RUSSIAN MARITIME REGISTER OF SHIPPING

RULES

FOR THE CLASSIFICATION AND CONSTRUCTION OF SHIPS CARRYING LIQUEFIED GASES IN BULK

ND No. 2-020101-176-E

RULE CHANGE NOTICE

ENTERS INTO FORCE:

01.07.2025

St. Petersburg
2025

RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SHIPS CARRYING LIQUEFIED GASES IN BULK

The present Rule Change Notice to the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk (hereinafter — RCN) has been approved in accordance with the established approval procedure and contains information on amendments and additions, except for editorial amendments. RCN amendments come into force on 1 July 2025.

REVISION HISTORY

RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SHIPS CARRYING LIQUEFIED GASES IN BULK

PART II. CLASSIFICATION

Item	Applicability	Description	Remarks
Para 1.26 (new)	Cargo machinery spaces and turret compartments	Requirements for location have been introduced	IGC Code (IMO resolution MSC.370(93)), paragraph 3.3
Para 1.27 (new)	Cargo control rooms	Requirements for location have been introduced	IGC Code (IMO resolution MSC.370(93)), paragraph 3.4

PART IV. CARGO CONTAINMENT

Item	Applicability	Description	Remarks
Para 19.4.8	LG carriers Cargo containment systems Alternative metallic materials	Reference to new Annex 6 "Guidelines on Acceptance of Alternative Metallic Materials for Cryogenic Service in Ships Carrying Liquified Gases in Bulk has been introduced"	

PART VI. SYSTEMS AND PIPING

Item	Applicability	Description	Remarks
Section 9 (deleted)	Cargo pump-rooms and cargo compressor rooms	Redundancy of requirements for location has been deleted	
Section 10 (deleted)	Cargo control rooms	Redundancy of requirements for location has been deleted	

PART IX. MATERIALS AND WELDING

Section 3	Containment system and piping Welding Non-destructive testing	The Section has been completely revised in order to unify the terminology and bring technical requirements into compliance with the requirements of the IGC Code and IACS unified requirements. References to applicable requirements have been updated	IGC Code IACS UR G2 (Rev.3 May 2023) IACS UR G3 (Rev.8 Oct 2023)

ANNEXES TO THE RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SHIPS CARRYING LIQUEFIED GASES IN BULK

Annex 6 (new)	LG carriers Alternative metallic materials Specifications and testing	New Annex 6 "Guidelines for the Acceptance of Alternative Metallic Materials for Cryogenic Service in Ships Carrying Liquified Gases in Bulk" has been introduced	IMO circulars: MSC.1/Circ.1622 MSC.1/Circ.1648

RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SHIPS CARRYING LIQUEFIED GASES IN BULK

PART II. SHIP ARRANGEMENT

1 GENERAL

New para 1.26 is introduced reading as follows:

"**1.26 Cargo machinery spaces and turret compartments.**

1.26.1 Cargo machinery spaces shall be situated above the weather deck and located within the cargo area. Fire integrity of bulkheads and decks of cargo machinery spaces and turret compartments shall comply with the requirements of 2.4.2 of Part VI "Fire Protection" of the Rules for the Classification imposed on cargo pump rooms.

1.26.2 When cargo machinery spaces are located at the after end of the aftermost hold space or at the forward end of the foremost hold space, the limits of the cargo area, as defined in 1.2.1 Part I "Classification", shall be extended to include the cargo machinery spaces for the full breadth and depth of the ship and the deck areas above those spaces.

1.26.3 Where the limits of the cargo area are extended by 1.26.2, the bulkhead that separates the cargo machinery spaces from accommodation and service spaces, control stations and machinery spaces of category A shall be located so as to avoid the entry of gas to these spaces through a single failure of a deck or bulkhead.

1.26.4 Cargo compressors and cargo pumps may be driven by electric motors in an adjacent gas-safe space separated by a bulkhead or deck, if the seal around the bulkhead penetration ensures effective gastight segregation of the two spaces. Alternatively, such equipment may be driven by certified safe electric motors adjacent to them if the electrical installation complies with the requirements of Part VII "Electrical Equipment".

1.26.5 Arrangements of cargo machinery spaces and turret compartments shall ensure safe unrestricted access for personnel wearing protective clothing and breathing apparatus, and in the event of injury to allow unconscious personnel to be removed. At least two widely separated escape routes and doors shall be provided in cargo machinery spaces, except that a single escape route may be accepted where the maximum travel distance to the door is 5 m or less.

1.26.6 All valves necessary for cargo handling shall be readily accessible to personnel wearing protective clothing.

1.26.7 Turret compartments shall be designed to retain their structural integrity in case of explosion or uncontrolled high-pressure gas release (overpressure and/or brittle fracture). A risk analysis with due consideration of the capabilities of the pressure relieving devices shall be conducted to substantiate the turret compartments characteristics.".

New para 1.27 is introduced reading as follows:

"**1.27 Cargo control rooms.**

1.27.1 Any cargo control room shall be above the weather deck and may be located in the cargo area. The cargo control room may be located within the accommodation spaces, service spaces or control stations, provided the following conditions are complied:

.1 the cargo control room is a gas-safe space;

.2 if the entrance complies with the requirements of 1.5.2 of this Part and 8.3.1 of Part VI "Systems and Piping", the control room may have access to the spaces described above; and

.3 if the entrance does not comply with 1.5.2 of this Part, the cargo control room shall have no access to the spaces described above, air inlets and openings shall comply with 1.5.7 and 1.12 of this Part and 8.3.1 of Part VI "Systems and Piping", the boundaries for such spaces shall be insulated to "A-60" class.

1.27.2 If the cargo control room is considered as gas-safe space, instrumentation shall, as far as possible, be by indirect reading systems.

The instrumentation shall, in any case, be designed to prevent any escape of gas into the atmosphere of the cargo control room.

Location of the gas detection system within the cargo control room does not cause the room to be considered as gas-dangerous space, if installed in accordance with Section 6 of Part VIII "Instrumentation and Automation Systems".

1.27.3 If the cargo control room for ships carrying flammable cargoes is considered as gas-dangerous space, sources of ignition shall be excluded and electrical equipment shall comply with the requirements of Part VII "Electrical Equipment".".

PART IV. CARGO CONTAINMENT

19 MATERIALS

19.4 THERMAL INSULATION AND OTHER MATERIALS USED IN CARGO CONTAINMENT SYSTEMS

New para 19.4.8 is introduced reading as follows:

"**19.4.8** When using metallic materials not listed in Tables 2.1-2 — 2.1-4, Part IX "Materials and Welding", provisions of Annex 6 ("Guidelines on the Acceptance of Alternative Metallic Materials for Cryogenic Service in Ships Carrying Liquified Gases in Bulk") shall be applied.".

PART VI. SYSTEMS AND PIPING

9 CARGO PUMP ROOMS AND CARGO COMPRESSOR ROOMS

Section 9 is deleted.

10 CARGO CONTROL ROOMS

Section 10 is deleted.

11 USE OF CARGO AS FUEL

Section 11 and **references thereto** are renumbered **9**.

Paras 11.1 — **11.17** and **references thereto** are renumbered **9.1** — **9.17** accordingly.

12 TESTING

Section 12 and **references thereto** are renumbered **10**.

Paras 12.1 — **12.2** and **references thereto** are renumbered **10.1** — **10.2** accordingly.

PART IX. MATERIALS AND WELDING

Section 3 is replaced by the following text:

"3 WELDING AND NON-DESTRUCTIVE TESTING

3.1 GENERAL

3.1.1 These requirements shall apply to welds of primary and secondary barriers, welds of inner hull where this forms the secondary barrier as well as welds of cargo and process piping including boil-off gas piping, gas fuel piping, exhausts and other.

The requirements of this Section are employed for welds made of carbon, carbon-manganese, nickel alloy and stainless steels, and may form the basis for weld testing of other material upon agreement with the Register in each particular case.

3.1.2 Impact tests of specimens from welded joints of aluminium alloys are not required. Impact tests of specimens from stainless steel welds shall be conducted on agreement with the Register, in case this type of testing is provided for the base metal by the rules or the documentation approved by the Register. Unless otherwise agreed, the temperature and estimation criteria for the impact test results shall comply with the values specified for the base metal.

3.1.3 The Register may demand other types of testing for any material of structures specified herein.

3.1.4 Requirements for weld joints.

Requirements for design (selection) of weld joints for cargo tanks of types A, B and C and process requirements for them are given in 20.2, Part IV "Cargo Containment".

Requirements for piping welds are specified in 2.3.2, Part VI "Systems and Piping".

3.2 WELDING CONSUMABLES

3.2.1 Welding consumables intended for welding of cargo tanks shall be approved by the Register, have the relevant Certificate of Approval for Welding Consumables and be in compliance with the standards and/or specifications agreed with the Register.

Deposited weld metal tests and butt weld tests shall be conducted for all welding consumables, unless otherwise stated.

Requirements for approval of welding consumables, in particular, regarding test results of specimens for tensile and impact tests are given in Section 4, Part XIV "Welding" of the RS Rules/C.

The chemical composition of the deposited weld metal hall be determined during the tests.

3.3 APPROVAL OF WELDING PROCEDURES FOR CARGO TANKS, PROCESS PRESSURE VESSELS, SECONDARY BARRIERS AND PIPING

3.3.1 Welding procedures shall be approved for all butt welds.

3.3.2 Welding of specimens for welding procedure approval shall be conducted for:

each base metal;

each type of consumable and welding process;

each welding position.

3.3.3 Butt test assemblies in steel plates shall be so prepared that the rolling direction is parallel to the direction of welding.

The range of thicknesses qualified by each welding procedure test is established taking into account requirements of Tables 6.6.2.2.2 and 6.6.2.2.9 (for steels) or Tables 7.5.2.2 and 7.5.2.4 (for aluminium alloys) of Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships[1].

Non-destructive testing of weld test assemblies shall be performed in compliance with the requirements of Table 6.4.1.1 (for steels) or Table 7.3.2.1 (for aluminium alloys) of Part III "Technical Supervision during Manufacture of Materials" of the Rules TSDCS.

3.3.4 Mechanical tests of weld specimens made from each butt weld assembly shall comply with the applicable requirements of Section 6, Part III "Technical Supervision during Manufacture of Materials" of the Rules TSDCS and 4.2, Part XIV "Welding" of the RS Rules/C and provide following types of testing:

.1 transverse flat tensile tests;

.2 longitudinal cylindrical tensile tests;

.3 transverse root bend and face bend tests. For different butt welds, longitudinal bend tests may be required in lieu of transverse bend tests;

.4 impact tests shall include series from three Charpy V-notch type specimens according to Fig. 3.3.4.4:

notch in center of weld (*1*);

notch on fusion line (FL) (*2*);

notch in HAZ, 1 mm from fusion line (*3*);

notch in HAZ, 3 mm from fusion line (*4*);

notch in HAZ, 5 mm from fusion line (*5*);

[1] Hereinafter referred to as "the Rules TSDCS".

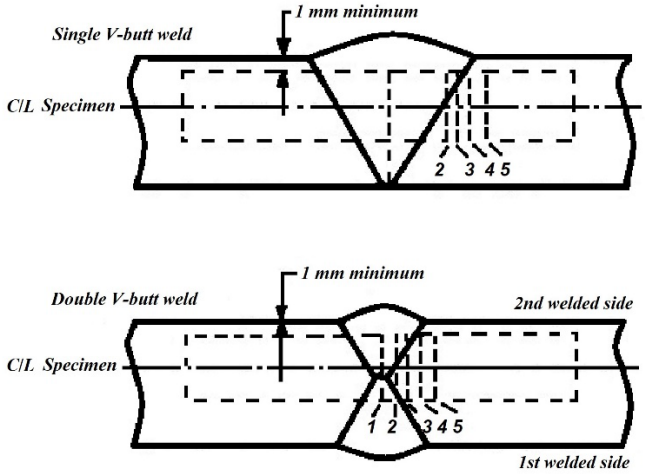

Fig. 3.3.4.4
Location of V-notch on specimens for impact test

.5 macrosection examination and hardness test.

3.3.5 Mechanical test results of weld specimens shall comply with the requirements of 3.3.5.1 — 3.3.5.3.

3.3.5.1 Transverse flat tensile tests.

Tensile strength (cross-weld tensile strength) in testing of welded joints shall not be less than required for the base metal. For materials with weld metal strength of under matched welds (where the weld metal has a lower tensile strength than the base metal), reference shall be made to 18.2.4, Part IV "Cargo Containment". In every case, during static tensile tests the position of fracture shall be recorded for base metal or for weld metal.

3.3.5.2 Transverse impact test.

During bend testing until the bending angle of 180° is reached on the mandrel diameter equal to four specimen thicknesses, after the testing, no defects more than 3 mm in length shall appear on the specimen surface. Cracks appearing at the corners of a test specimen during testing shall be neglected.

3.3.5.3 Charpy V-notch impact tests.

Charpy tests shall be conducted at the temperature prescribed for the base materials being joined according to values given in Tables 2.1-1 — 2.1-4.

In impact test of the weld metal (specimens with notch in center of weld), the impact energy value shall be at least 27 J.

The requirements in testing of subsize specimens and the permissible impact energy value for a single specimen shall be in accordance with 2.2.3.1 and Table 2.2.3.1-4, Part XIII "Materials" of the RS Rules/C. The impact tests on subsize specimens with thickness of less than 2,5 mm shall not be performed.

The results of fusion line and heat affected zone impact tests shall meet the requirements for the base material for longitudinal or transverse specimens whichever is applicable.

3.3.6 Approval of welding procedures for corner, lap, (T-) and cruciform joints fillet-welded in plate.

The requirements for fillet welding procedures are given in 6.3.1.4 — 6.3.1.5, Part III "Technical Supervision during Manufacture of Materials" of the Rules TSDCS. Welding consumables shall be selected which exhibit Charpy V-notch impact properties complying with the Register requirements.

3.4 APPROVAL OF WELDING PROCEDURES FOR PIPING

3.4.1 Welding procedures for piping shall be approved in compliance with applicable requirements for testing given in 3.3 of the Section taking into account applicable requirements of Section 6, Part III "Technical Supervision during Manufacture of Materials" of the Rules TSDCS.

3.5 MECHANICAL PRODUCTION WELD TESTS

3.5.1 For all cargo tanks and process pressure vessels except integral and membrane tanks, mechanical production weld tests shall generally be performed for approximately each 50 m of butt-welded joints and shall be representative of each welding position.

For secondary barriers, the same type production tests shall be performed, but their scope may be reduced on agreement with the Register.

Tests, other than those specified in 3.5.2 — 3.5.5, may be required for cargo tanks or secondary barriers at the discretion of the Register.

Mechanical test shall be conducted in compliance with the requirements of 3.3.5.

3.5.2 Mechanical production weld tests for types A and B independent tanks and semi-membrane tanks shall be conducted in scope of transverse tensile test and impact test of weld specimens if required for approval of welding procedures. One series of three Charpy V-notch specimens shall be tested for each 50 m of weld. The impact tests shall be made with specimens having the notch located either in the centre of the weld or in the heat affected zone (most critical location based on procedure qualification results where tests results have lower values). For specimens of austenitic stainless steel, all notches shall be in the centre of the weld.

3.5.3 For type C independent tanks and process pressure vessels, transverse weld tensile tests are required in addition to the tests listed in 3.5.2. These tests shall meet the requirements of 3.3.5.1.

3.5.4 The test program shall be developed by the firm (manufacturer) based on provisions of 3.5.1 — 3.5.5 and shall be approved by the Register.

3.5.5 Production weld tests for integral and membrane cargo tanks shall be performed in accordance with 3.3.

3.6 PRODUCTION NON-DESTRUCTIVE TESTING

3.6.1 Non-destructive testing and quality assessment shall be in accordance with the requirements of Section 3, Part XIV "Welding" of the RS Rules/C and requirements given below. Radiographic testing (hereinafter, RT) of welded joints shall be used, in principle, to detect internal defects. Alternatively, a non-destructive ultrasonic testing (UT) procedure in lieu of radiographic testing may be conducted considering possibility of its performance depending of material to be welded and weld thicknesses and provided, that not less than 10 % from the number of areas tested with UT are supplementary tested with RT. Supplementary RT shall be carried out at areas previously tested by UT. UT results are deemed satisfactory only upon satisfactory results of supplementary RT.

3.6.2 For type A independent tanks and semi-membrane tanks, where the design temperature is below –20 °C, and for type B independent tanks, regardless of temperature, all full penetration butt welds of the shell plating of cargo tanks shall be subjected to

non-destructive testing suitable to detect internal defects over their full length. UT in lieu of RT may be carried out under the same conditions as described in 3.6.1.

N o t e . Design temperature means the minimum temperature for selection of materials at which the cargo may be loaded on board and/or transported in the cargo tanks.

3.6.3 Where the design temperature is higher than –20 °C, all full penetration butt welds in way of intersections and at least 10 % of the remaining full penetration butt welds of tank structures shall be subjected to RT or UT provided the conditions given in 3.6.1 are met.

3.6.4 The welds of other cargo tank structures including the welding of stiffeners and other fittings and attachments shall be subjected to magnetic particle or dye penetrant testing on agreement with the Register, as considered necessary. Magnetic particle testing is not allowed to stainless steel structures.

3.6.5 For type C independent tanks and process pressure vessels, the extent of non-destructive testing shall be total or partial according to RS approved manufacture quality standards, but the controls to be carried out shall not be less than those specified in 3.6.5.1 and 3.6.5.2.

3.6.5.1 Total non-destructive testing includes:

.1 RT of all butt welds over their full length;

.2 dye penetrant or magnetic particle testing (depending on the material of cargo tank) for surface crack detection of all welds to the extent not less than 10 % of their full length;

.3 dye penetrant or magnetic particle testing of welds of reinforcement rings around holes, nozzles, etc., over their full length.

As an alternative, UT as described in 3.6.1 may be accepted as a partial substitute for the RT. In addition, total ultrasonic testing on welding of reinforcement rings around holes, nozzles, etc. may be required by the Register.

3.6.5.2 Partial non-destructive testing includes:

.1 RT of all full penetration butt-welded crossing joints (butt – seam) and at least 10 % of the full length of full penetration butt welds at selected positions uniformly distributed;

.2 dye penetrant or magnetic particle testing (depending on the material of cargo tank) for surface crack detection of reinforcement rings around holes, nozzles, etc., over their full length;

.3 UT may be additionally required by the Register in each particular case.

3.6.6 Methods, instructions (working procedures) for each method of non-destructive testing of welds shall ensure its proper performance in accordance with quality manual adopted at the manufacturer and RS-recognized standards and Section 3, Part XIV "Welding" of the RS Rules/C.

3.6.7 Non-destructive testing of piping located inside and outside cargo tanks shall be carried out to the extent of the following:

.1 visual testing over the full length;

RT or UT (if applicable) over the full length in the following cases:

piping design temperature is less than – 10 °C, or

for piping with inside diameter of more than 75 mm or wall thicknesses greater than 10 mm;

.2 when such butt-welded joints of piping sections are made by automatic or fully mechanical welding procedures approved by the Register and satisfactory quality of welds is documented, then a progressive reduction in the extent of RT or UT can be agreed, but in no case to less than 10% of each joint. If impermissible defects are revealed, the extent of examination shall be increased to 100% and shall include inspection of previously accepted

welds. This agreement can only be granted if results of non-destructive testing are submitted regularly that confirms the ability to produce satisfactory welds consistently;

.3 for other butt-welded joints of pipes not covered by 3.6.7.1 and 3.6.7.2, spot non-destructive tests shall be carried out in compliance with the requirements of 3.3.4, Part XIV "Welding" of the RS Rules/C taking into account pipe class and material. Herewith, at least 10 % of butt-welded joints of pipes shall be subjected to RT or UT (if applicable).

.4 parts of the gas fuel piping that are not enclosed in a ventilated pipes or ducts according to 11.2, Part VI "Systems and Piping", and are on the weather decks outside the cargo area, shall have full penetration butt-welded joints and shall be subjected to full RT or UT (if applicable) over their full length.

3.6.8 After visual testing the welds of secondary barrier structures are subject to RT or UT (if applicable) for inner defect detection in the scope agreed with the Register.

Where the outer shell of the hull is part of the secondary barrier, all sheer strake butts and the intersections of all butts and seams in the side shell are subject to RT or UT provided the conditions given in 3.6.1 are met.

3.7 POST-WELD HEAT TREATMENT

3.7.1 For type C independent tanks of carbon or carbon-manganese steel, post-weld heat treatment shall be performed after welding, if the design temperature is below – 10 °C. Heat-treatment modes (soaking temperature and holding time) shall meet the RS-agreed standards.

3.7.2 In the case of type C independent tanks and large cargo pressure vessels of carbon or carbon-manganese steel, for which it is difficult to perform the heat treatment, mechanical stress relieving by pressurizing may be carried out as an alternative to the heat treatment and subject to the following conditions:

.1 complicated welded pressure vessel parts such as sumps or domes with nozzles (hatches), shall be heat treated before they are welded to larger parts (shell plates) of the pressure vessel;

.2 the mechanical stress relieving process shall preferably be carried out during the hydrostatic pressure test measured in the upper tank part and being not less than $1,5P_o$ (where P_o is a design pressure, in MPa). The pressurizing medium shall be water;

.3 the temperature of the water used for the hydrostatic test shall be at least 30 °C above nil-ductility transition temperature of the structure material;

.4 stress relieving shall be performed while the tank is supported by its regular saddles or supporting structure or, when stress relieving cannot be carried out on board, in a manner which will give the same stresses and stress distribution as when supported by its regular saddles or supporting structure;

.5 the maximum stress relieving pressure shall be held for 2 h per 25 mm of thickness, but in no case less than 2 h;

.6 the upper limits placed on the calculated stress levels during stress relieving shall be the following:

equivalent general primary membrane stress equal to 0,9 R_e;

equivalent (given) stress composed of primary bending stress plus membrane stress equal to 1,35 R_e where R_e is the specific lower minimum yield stress or 0,2 % proof stress ($R_{p0,2}$) at test temperature of the steel used for the tank;

.7 strain measurements will normally be required to prove these limits for at least the first tank of a series of identical tanks built consecutively. The location of strain gauges shall

be included in the mechanical stress relieving procedure to be submitted in accordance with 3.7.2;

.8 the test procedure shall demonstrate that a linear relationship between pressure and strain is achieved at the end of the stress relieving process when the pressure is raised again up to the design pressure;

.9 high-stress areas in way of geometrical discontinuities such as nozzles and other openings shall be checked for cracks by dye penetrant or magnetic particle inspection after mechanical stress relieving. Particular attention in this respect shall be paid to plates exceeding 30 mm in thickness;

.10 steels which have a ratio of yield stress to ultimate tensile strength greater than 0,8 shall generally not be mechanically stress relieved. If, however, the yield stress is raised by a method giving high ductility of the steel, slightly higher rates may be accepted upon consideration in each case;

.11 mechanical stress relieving may not be substituted for heat treatment of cold formed parts of tanks (by bending or stamping) in cases when such heat treatment is required at this type of manufacture;

.12 the thickness of the shell and bottoms of the tank shall not exceed 40 mm. Higher thicknesses may be accepted for parts which are thermally stress relieved;

.13 local buckling shall be guarded against, particularly when tori-spherical heads are used for domes and bottoms of tanks;

.14 the procedure (instructions) for mechanical stress relieving shall be to a recognized standard.

3.7.3 Post-weld heat treatment shall be performed for all butt welds of pipes made with carbon, carbon-manganese or low alloy steels located inside and outside cargo tanks. Upon agreement with the Register, thermal stress relieving may be omitted for pipes with wall thickness less than 10 mm in relation to the design temperatures and pressure of the piping system concerned.".

ANNEXES TO THE RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SHIPS CARRYING LIQUEFIED GASES IN BULK

New Annex 6 is introduced reading as follows:

"ANNEX 6

GUIDELINES ON THE ACCEPTANCE OF ALTERNATIVE METALLIC MATERIALS FOR CRYOGENIC SERVICE IN SHIPS CARRYING LIQUIFIED GASES IN BULK

1 APPLICATION

1.1 Guidelines on the Acceptance of Alternative Metallic Materials for Cryogenic Service in Ships Carrying Liquified Gases in Bulk (hereinafter — these Guidelines) apply to metallic materials not listed in Tables 2.1-2 — 2.1-4, Part IX "Materials and Welding". The testing requirements set out herein provide guidance for the acceptance of alternative metallic materials based upon the equivalency provisions contained in Section 1.3 of the International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)[1]. These Guidelines apply to materials used for containment and transportation of substances specified in Annex 1.

1.2 The Guidelines also apply to alternative metallic materials having a minimum design temperature between 0 °C and –165 °C or lower if agreed by the Register in the range of minimum and maximum thicknesses tested during the approval process, up to a maximum thickness of 40 mm. Thicknesses in excess of 40 mm shall be approved by the Register. In addition to approval for a minimum design temperature of –165 °C, alternative metallic materials may be approved for intermediate minimum design temperatures of –55 °C, –60 °C, –65 °C, –90 °C and –105 °C. Alternative metallic materials qualified at a lower temperature are suitable for use at the intermediate minimum design temperature.

1.3 These Guidelines only apply to alternative metallic materials formed or manufactured by rolling, extrusion, casting or forging.

1.4 Alternative metallic materials approved in accordance with the Guidelines may be used in the cargo containment and piping systems in compliance with Part IV "Cargo Containment" and/or Section 2.1, Part VI "Systems and Piping". Materials shall be approved for specific cargoes listed in the LG Rules, based upon their design temperature and their compatibility with the cargo. These Guidelines do not address material forming part of the hull structure.

1.5 These Guidelines apply to alternative metallic materials formed or manufactured by rolling, extrusion, casting or forging.

1.6 Alternative metallic materials approved in accordance with the Guidelines may be used in the construction of cargo containment and piping system according to Part IV "Cargo Containment" and/or 2.1, Part VI "Systems and Piping". They should be approved for specific cargoes or fuels listed in the LG Rules based upon their design temperature and their compatibility with the cargo or fuel. These Guidelines do not cover material forming part of the hull structure.

[1] Hereinafter referred to as "the IGC Code".

2 DEFINITIONS

2.1 The following definitions have been adopted for these Guidelines.

Alternative metallic materials are homogeneous ferrous and non-ferrous alloys having uniform composition in any direction formed by hot rolling, cold rolling, extrusion, casting or forging, whose compositions or heat treatments are not listed in Tables 2.1-2 — 2.1-4, Part IX "Materials and Welding".

Other alternative metallic materials are metallic materials having mechanical properties that do not meet those listed in Tables 2.1-2 — 2.1-4, Part IX "Materials and Welding".

Established metallic materials are metallic materials listed in Tables 2.1-2 — 2.1-4, Part IX "Materials and Welding".

Equivalent alternative metallic materials are metallic materials having chemical and mechanical properties that are equivalent or superior to those listed in Tables 2.1-2 — 2.1-4, Part IX "Materials and Welding", that have been approved under these Guidelines.

Recognized standards – refer to the definition in 1.1.2, Part I "Classification" of the Rules for Classification and Construction of Sea-Going Ships[1].

[1] Hereinafter referred to as "the Rules for Classification".

3 MATERIAL SPECIFICATION AND TESTING REQUIREMENTS

3.1 Material specification.

3.1.1 All alternative metallic materials shall have a recognized standard for cryogenic service for consideration under these Guidelines. The standard shall cover specific forms of the material being approved (forms), including plates, sections, castings, forgings or pipes, and shall specify heat treatment and grain structure. The standard shall meet the scope and general requirements of Section 1, Part IX "Materials and Welding". Micro-alloying elements not identified in the recognized standards may be considered subject to approval by the Register.

3.1.2 Alternative metallic material, including plates, castings and forgings, shall be joined using an approved method specified by a recognized standard. When applied, conventional welding procedures qualified in accordance with a recognized standard and complying with requirements of Section 3, Part IX "Materials and Welding". The welding procedures shall specify heat input and pre- and post-weld heat treatment.

3.1.3 Welding procedures and non-destructive testing (NDT) shall be specified for all alternative metallic materials. These procedures shall conform to a recognized standard and comply with testing requirements specified in Section 3, Part IX "Materials and Welding".

3.2 Testing.

3.2.1 Test requirements are provided in Section 4.

3.2.2 Depending on the design temperature, Charpy V-notch tests shall be conducted in accordance with the footnotes in the applicable Tables 2.1-2 – 2.1-4, Part IX "Materials and Welding".

3.2.3 Test methods, not specified in this Section, are subject to approval of the Register provided for a valid technical justification, ensuring an equivalent level of safety by use of an alternative test method. Test requirements may be waived if not required for specific tank types within Part IV "Cargo Containment" or if not required for similar established metallic materials.

3.2.4 The testing of alternative metallic material shall be conducted on at least one of the following forms: plates, castings, forgings or pipes. The testing of any form shall meet the sampling and specimen position requirements of Section 2, Part IX "Materials and Welding". Initial testing shall be conducted on the form reflecting the application of an alternative metallic material. Approval is limited to forms for which test results are provided. All above forms do not have to be considered for approval of the alternative metallic material.

3.2.5 When corrosion sensitization occurs in stainless and other austenitic steels the Register may require additional corrosion testing such as an Intergranular Corrosion Test such as ASTM A262 and a Stress Corrosion Cracking Test such as ASTM G36 or ASTM G123.

3.3 Acceptance criteria.

3.3.1 Test acceptance criteria are provided in Section 4.

3.3.2 The application of an alternative metallic material in a specific design shall be based upon the adequacy of the material for the design loads and the suitability of the material properties for their intended use in accordance with the design conditions specified in Section 18, Part IV "Cargo Containment".

3.3.3 Approval of alternative metallic materials shall be for each form of the material based on the satisfactory test results.

3.4 Novel design and equivalent arrangements.

3.4.1 Alternative metallic materials may be used in the design of novel containment systems in accordance with Section 27, Part IV "Cargo Containment". The use of other alternative metallic materials shall not be considered by these Guidelines.

3.5 Approval procedure.

3.5.1 Upon satisfactory completion of testing of the appropriate forms and acceptance of the results, an alternative metallic material is considered to be an accepted equivalent alternative metallic material.

3.5.2 The approval shall specify any limitations that have been identified in the inherent properties of the approved alternative metallic material that may need to be considered in its use. These properties may include, but are not limited to:

under-matching/over-matching of welds;

pre- and post-weld heat treatment;

corrosion resistance;

specific NDT requirements;

toxicity of welding fumes.

3.5.3 Tables 2.1-2 — 2.1-4, Part IX "Materials and Welding" may be modified to incorporate new alternative metallic materials under the following conditions:

material shall be approved in accordance with the provisions of these Guidelines;

material compatibility for all intended cargoes shall be demonstrated;

relevant fabrication experience on any tank type on a ship shall be documented;

material shall have minimum of 5 years of service experience on board a ship or equivalent to one special survey cycle;

service experience shall be on a ship in service in cargo containment and piping systems;

if simulation is used, credit may be given to a reduced service period upon completion of the first intermediate survey. The scope of this survey shall be in accordance with the requirements of the first special survey, including NDT, of the tank.

3.6 Safety factors.

3.6.1 Safety factors shall be approved based upon those for nickel steels, carbon manganese steels, austenitic steels or aluminium alloys in the IGC Code and approved by the Register.

4 MATERIAL TESTING REQUIREMENTS AND ACCEPTANCE CRITERIA

4.1 Test of base material.

4.1.1 Technical specifications.

4.1.1.1 Chemical composition and mechanical properties shall meet the requirements of an agreed standard for the alternative metallic material intended for cryogenic service.

4.1.1.2 Acceptance criteria shall be in accordance with the agreed standard.

4.1.2 Micrographic examination.

4.1.2.1 The test shall be carried out in accordance with 1.9, Part IX "Materials and Welding" and agreed standards, e.g. ASTM E112.

4.1.2.2 Acceptance criterium is microstructure including grain size, namely the absence of precipitations, segregation and cracking. Acceptance shall be carried out according to the RS-approved program.

4.1.3 Tensile test.

4.1.3.1 The test shall be carried out in accordance with 1.4, Part IX "Materials and Welding". Samples shall be taken from three heats of different compositions, both at room and

cryogenic temperatures equal to the minimum design temperature of the material. The number of samples shall be sufficient to provide statistically valid results.

4.1.3.2 Acceptance criteria are the yield strength, tensile strength and elongation. The criteria shall be in accordance with the recognized standard for the chemical composition given in 4.1.1.

4.1.4 Charpy impact test.

4.1.4.1 The test shall be carried out in accordance with 1.3, Part IX "Materials and Welding". Samples shall be taken from three heats of different compositions, both at room and cryogenic temperatures equal to the required test temperature. Impact tests shall be carried out for austenitic steels as well. Test temperatures shall meet the requirements of Table 4.1.4.1.

Table 4.1.4.1

Material thickness, *t*, in mm	**Test temperature, in °C**
$t < 25$	5 °C below design temperature (ferritic steel only)
$25 < t \leq 30$	10 °C below design temperature
$30 < t \leq 35$	15 °C below design temperature
$35 < t \leq 40$	20 °C below design temperature

4.1.4.2 Acceptance criterium is the minimum average energy in accordance with Table 4.1.4.2 (unless higher values are required by material specification).

Table 4.1.4.2

Material	**Test piece**	**Minimum average energy, *KV***
Ferrous alloy plates	Transverse	27 J
Ferrous alloy sections and forgings	Longitudinal	41 J
Non-Ferrous alloy	-	Not required, subject to the RS approval

4.1.5 Charpy impact test on strain aged specimens.

4.1.5.1 The test shall be carried out in accordance with an agreed standard such as ASTM E23. Strain ageing consists of 5 % deformation for 1 h at 250 °C in accordance with 2.2.3.4, Part XIII "Materials" of the Rules for Classification. Samples shall be taken from three heats of different compositions, both at room and cryogenic temperatures equal to the minimum test temperature. Impact tests shall be carried out for austenitic steels as well. Test temperatures shall meet the requirements of Table. 4.1.5.1.

Table 4.1.5.1

Material thickness, in mm	**Test temperature, in°C**
$t < 25$	5 °C below design temperature (ferritic steel only)
$25 < t \leq 30$	10 °C below design temperature
$30 < t \leq 35$	15 °C below design temperature
$35 < t \leq 40$	20 °C below design temperature

4.1.5.2 Acceptance criterium is the minimum average energy in accordance with Table 4.1.5.2 (unless higher values are required by material specification).

Table 4.1.5.2

Material	Test piece	Minimum average energy, *KV*
Ferrous alloy plates	Transverse	27 J
Ferrous alloy sections and forgings	Longitudinal	41 J
Non-Ferrous alloy	–	Not required, subject to the Register approval

4.1.6 Drop weight test.

4.1.6.1 The testing is applicable only for ferritic steels including ferritic-austenitic (duplex) grade. The aim of the test is to establish the nil ductility transition temperature (NDTT). Samples shall be taken from three heats of different compositions, both at room and cryogenic temperatures equal to the minimum test temperature. The test shall be carried out in accordance with 2.2.6, Part XIII "Materials" of the Rules for Classification or an agreed standard such as ASTM E208 for ferritic steels.

4.1.6.2 Acceptance criterium is no break at 10 °C below the design temperature.

4.1.7 Fatigue test.

4.1.7.1 The basis for documenting adequate fatigue performance (*S — N* curves) for alternative metallic materials shall be in accordance with 18.3.4.2, Part IV "Cargo Containment". The extent of fatigue testing is based on comparison with recognized *S — N* curves for metallic materials (such as IIW or BS 7608).

The fatigue tests shall be based on a minimum of five test samples at each stress level. For a "one slope *S — N* curve" a minimum of three stress levels shall be tested. Additional stress levels are to be tested for "two slope *S — N* curves". As guidance, stress levels shall be selected to achieve in the range of 10^5 до 10^8 cycles.

4.1.7.2 Acceptance criterium is the fatigue test results that shall be at least equal to or better than the reference *S — N* curve.

4.1.8 Crack Tip Opening Displacement (*CTOD*) test.

4.1.8.1 The test shall be carried out in accordance with an agreed standard such as ASTM E1820, BS 7448 or ISO 12135.

4.1.8.2 Acceptance criterium is *CTOD* minimum value which shall be in accordance with the design specification for testing at room and cryogenic temperatures equal to the minimum design temperature of the material. A minimum of three successful tests shall be performed at room and cryogenic temperatures. As guidance a minimum *CTOD* value of 0,2 mm is often required.

4.1.9 Corrosion test.

4.1.9.1 The type of corrosion tests to be applied shall depend on the material to be qualified, type of weld and the specific cargoes (refer to Annex 1). The tests shall include tests for general corrosion, intergranular corrosion and stress corrosion. The test shall be carried out in accordance with agreed standards such as ASTM A262, ASTM G31, ASTM G36, ASTM G58 or ASTM G123. In the absence of a relevant agreed standard for the specific cargo, the test procedures shall align with the general principles of corrosion tests that follow the agreed standards listed herein.

4.1.9.2 Acceptance criteria shall be in accordance with the relevant recognized standard. In the absence of a relevant recognized standard for the specific cargoes, the projected corrosion rates and test outcomes shall be approved by the Register.

4.1.10 Corrosion test for ammonia compatibility.

4.1.10.1 The test shall be carried out in accordance with an agreed standard such as ASTM B858, taking into consideration the requirements of 4.1.10.1.1 – 4.1.10.1.3.

4.1.10.1.1 Specimens shall be prepared in accordance with standards ISO 7539-2 and ISO 16540. The specimens shall be bent, prior to testing, using the four points bending test under constant strain. The total maximum strain of the sample shall be equal to the yield strength of the material at atmospheric temperature. Strain gauges shall be applied to measure the strain applied. In the case of welded specimens, strain gauges shall be applied to each side of the welded joint. The sample shall be constrained to maintain its form during testing.

4.1.10.1.2 Two specimens (one welded and one base metal) shall each be immersed in the following four ammonia environments for a period of 30 days:

liquid phase ammonia environments obtained by cooling of ammonia below liquefaction temperature with the following liquid ammonia compositions:

0,1 % weight of water and 2,5 ppm of oxygen (type 1); and

2,5 ppm of oxygen (type 2).

gas phase ammonia environments, at ambient temperature and atmospheric pressure with the following compositions:

pure ammonia (type 3); and

0,9 % volume of oxygen and 99,1 % volume of ammonia (type 4).

Stress corrosion cracking tests shall be performed in agreement with requirements of standards ISO 7539 and ISO 16540.

4.1.10.1.3 Test report shall provide all procedures, set-up data, examinations, information about the environment, in agreement with standard ISO 16540 and include:

the orientation, types and dimensions of specimens;

four points bending test set-up data;

target stress and applied deflection;

strain measurement procedures;

loading procedures; and

test environment.

4.1.10.2 Acceptance criterium is the presence of stress corrosion cracking examined under an optical microscope with proper magnification. The location and the number of cracks shall be specified, and a dye penetrant test performed to confirm the results as necessary. For welded joints, the location of cracks shall be described as located in the base metal, weld or HAZ. If no superficial crack is observed, a longitudinal cut shall be done at two different locations and a cross section examination with proper magnification shall be performed. The presence of any corrosion pitting and the maximum depth shall be reported. The results shall be approved by the Register.

4.2 Test of welded condition (including HAZ).

4.2.1 Micrographic examination.

4.2.1.1 The test shall be carried out in accordance with 1.9, Part IX "Materials and Welding" and agreed standards such as ASTM E112.

4.2.1.2 Acceptance criterium is microstructure including grain size, namely the absence of precipitations, segregation and cracking. Acceptance shall be carried out according to the program agreed with the Register.

4.2.2 Hardness test.

4.2.2.1 The test shall be carried out in accordance with 1.9, Part IX "Materials and Welding" and agreed standards such as ISO 6507-1.

4.2.2.2 Acceptance criteria shall be in accordance with the relevant agreed standard.

4.2.3 Cross-weld tensile test.

4.2.3.1 The test shall be carried out in accordance with 3.4.1, Part IX "Materials and Welding", 4.2.2.1, Part XIV "Welding" of the Rules for Classification and agreed standards such as ASTM E8/E8M, if applicable.

4.2.3.2 Acceptance criteria shall be in accordance with 3.4.1.1, Part IX "Materials and Welding". The presence of under-matched welds shall be considered for the intended application in accordance with 18.2.4.1.2, Part IV "Cargo Containment".

4.2.4 Charpy impact test.

4.2.4.1 The test shall be carried out in accordance with 1.3 and 3.3.2.1.4, Part IX "Materials and Welding".

4.2.4.2 Acceptance criteria shall be in accordance with 3.4.3.1, Part IX "Materials and Welding".

4.2.5 Crack Tip Opening Displacement (*CTOD*) test.

4.2.5.1 The test shall be carried out in accordance with an agreed standard such as ASTM E1820 or ISO 15653. The notch introduced in the test shall be positioned in the microstructure with the lowest fracture toughness.

4.2.5.2 Acceptance criterium is *CTOD* minimum value which shall be in accordance with the Register-agreed design specification for testing at room and cryogenic temperatures equal to the minimum design temperature of the material. A minimum of three successful tests shall be performed at room and cryogenic temperatures. As guidance a minimum *CTOD* value of 0,2 mm is often required.

4.2.6 Ductile fracture toughness test (J_{Ic}).

4.2.6.1 The test shall be carried out in accordance with an agreed standard such as ASTM E1820, ASTM E2818, ISO 15653 or ISO 12135. The notch introduced in the test shall be positioned in the microstructure with the lowest fracture toughness. The ductile fracture toughness test may be carried out as an alternative to the *CTOD* test in 4.2.5 upon the Register approval.

4.2.6.2 Acceptance criteria shall be in accordance with the recognized standard. A minimum of three successful tests shall be performed at room and cryogenic temperatures.

4.2.7 Bending test.

4.2.7.1 The test shall be carried out in accordance with 1.5, Part IX "Materials and Welding".

4.2.7.2 Acceptance criterium is no fracture after a 180° bend as required for welded material in accordance with 3.3.2.1.3 and 3.4.2.1, Part IX "Materials and Welding".

4.2.8 Fatigue test.

4.2.8.1 The basis for documenting adequate fatigue performance (*S* — *N* curves) shall be in accordance with requirements of 18.3.4.2, Part IV "Cargo Containment". The extent of fatigue testing is determined taking into account *S* — *N* curves for metallic materials in the agreed standards such as IIW.

The fatigue tests shall be based on a minimum of five test samples at each stress level. For a "one slope *S* — *N* curve" a minimum of three stress levels shall be tested. Additional stress levels to be tested for "two slope *S* — *N* curves". As guidance, stress levels shall be selected to achieve in the range of 10^5 to 10^8 cycles.

4.2.8.2 Acceptance criterium is the fatigue test results that shall be at least equal to, or better than, the reference *S* — *N* curve.

4.2.9 Corrosion test.

4.2.9.1 The type of corrosion tests to be applied shall depend on the material, type of weld and the specific cargoes (refer to Annex 1). The tests shall include tests for general corrosion, intergranular corrosion and stress corrosion. The tests shall be carried out in

accordance with, ASTM A262, ASTM G31, ASTM G36, ASTM G58 or ASTM G123. In the absence of a relevant agreed standard for the specific cargo, the test procedures shall align with the general principles of corrosion tests that follow the above specified agreed standards.

4.2.9.2 Acceptance criteria shall be in accordance with the relevant agreed standard. In the absence of a relevant agreed standard for the specific cargoes, the projected corrosion rates and test outcomes shall be agreed with the Register.

4.2.10 Corrosion test for ammonia compatibility.

4.2.10.1 The test shall be carried out in accordance with an agreed standard such as ASTM B858 considering requirements of 4.2.10.1.1 – 4.2.10.1.3.

4.2.10.1.1 Specimens shall be prepared in accordance with standards ISO 7539-2 and ISO 16540. The specimens shall be bent, prior to testing, using the four points bending test under constant strain. The total maximum strain of the sample shall be equal to the yield strength of the material at atmospheric temperature. Strain gauges shall be applied to measure the strain applied. In the case of welded specimens, strain gauges shall be applied to each side of the welded joint. The sample shall be constrained to maintain its form during testing.

4.2.10.1.2 Two specimens (one welded and one base metal) shall each be immersed in the following four ammonia environments for a period of 30 days:

liquid phase ammonia environments, obtained by cooling of ammonia below liquefaction temperature with the following liquid ammonia compositions:

0,1% weight of water and 2,5 ppm of oxygen (type 1); and

2,5 ppm of oxygen (type 2).

gas phase ammonia environments, at ambient temperature and atmospheric pressure with the following compositions:

pure ammonia (type 3); and

0,9% volume of oxygen and 99,1% volume of ammonia (type 4).

Stress corrosion cracking tests shall be performed in agreement with requirements of standards ISO 7539 and ISO 16540.

4.2.10.1.3 Test report shall provide all procedures, set-up data, examinations, information about the environment, in agreement with standard ISO 16540 and include:

the orientation, types and dimensions of specimens;

four points bending test set-up data;

target stress and applied deflection;

strain measurement procedures;

loading procedures; and

test environment.

4.2.10.2 Acceptance criterium is the presence of stress corrosion cracking examined under an optical microscope with proper magnification. The location and the number of cracks shall be specified, and a dye penetrant test performed to confirm the results as necessary. For welded joints, the location of cracks shall be described as located in the base metal, weld or HAZ. If no superficial crack is observed, a longitudinal cut shall be done at two different locations and a cross section examination with proper magnification shall be performed. The presence of any corrosion pitting and the maximum depth shall be reported. The results shall be agreed with the Register."

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