

1.1.6 For Type C independent tanks, if the design of tank size is in line with relevant requirements of Section 3 of ~~this~~ Appendix 2, in normal conditions, fatigue strength assessment is not necessary for C type tanks. Fatigue analysis of bi-lobe and tri-lobe tanks of Type C independent tanks in way of Y type connection is to be carried out according to relevant requirements of Section 5 of this Appendix.

Section 3 FATIGUE STRENGTH ASSESSMENT OF TYPE B INDEPENDENT TANK STRUCTURE

3.4 Acceptance criteria

3.4.1 The total fatigue damage ratio D calculated according to 3.3.5 is to be in compliance with the following criteria:

$$D \le C_w$$

Where: C_w —— maximum allowable cumulative fatigue damage ratio, and for tank and support structures, to be taken according to the provisions of 4.18.2.7 to 4.18.2.9 in Chapter 4 of PART THREE of the Rules, for example, to be taken as 0.5 for accessible positions and 0.1 for inaccessible positions. ~~C_w=0.5.~~

Section 5 FATIGUE STRENGTH ASSESSMENT OF TYPE C INDEPENDENT TANK STRUCTURE

5.1 General requirements

5.1.2 For Y-shaped connection of type C independent tank, the structural fatigue assessment screening criteria is as follows:

$$\Delta P \le \frac{1}{27}\left[1.76\times10^{13}\frac{C_w}{T_F}\left[\frac{P}{f_t S(P)}\right]^3 - N_T P_0^3\right]^{\frac{1}{3}} \quad \text{MPa}$$

where: ΔP——range of heaving dynamic pressure at Y-shaped connection of cargo tank, in Mpa, to be calculated as follows:

~~$\Delta P = P_{ed}|_2^1 - P_{ed}|_1^1$~~ $\Delta P = P_{gd}|_{j=2}^{i=1} - P_{gd}|_{j=1}^{i=1}$, where ~~$P_{ed}|_2^1$~~ $P_{gd}|_{j=2}^{i=1}$ and ~~$P_{ed}|_1^1$~~ $P_{gd}|_{j=1}^{i=1}$ are calculated according to 5.4.3(3) of this Section, and correspond to 10^{-8} wave exceedance probability level,

…

5.3 Loading condition

5.3.1 The fatigue loading condition of type C independent tank is composed of fully-loaded condition and empty condition. The dominant load condition in the fatigue assessment corresponds to heaving and the roll of the maximum dynamic pressure difference of the liquid cargo. The loading condition of type C independent tank applied to FE direct calculation for fatigue strength check is shown in Table 5.3.1. See Table 5.3.1. Generally, temperature stress changes are not considered.

5.3.2 Generally, thermal stress changes are not considered.

The calculation condition of type C independent tank applied to FE direct calculation for Fatigue strength check **Table 5.3.1**

Loading condition(dominant load condition)	Load Description
Fatigue Limit State (FLS): − Heaving (roll angle is 0°)and rolling conditions − Heaving + rolling (roll angles for minimum and maximum dynamic pressure of liquid cargo: β_1, β_2)	− 0° and roll angles β_1, β_2 corresponding to minimum and maximum dynamic pressure of liquid cargo under heaving + rolling condition maximum roll angle β_m under fatigue load; − self-weight of shell; − self-weight of cargo; − dynamic pressure of cargo; − minimum temperature of tank; − vapor pressure
Note: the dominant loading condition is the loading condition under which the design stress range is the maximum at the hot spot in each roll angle (0°/ maximum roll angle β_m in fatigue load). Notes: ① β_1, and β_2 are shown in Figure 5.4.3(2); ② Description of maximum dynamic pressure difference may be referred to in CCS4.23.1.2.b of Chapter 4 of PART THREE of the Rules.	

5.4 Fatigue loads

5.4.3 High cycle loads (loads due to ship motion)

(1) acceleration of ship motion:

① The maximum non-dimensional acceleration of vertical direction (i.e. relative to gravity) a_z:

$$a_z = C_{z,ij} f_r f_p |a_{z0}|$$

② The maximum non-dimensional acceleration of transverse direction (i.e. relative to gravity) a_y:

$$a_y = C_{y,ij} f_r f_p |a_{y0}|$$

where: $C_{z,ij}$, $C_{y,ij}$ ——the load combination factor corresponding to the loading condition ij; see Table 5.4.3(1);

a_{z0}, a_{y0} ——same as a_z, a_y in 4.28.2.1, Chapter 4, PART THREE of the Rules; however, when calculating a_0, the calculation result is to be multiplied with $f_r \times f_p$, i.e.:

$$a_0 = f_r f_p a_0'$$

a_0' ——same as a_0 in 4.28.2.1, Chapter 4, PART THREE of the Rules;

…

Loading combination Coefficient **Table 5.4.3**

loading condition	*i* (two different motions ~~different angle~~)	*i*=1 heaving only		*i*=2 heaving+rolling	
	j (left and right roll direction)	1	2	1	2
Roll angle (°) β_1, β_2 - roll angles corresponding to minimum and maximum dynamic pressure of liquid cargo ~~β_m—— maximum roll angle under fatigue load~~		0	0	~~$-\beta_m$~~ β_1	~~β_m~~ β_2
$C_{z,ij}$		1	-1	1	-1
$C_{y,ij}$		0	0	-1	1
Note: The values of β_1 and β_2 are to be less than $\beta_m = \arctan(\frac{a_y}{\sqrt{1-a_z^2}})$					

(2) in dominant loading condition for fatigue calculation, non-dimensional acceleration a_β of direction β is calculated according to the following formulae:

① Heaving only (β_1, $\beta_2 = 0°$, $a_y = 0$):

$$a_\beta \Big|_{j=1}^{i=1} = 1\text{-}a_z$$

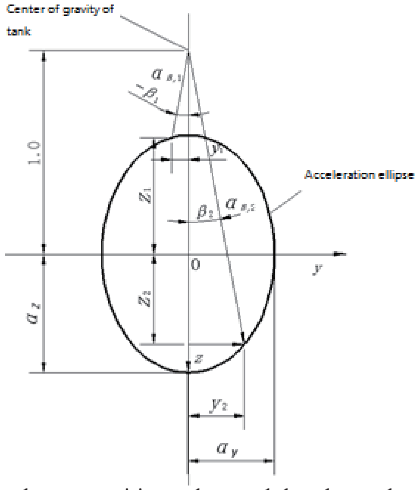
$$a_\beta \Big|_{j=2}^{i=1} = 1+a_z$$

② Heaving+rolling (β_1, $\beta_2 \neq 0°$, $a_y \neq 0$):

$$\alpha_\beta \Big|_{j=1}^{i} = \frac{a_y^2 \cos\beta_1 - a_y a_z \sqrt{(a_y \cos\beta_1)^2 + (a_z \sin\beta_1)^2 - (\sin\beta_1)^2}}{(a_y \cos\beta_1)^2 + (a_z \sin\beta_1)^2}$$

$$\alpha_\beta \Big|_{j=2}^{i} = \frac{a_y^2 \cos\beta_2 + a_y a_z \sqrt{(a_y \cos\beta_2)^2 + (a_z \sin\beta_2)^2 - (\sin\beta_2)^2}}{(a_y \cos\beta_2)^2 + (a_z \sin\beta_2)^2}$$

where: β_1, β_2—— left and right roll angles corresponding to minimum and maximum dynamic pressure of liquid cargo ~~under the roll loading condition~~, see Table 5.4.3 and Figure 5.4.3(2);
I, j —— see Figure 5.4.3~~(1)~~;
a_z, a_y—— see 5.4.3(1)①, ②~~and Figure 5.4.3(2)~~;
y, z —— transverse and vertical coordinates of the calculation point on the tank body, in m, see Figure 5.4.3(2);



Note: in the relevant formulae, β is to be taken as positive value, and the plus and minus signs in the figure indicate direction.

Figure 5.4.3(2) Example of cargo acceleration ellipse

(3) Internal liquid pressure

Internal liquid pressure P_{gd} is calculated based on 4.28.1.2, Chapter 4, PART THREE of the Rules, and for fatigue loading condition of bi-lobe and tri-lobe tanks, P_{gd} is calculated as follows:

① bi-lobe tank:

$$P_{gd}\Big|_{j=1}^{i=1,2} = a_\beta\Big|_{j=1}^{i=1,2} \cdot \left[R + (R-z)\cos\beta_1 + (\frac{L}{2} + y)\sin\beta_1 \right] \frac{\rho}{1.02\times10^5}$$

$$P_{gd}\Big|_{j=2}^{i=1,2} = a_\beta\Big|_{j=2}^{i=1,2} \cdot \left[R + (R-z)\cos\beta_2 + (\frac{L}{2} - y)\sin\beta_2 \right] \frac{\rho}{1.02\times10^5}$$

$$P_{gd}\Big|_{j=1}^{i} = \frac{a_y^2\cos\beta_1 - a_y a_z\sqrt{(a_y\cos\beta_1)^2 + (a_z\sin\beta_1)^2 - (\sin\beta_1)^2}}{(a_y\cos\beta_1)^2 + (a_z\sin\beta_1)^2} \left[R + (R-z)\cos\beta_1 + (\frac{L}{2} + y)\sin\beta_1 \right] \frac{\rho}{1.02\times10^5}$$

$$P_{gd}\Big|_{j=2}^{i} = \frac{a_y^2\cos\beta_2 + a_y a_z\sqrt{(a_y\cos\beta_2)^2 + (a_z\sin\beta_2)^2 - (\sin\beta_2)^2}}{(a_y\cos\beta_2)^2 + (a_z\sin\beta_2)^2} \left[R + (R-z)\cos\beta_2 + (\frac{L}{2} - y)\sin\beta_2 \right] \frac{\rho}{1.02\times10^5}$$

where: R —— radius of tank body of left and right single tank, in m; see Figure 5.4.3(3)①;
L —— center distance of left and right tanks; see Figure 5.4.3(3)①;
Other symbols——see 5.4.3(2).

② tri-lobe tanks:

$$P_{gd}\Big|_{j=1}^{i=1,2} = a_\beta\Big|_{j=1}^{i=1,2} \cdot \left[R + \frac{L\cos(\frac{\theta}{2} - \beta_1)}{2\sin\frac{\theta}{2}} + (R-z)\cdot\cos\beta_1 + (y - \frac{L}{2})\sin\beta_1 \right] \frac{\rho}{1.02\times10^5}$$

$$P_{gd}\Big|_{j=2}^{i=1,2} = a_\beta\Big|_{j=2}^{i=1,2} \cdot \left[R + \frac{L\cos(\frac{\theta}{2} - \beta_2)}{2\sin\frac{\theta}{2}} + (R-z)\cdot\cos\beta_2 - (y + \frac{L}{2})\sin\beta_2 \right] \frac{\rho}{1.02\times10^5}$$

$$P_{gd}\Big|_{j=1}^{i} = \frac{a_y^2\cos\beta_1 - a_y a_z\sqrt{(a_y\cos\beta_1)^2 + (a_z\sin\beta_1)^2 - (\sin\beta_1)^2}}{(a_y\cos\beta_1)^2 + (a_z\sin\beta_1)^2} \left[R + \frac{L\cos(\frac{\theta}{2} - \beta_1)}{2\sin\frac{\theta}{2}} + (R-z)\cdot\cos\beta_1 + (y - \frac{L}{2})\sin\beta_1 \right] \frac{\rho}{1.02\times10^5}$$

$$P_{gd}\Big|_{j=2}^{i} = \frac{a_y^2\cos\beta_2 + a_y a_z\sqrt{(a_y\cos\beta_2)^2 + (a_z\sin\beta_2)^2 - (\sin\beta_2)^2}}{(a_y\cos\beta_2)^2 + (a_z\sin\beta_2)^2} \left[R + \frac{L\cos(\frac{\theta}{2} - \beta_2)}{2\sin\frac{\theta}{2}} + (R-z)\cdot\cos\beta_2 - (y + \frac{L}{2})\sin\beta_2 \right] \frac{\rho}{1.02\times10^5}$$

5.5 Fatigue cumulative damage calculation

$D_{(k)}$ in 5.5.1 is revised into:

$D_{(k)}$——high cycle fatigue cumulative damage of structural details in each loading condition "(k)", see ~~3~~2.5.1 of CCS Guidelines for Fatigue Strength of Ship Structure;

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

CHAPTER 1 GENERAL

1.2.51 Tank dome is the upward extension of a portion of a cargo tank. In the case of below-deck cargo containment systems, the tank dome protrudes through the weather deck or through a tank cover.

CCS 1.2.51 Dome is also referred to as liquid dome or tank dome, into which gas and liquid can enter.

CHAPTER 4 CARGO CONTAINMENT

PART A CARGO CONTAINMENT

4.6   Design of secondary barriers

4.6.2   The design of the secondary barrier shall be such that:

.1   it is capable of containing any envisaged leakage of liquid cargo for a period of 15 days, unless different criteria apply for particular voyages, taking into account the load spectrum referred to in 4.18.2.6;

.2   physical, mechanical, or operational events within the cargo tank that could cause failure of the primary barrier shall not impair the due function of the secondary barrier, or vice versa;

.3   failure of a support or an attachment to the hull structure will not lead to loss of liquid tightness of both the primary and secondary barriers;

.4   it is capable of being periodically checked for its effectiveness by means acceptable to the Administration. This may be by means of a visual inspection or a pressure/vacuum test or other suitable means carried out according to a documented procedure agreed with the Administration;

.5   the methods required in .4 above shall be approved by the Administration and shall include, where applicable to the test procedure:

  .1 details on the size of defect acceptable and the location within the secondary barrier, before its liquid-tight effectiveness is compromised;

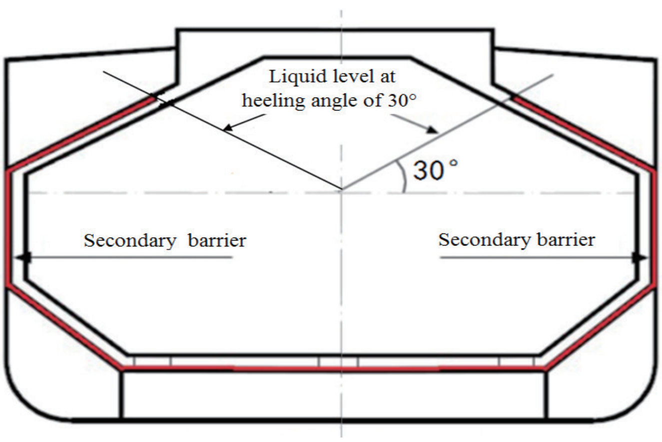
  .2 accuracy and range of values of the proposed method for detecting defects in .1 above;

  .3 scaling factors to be used in determining the acceptance criteria, if full scale model testing is not undertaken; and

  .4 effects of thermal and mechanical cyclic loading on the effectiveness of the proposed test; and

.6   the secondary barrier shall fulfill its functional requirements at a static angle of heel of 30°.

<u>*CCS 4.6.2 For Type A independent cargo tanks, when the hull acts as the secondary barrier, the range of the secondary barrier is at least to be sufficient to cover the liquid level height at the assumed static heeling of the ship at an angle of 30°, and the volume of the liquid cargo in the secondary barrier equals to that in the main barrier in the intact state (generally calculated at the loading rate of 98%) or other specific heights.*</u>



<u>Figure CCS 4.6.2 Range of the secondary barrier covering static heeling of the ship at an angle of 30°</u>

PART D MATERIALS AND CONSTRUCTION

4.19 Materials

CCS 4.19.1 When implementation for 4.19.1.2, it is assumed that the ambient sea and air temperatures are 0°C and 5°C respectively. Under the design conditions, it is to be assumed that the complete or partial secondary barriers are in the cargo temperature state at atmospheric pressure for any one cargo tank only. For cargo tanks not provided with secondary barriers, it is to be assumed that the primary barrier is in the cargo temperature state.

4.19.1.6 The means of heating referred to in 4.19.1.5 shall comply with the following requirements:

.1 the heating system shall be arranged so that, in the event of failure in any part of the system, standby heating can be maintained equal to not less than 100% of the theoretical heat requirement;

.2 the heating system shall be considered as an essential auxiliary. All electrical components of at least one of the systems provided in accordance with 4.19.1.5.1 shall be supplied from the emergency source of electrical power; and

.3 the design and construction of the heating system shall be included in the approval of the containment system by the Administration.

CCS 4.19.1.6.1 The heating system referred to in paragraph 4.19.1.6.1 should be such that, in case of a single failure of a mechanical or electrical component in any part of the system, heating can be maintained at not less than 100% of the theoretical heat requirement.

CCS 4.19.1.6.2 Where the above requirements are met by duplication of the system components, i.e. heaters, glycol circulation pumps, electrical control panel, auxiliary boilers, etc., all electrical components of at least one of the systems should be supplied from the emergency source of electrical power.

CCS 4.19.1.6.3 Where duplication of the primary source of heat, e.g. oil-fired boiler is not feasible, alternative proposals can be accepted such as an electric heater capable of providing 100% of the theoretical heat requirement provided and supplied by an individual circuit arranged separately on the emergency switchboard. Other solutions may be considered towards satisfying the requirements of paragraph 4.19.1.6.1, provided a suitable risk assessment is conducted to the satisfaction of the Administration. The requirement in paragraph 2 of this interpretation should continue to apply to all other electrical components in the system.

4.19.2.6 Consideration may be given to the use of materials in the primary and secondary barrier, which are not resistant to fire and flame spread, provided they are protected by a suitable system such as a permanent inert gas environment, or are provided with a fire-retardant barrier.

4.20.1 Weld joint design

4.20.1.1 All welded joints of the shells of independent tanks shall be of the in-plane butt weld full penetration type. For dome-to-shell connections only, tee welds of the full penetration type may be used depending on the results of the tests carried out at the approval of the welding procedure. Except for small penetrations on domes, nozzle welds shall also be designed with full penetration.

~~*CCS 4.20.1 Tee welds of the full penetration type may be used in Y-connection between bi-lobe and tri-lobe tank shell and longitudinal bulkhead with the agreement of CCS.*~~

CCS 4.20.1 Paragraph 4.20.1.1 is clarified as follows:

(1) The regulation 4.20.1.1 is applicable to independent tanks of type A or type B, primarily constructed of plane surfaces. This includes the tank corners which are constructed using bent plating which is aligned with the tank surfaces and connected with in-plane welds.

(2) The applicability of the expression "For dome-to-shell connections only" is clarified as follows:

- Welded corners (i.e. corners made of weld metal) shall not be used in the main tank shell construction, i.e. corners between shell side (sloped plane surfaces parallel to hopper or top side inclusive if any) and bottom or top of the tank, and between tank end transverse bulkheads and bottom, top or shell sides (sloped plane surfaces inclusive if any) of the tank. Instead, tank corners which are constructed using bent plating aligned with the tank surfaces and connected with in-plane welds are to be used.

- Tee welds can be accepted for other localised constructions of the shell such as suction well, sump, dome, etc. where tee welds of full penetration type shall also be used.

4.20.1.2 Welding joint details for type C independent tanks, and for the liquid-tight primary barriers of type B independent tanks primarily constructed of curved surfaces, shall be as follows:

.1 all longitudinal and circumferential joints shall be of butt welded, full penetration, double vee or single vee type. Full penetration butt welds shall be obtained by double welding or by the use of backing rings. If used, backing rings shall be removed except from very small process pressure vessels. Other edge preparations may be permitted, depending on the results of the tests carried out at the approval of the welding procedure; and

.2 the bevel preparation of the joints between the tank body and domes and between domes and relevant fittings shall be designed according to a standard acceptable to the Administration. All welds connecting nozzles, domes or other penetrations of the vessel and all welds connecting flanges to the vessel or nozzles shall be full penetration welds.

CCS 4.20.2(1) Paragraph 4.10.1.2 is clarified as follows:

(a) The regulation 4.20.1.2 is applicable to type C independent tanks including bi-lobe tanks, primarily constructed of curved surfaces fitted with a centreline bulkhead.

(b) The applicability of the expression "Other edge preparations" is clarified as follows:

- Cruciform full penetration welded joints in a bi-lobe tank with centreline bulkhead can be accepted for the tank structure construction at tank centreline welds with bevel preparation subject to the approval of the Administration or recognised organisation acting on its behalf, based on the results of the tests carried out at the approval of the welding procedure. (See example in Figure CCS 4.20.2(1) below)

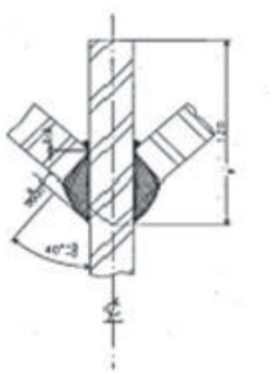


Figure CCS 4.20.2(1) Cruciform full penetration welded joints in a bi-lobe tank in way of centreline bulkhead

CCS 4.20.2(2) Tee welds of the full penetration type (cruciform welded joints) may be used in Y-connection between bi-lobe and tri-lobe tank shell and longitudinal bulkhead (for tri-lobe, also including two sloping inner walls) with the agreement of CCS.

PART E TANK TYPES

4.23 Type C independent tanks

4.23.6 Testing

4.23.6.1 Each pressure vessel shall be subjected to a hydrostatic test at a pressure measured at the top of the tanks, of not less than 1.5 Po. In no case during the pressure test shall the calculated primary membrane stress at any point exceed 90% of the yield stress of the material. To ensure that this condition is satisfied where calculations indicate that this stress will exceed 0.75 times the yield strength, the prototype test shall be monitored by the use of strain gauges or other suitable equipment in pressure vessels other than simple cylindrical and spherical pressure vessels.

CCS 4.23.6.1 For stress criteria under the test condition, the value is to be taken depending on the mesh size of the model in accordance with Table 5.6.2 (1) in Section 5 of Appendix 2 of PART TWO of the Rules.

PART G GUIDANCE

4.28 Guidance notes for chapter 4

The definition of α_β in 4.28.1.2 is revised as follows:

4.28.1.2 …

where: α_β = dimensionless acceleration (i.e. relative to the acceleration of gravity), resulting from gravitational and dynamic loads, in an arbitrary direction β (see figure 4.1).

CCS 4.28.1.2.d For acceleration ellipsoid method, Figure 4.1 of this Chapter is to be followed.

The formula in accordance with Figure CCS 4.28.1.2.d is as follows:

$$\frac{x^2}{a_x^2}+\frac{y^2}{a_y^2}+\frac{z^2}{a_z^2}=1$$

The maximum heeling angle $\theta_{max}(\alpha)$ corresponding to a certain trimming angle α:

$$\theta_{\max}(\alpha)=\arctan\left(\frac{a_y}{a_{\cancel{z}x}}\sqrt{\frac{a_x^2}{1-a_z^2}-\tan^2\alpha}\right)$$

The maximum trimming angle $\alpha_{max}(\theta)$ corresponding to a certain heeling angle θ:

$$\alpha_{\max}(\theta)=\arctan\left(\frac{a_x}{a_y}\sqrt{\frac{a_y^2}{1-a_z^2}-\tan^2\theta}\right)$$

Where: a_x, a_y, a_z —— see 4.28.2.1.

4.28.3.8 *Primary local membrane stress* arises where a membrane stress produced by pressure or other mechanical loading and associated with a primary or a discontinuity effect produces excessive distortion in the transfer of loads for other portions of the structure. Such a stress is classified as a primary local membrane stress, although it has some characteristics of a secondary stress. A stress region may be considered as local, if:

$$S_1 \leq 0.5\sqrt{Rt} \text{ and}$$
$$S_2 \geq 2.5\sqrt{Rt} \text{ ,}$$

where: S_1 = distance in the meridional direction over which the equivalent stress exceeds 1.1*f*;

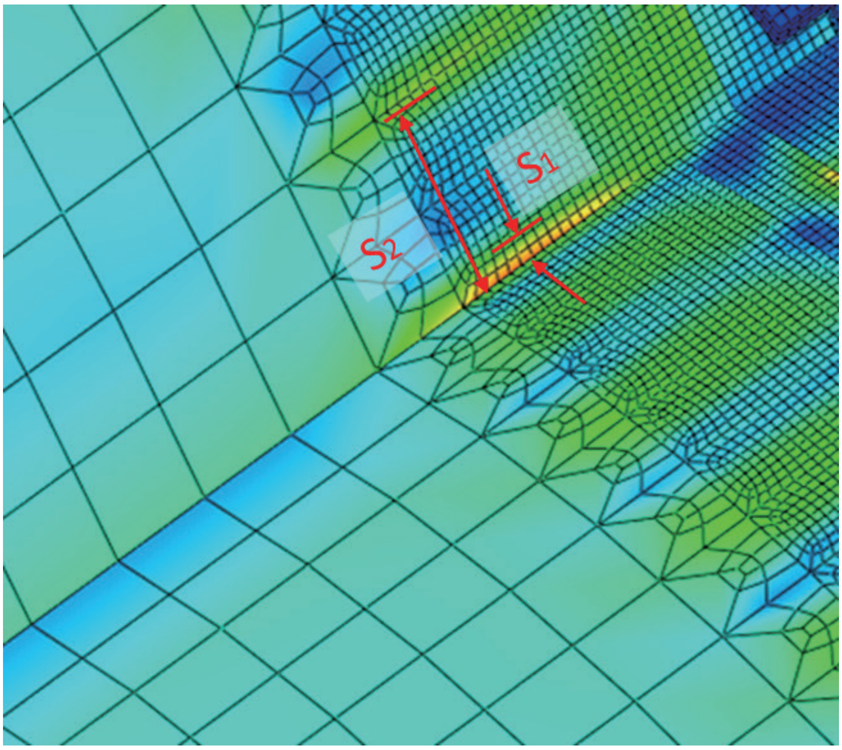
S_2 = distance in the meridional direction to another region where the limits for primary general membrane stress are exceeded;

R = mean radius of the vessel;

t = wall thickness of the vessel at the location where the primary general membrane stress limit is exceeded; and

f = allowable primary general membrane stress.

CCS 4.28.3.8 The direction of measuring S_1 and S_2 is shown in Figure CCS 4.28.3.8.



Fgiure CCS 4.28.3.8 Direction of measuring S_1 and S_2

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

5.7.2 Precautions against low temperature

Low temperature piping shall be thermally isolated from the adjacent hull structure, where necessary, to prevent the temperature of the hull from falling below the design temperature of the hull material. Where liquid piping is dismantled regularly, or where liquid leakage may be anticipated, such as at shore connections and at pump seals, protection for the hull beneath shall be provided.

CCS 5.7.2.a For positions where the risk of leakage exists (such as at shore connections and at pump seals and flanges), a drip tray is to be fitted below the position. The drip tray is to be made of low temperature resistant material and the leakage is discharged outside board through a discharge pipe leading downward and close to the water surface. Effective thermal insulation is to be provided in way of drip tray to ensure that the hull or deck structures will not suffer from super cold during the leakage of ~~LNG~~ liquid cargo.

CCS 5.7.2.b Where necessary, high temperature pipes are to be thermally isolated from the adjacent structures. In particular, the temperature of pipelines is not to exceed 220°C in gas-dangerous zones.

5.13 Testing requirements

5.13.1 Type testing of piping components

5.13.1.1 Valves①

Each type of valve intended to be used at a working temperature below -55℃ shall be subject to the following type tests:

.1 each size and type of valve shall be subjected to seat tightness testing over the full range of operating pressures for bi-directional flow and temperatures, at intervals, up to the rated design pressure of the valve. Allowable leakage rates shall be to the requirements of the Administration. During the testing, satisfactory operation of the valve shall be verified;

.2 the flow or capacity shall be certified to a recognized standard for each size and type of valve;

.3 pressurized components shall be pressure tested to at least 1.5 times the rated pressure; and

.4 for emergency shutdown valves, with materials having melting temperatures lower than 925°C, the type testing shall include a fire test to a standard acceptable to the Administration.

CCS 5.13.1.1.4 "Emergency shutdown valves, with materials having melting temperatures lower than 925°C", should not include an emergency shutdown valve in which components made of materials having melting temperatures lower than 925°C do not contribute to the shell or seat tightness of the valve.

CCS 5.13.1.a Valves

…

① Refer to SIGTTO Publication on "The Selection and Testing of Valves for LNG Applications".

CHAPTER 6 MATERIALS OF CONSTRUCTION AND QUALITY CONTROL

6.5 Welding of metallic materials and non-destructive testing

6.5.5 Production weld tests

6.5.5.2 The production tests for type A and type B independent tanks and semi-membrane tanks shall include bend tests and, where required for procedure tests, one set of three Charpy V-notch tests. The tests shall be made for each 50 m of weld. The Charpy V-notch tests shall be made with specimens having the notch alternately located in the centre of the weld and in the heat-affected zone (most critical location based on procedure qualification results). For austenitic stainless steel, all notches shall be in the centre of the weld.

6.6.2 Independent tank

6.6.2.2 For type C tanks of carbon and carbon-manganese steel, post-weld heat treatment shall be performed after welding, if the design temperature is below -10°C. Post-weld heat treatment in all other cases and for materials other than those mentioned above shall be to recognized standards. The soaking temperature and holding time shall be to the recognized standards.

CCS 6.6.2 ~~*For the post-weld heat treatment of type C independent tanks of materials other than those in 6.6.2.2, and for cargo tanks of carbon or carbon-manganese steels, the post-weld heat treatment is required by CCS.*~~ *For type C independent tanks made of materials other than carbon or carbon-manganese steels, post-weld heat treatment is normally not necessary.*

CHAPTER 8 VENT SYSTEMS FOR CARGO CONTAINMENT

8.2 Pressure relief systems

8.2.3 The setting of the PRVs shall not be higher than the vapour pressure that has been used in the design of the tank. Where two or more PRVs are fitted, valves comprising not more than 50% of the total relieving capacity may be set at a pressure up to 5% above MARVS to allow sequential lifting, minimizing unnecessary release of vapour.

CHAPTER 11 FIRE PROTECTION AND EXTINCTION

11.2.1 Irrespective of size, ships carrying products that are subject to the Code shall comply with the requirements of regulation ll-2/10.2 of the SOLAS Convention, as applicable to cargo ships, except that the required fire pump capacity and fire main and water service pipe diameter shall not be limited by the provisions of regulations ll-2/10.2.2.4.1 and ll-2/10.2.1.3, when a fire pump is used to supply the water-spray system, as permitted by 11.3.3 of the Code. The capacity of this fire pump shall be such that these areas can be protected when simultaneously supplying two jets of water from fire hoses with the largest size nozzles at a pressure of at least 0.5 MPa gauge.

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

…..

.6 exposed boundaries facing the cargo area, such as bulkheads of superstructures and deckhouses normally manned, cargo machinery spaces, store-rooms containing high fire-risk items and cargo control rooms. Exposed horizontal boundaries of these areas do not require protection unless detachable cargo piping connections are arranged above or below. Boundaries of unmanned forecastle structures not containing high fire-risk items or equipment do not require water-spray protection;

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

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

<u>*CCS 11.3.1.7.a Water spray protection should be considered for exposed embarkation stations and exposed launching routes from the life rafts stowage location to the ship side unless the life rafts are located and ready for launching at both sides.*</u>

<u>*CCS 11.3.1.7.b With reference to sub-paragraph .7 of IGC Code, paragraph 11.3.1, the survival craft on board, including remote survival craft (SOLAS regulation III/31.1.4) facing the cargo area, should be protected by a water-spray system, taking into consideration cargo area extension for fire-fighting purposes as stated in paragraph 11.1.4.*</u>

<u>*CCS 11.3.1.7.c Remote liferafts located in areas covered by water-spray protection as required in 11.3.1.6 may be considered as adequately protected.*</u>

11.3.3 The capacity of the water-spray pumps shall be capable of simultaneous protection of the greater of the following:

.1 any two complete athwartship tank groupings, including any gas process units within these areas; or

.2 for ships intended for operation as listed in 1.1.10, necessary protection subject to special consideration under 11.3.1 of any added fire hazard and the adjacent athwartship tank grouping,

in addition to surfaces specified in 11.3.1.4 to 11.3.1.8. Alternatively, the main fire pumps may be used for this service, provided that their total capacity is increased by the amount needed for the water-spray system. In either case, a connection, through a stop valve, shall be made between the fire main and water-spray system main supply line outside the cargo area.

<u>*CCS 11.3.3.a The expression "two complete athwartship tank groupings" means any two groups of tanks where one group is defined as tanks located in transverse direction from ship side to ship side. Where there is only one cargo tank occupying a hold space from ship side to ship side, it should be considered as a "grouping".*</u>

CCS 11.3.3.b "Any two complete athwartship tank groupings" should represent an area equal to the combined area of the two largest tank groupings, including any gas process units within these areas.

11.3.2.1 The system shall be capable of covering all areas mentioned in 11.3.1.1 to 11.3.1.8, with a uniformly distributed water application rate of at least 10 $l/m^2/min$ for the largest projected horizontal surfaces and 4 $l/m^2/min$ for vertical surfaces. For structures having no clearly defined horizontal or vertical surface, the capacity of the water-spray system shall not be less than the projected horizontal surface multiplied by 10 $l/m^2/min$.

11.3.2.2 On vertical surfaces, spacing of nozzles protecting lower areas may take account of anticipated rundown from higher areas. Stop valves shall be fitted in the main supply line(s) in the water-spray system, at intervals not exceeding 40 m, for the purpose of isolating damaged sections. Alternatively, the system may be divided into two or more sections that may be operated independently, provided the necessary controls are located together in a readily accessible position outside the cargo area. A section protecting any area included in 11.3.1.1 and .2 shall cover at least the entire athwartship tank grouping in that area. Any gas process unit(s) included in 11.3.1.3 may be served by an independent section.

11.3.3 The capacity of the water-spray pumps shall be capable of simultaneous protection of the greater of the following:

.1 any two complete athwartship tank groupings, including any gas process units within these areas; or

.2 for ships intended for operation as listed in 1.1.10, necessary protection subject to special consideration under 11.3.1 of any added fire hazard and the adjacent athwartship tank grouping,

in addition to surfaces specified in 11.3.1.4 to 11.3.1.8. Alternatively, the main fire pumps may be used for this service, provided that their total capacity is increased by the amount needed for the water-spray system. In either case, a connection, through a stop valve, shall be made between the fire main and water-spray system main supply line outside the cargo area.

CCS11.3.4 No matter whether the fire pumps are also used as the water supply pumps for water-spray systems or not, an additional fire pump or emergency fire pump is to be provided for water supply to water-spray system so as to provide protection for spaces mentioned in 11.3.4.

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

11.3.6 All pipes, valves, nozzles and other fittings in the water-spray system shall be resistant to corrosion by seawater. Piping, fittings and related components within the cargo area (except gaskets) shall be designed to withstand 925°C. The water-spray system shall be arranged with in-line filters to prevent blockage of pipes and nozzles. In addition, means shall be provided to back-flush the system with fresh water.

11.3.7 Remote starting of pumps supplying the water-spray system and remote operation of any normally closed valves in the system shall be arranged in suitable locations outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the protected areas.

11.5.3 Turret compartments of any ship shall be protected by internal water spray, with an application rate of not less than 10 $l/m^2/min$ of the largest projected horizontal surface. If the pressure of the gas flow through the turret exceeds 4 MPa, the application rate shall be increased to 20 $l/m^2/min$. The system shall be designed to protect all internal surfaces.

CHAPTER 12 ARTIFICIAL VENTILATION IN THE CARGO AREA

12.2.2 For permanent installations, the capacity of 8 air changes per hour shall be provided and for portable systems, the capacity of 16 air changes per hour.

CCS12.2.2.a The particulars of portable mechanical ventilators on their type, number, arrangement and accessories are to be submitted for examination in accordance with the internal and external arrangement of related spaces.

~~CCS12.2.2.b For independent cargo tank spaces, if air changes can be satisfactorily completed for the corresponding cargo tank spaces within less than 5 hours, it is acceptable that air exchanges are lower than the requirements in this paragraph, or 2 air changes per hour are carried out. It is also acceptable that oxygen content in all positions in an inerted space increases from 0% to 20% within 5 hours~~.

17.14.10 The water-spray system required by 17.18.29 and that required by 11.3 shall operate automatically in a fire involving the cargo containment system.

17.18.29 A water-spray system of sufficient capacity shall be provided to blanket effectively the area surrounding the loading manifold, the exposed deck piping associated with product handling and the tank domes. The arrangement of piping and nozzles shall be such as to give a uniform distribution rate of 10l/ m^2/ min. The arrangement shall ensure that any spilled cargo is washed away.

17.18.30 The water-spray system shall be capable of local and remote manual operation in case of a fire involving the cargo containment system. Remote manual operation shall be arranged such that the remote starting of pumps supplying the water-spray system and remote operation of any normally closed valves in the system can be carried out from a suitable location outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected.

17.18.31 When ambient temperatures permit, a pressurized water hose ready for immediate use shall be available during loading and unloading operations, in addition to the above water-spray requirements.

CHAPTER 18 OPERATING REQUIREMENTS

18.2 Cargo operations manuals

18.2.2 The content of the manuals shall include, but not be limited to:

…

.11 emergency procedures, including cargo tank relief valve isolation, single tank gas-freeing and entry and emergency ship-to-ship transfer operations.

Other (editorial changes):

The headings of 4.13.2 to 4.13.10 in Chapter 4 of PART Three of the Chinese version of Rules are all to be bolded.