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:

01.07.2026

St. Petersburg
2026

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 2026.

REVISION HISTORY

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

PART I. CLASSIFICATION

Item	Applicability	Description	Remarks
Para 1.1.1	Ships carrying liquified gasses in bulk	Provisions on application of other RS rules have been deleted in connection with their revision and transfer to new para 1.1.2	
Para 1.1.2 (new)	Ships carrying liquified gasses in bulk	Revised provisions on application of other RS rules have been introduced	
Para 1.1.3 (new)	Ships carrying liquified gasses in bulk	Requirement has been introduced for application of IMO interim recommendations for ships carrying liquefied hydrogen in bulk	IMO resolution MSC.565(108)
Para 1.1.4 (new)	Ships carrying liquified gasses in bulk	Provisions have been introduced on application of requirements of these Rules for ships intended for carriage of several specific cargoes (they have been transferred from existing para 2.2.4)	

Item	Applicability	Description	Remarks
Para 1.2.1	Ships carrying liquified gasses in bulk	New definitions "LG barge", "LNG bunkering ship" have been introduced and definition "LG carrier" has been amended in order to bring into compliance with the definitions of ship types given in Appendix 1 to Part I "Classification" of the RS Rules/C. Abbreviation for the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk has been amended in definition of "Thermal oxidation method"	
Paras 2.2 — 2.2.6 (new)	Ships carrying liquified gasses in bulk Class notation Distinguishing marks	Requirements for assignment of distinguishing marks **RGU**, **RLU**, **GCU**, **highPRESS(pressure)**, **GFS** have been transferred from existing paras 2.2.9 — 2.2.13. Requirements have been introduced for assignment of distinguishing marks **BUNKER-LNG**, **RE**, **IG-Supply**, **BOG**. Existing paras 2.2 — 2.2.2 and 2.2.3 and references thereto have been renumbered 2.3 — 2.3.2 and 2.2.4, respectively. Existing paras 2.2.4 — 2.2.13 have been deleted	
Para 2.2 (renumbered to 2.3)	Ships carrying liquified gasses in bulk Class notation Descriptive and additional notations	Reference to distinguishing marks in the class notation has been deleted due to transfer of requirements to new paras 2.2 — 2.2.6	

Item	Applicability	Description	Remarks
Para 2.3.3 (new)	Ships carrying liquified gasses in bulk Class notation Descriptive and additional notations	Requirements for cargo stowage have been transferred from existing paras 2.2.5 — 2.2.8 for ships of **types 1G** and **2G/2PG**	
Section 3 (deleted)	Ships carrying liquified gasses in bulk Technical documentation	Requirements for survey have been deleted in connection with availability of such requirements in other RS normative documents. Existing Section 4, existing Chapters 4.1 — 4.3, paras and references thereto have been renumbered 3 and 3.1 — 3.3, respectively	
Para 4.2.8 (renumbered to 3.2.8)	Ships carrying liquified gasses in bulk Technical documentation	Reference to distinguishing mark **RLU** has been introduced to the para title	

PART IV. CARGO CONTAINMENT

Item	Applicability	Description	Remarks
Para 19.3	LG carriers Cargo containment systems Primary and secondary barriers	Reference has been introduced to new Annex 7 "Guidelines on the Application of High Manganese Austenitic Steel for Cryogenic Service". Industry-specific terminology has been specified in accordance with the original text of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)	Chapter 4.19.2 of the IGC Code
Para 19.4.8	LG carriers Cargo containment systems Alternative metallic materials	Para has been deleted. The text of the para has been transferred to new Chapter 19.5 with minor specifications	
Chapter 19.5 (new)	LG carriers Cargo containment systems Alternative metallic materials	New Chapter 19.5 has been introduced in connection with introduction of Annex 6	

PART V. FIRE PROTECTION

Item	Applicability	Description	Remarks
Section 4	Fireman's outfit, safety equipment and protective equipment for crew members involved in loading and discharging operations	Section has been renamed "Fire-Fighting Outfit"	

Item	Applicability	Description	Remarks
Para 4.3	Protective equipment for crew members involved in loading and discharging operations	Requirements have been transferred to para 2.1.1, Part X "Special Requirements"	
Paras 4.4 — 4.10 (deleted)	Safety equipment and protective equipment for crew members involved in loading and discharging operations	Paras 4.4 — 4.10 and references thereto have been deleted. Requirements have been transferred to Section 2, Part X "Special Requirements"	

PART VI. SYSTEMS AND PIPING

Item	Applicability	Description	Remarks
Para 2.1.1	LG carriers Piping Alternative metallic materials	Reference has been introduced to Annex 6 "Guidelines on the Acceptance of Alternative Metallic Materials for Cryogenic Service in Ships Carrying Liquefied Gases in Bulk"	
Para 2.2.1	Piping Pipe wall thickness	Reference to Formula (2.3.1), Part VIII "Systems and Piping" of the RS Rules/C has been replaced by the requirement to determination of the pipe wall thickness based on para 5.11.2.2 of the IGC Code	
Para 2.2.1.4	Piping Pipe wall thickness	Reference to para 2.3.1, Part VIII "Systems and Piping" of the RS Rules/C has been replaced by the requirement to determination of the pipe wall thickness based on para 5.11.2.2 of the IGC Code	

Item	Applicability	Description	Remarks
Para 2.2.1.5	Piping Pipe wall thickness	Reference to the Certificate has been replaced by the requirement to determination of the pipe wall thickness based on para 5.11.3.1 of the IGC Code	
Para 2.2.2	Piping Pipe wall thickness	Area of application of the requirements in Part VIII "Systems and Piping" of the RS Rules/C has been corrected for cargo piping systems	
Para 9.1.1 (new)	LG carriers Use of cargo as fuel	Requirements have been introduced for conditions of using toxic cargoes as fuel	IMO resolution MSC.566(109)

PART X. SPECIAL REQUIREMENTS

Item	Applicability	Description	Remarks
Section 2	Safety equipment and protective equipment for crew members involved in loading and discharging operations	The Section has been completely revised taking into account the requirements transferred from Section 4 of Part V "Fire Protection". Reference to the requirements of Chapter 19 of the IMG Code for gas tightness of protective clothing during carriage of particular cargoes has been introduced.	

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

Item	Applicability	Description	Remarks
Annex 6, para 3.2.4	LG carriers Alternative metallic materials Heat treatment	Requirements for heat treatment of material have been specified.	IMO circular MSC.1/Circ.1622/Rev.1
Annex 6, paras 4.1.10 and 4.2.10	LG carriers Alternative metallic materials Corrosion test for ammonia compatibility	References for procedure of corrosion testing for ammonia compatibility have been introduced; paras 4.1.10.1 and 4.1.10.2 и paras 4.2.10.1 and 4.2.10.2 have been deleted, their amended requirements have been transferred to new para 4.3.	IMO circular MSC.1/Circ.1622/Rev.1
Annex 6, para 4.3 (new)	LG carriers Alternative metallic materials Corrosion test for ammonia compatibility	Additional requirements for a corrosion test for ammonia compatibility have been introduced.	IMO circular MSC.1/Circ.1622/Rev.1
Annex 7 (new)	LG carriers High manganese austenitic steel Technical requirements and tests	New Annex 7 "Guidelines on the Application of High Manganese Austenitic Steel for Cryogenic Service" has been introduced	IMO Circular Letter: MSC.1/Circ.1599/Rev.3

PART I. CLASSIFICATION

1 GENERAL

Para 1.1.1 is amended as follows:

"**1.1.1** Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk[1] apply to specially built or converted ships, regardless of their gross tonnage and power plant output, intended for the carriage of liquefied gases in bulk having a vapour pressure exceeding 280 kPa absolute at a temperature of 37,8 °C, and other substances listed in Annex 1 to these Rules.

~~Ships carrying liquefied gases in bulk[2] are in full measure covered by the requirements of the Rules for the Equipment of Sea-Going Ships, Rules for the Cargo Handling Gear of Sea-Going Ships, Load Line Rules for Sea-Going Ships, Rules for the Classification and Construction of Sea-Going Ships[3] apply to LG carriers to the extent stipulated in the text of the LG Rules.~~".

New **paras 1.1.2** — **1.1.4** are introduced reading as follows:

"**1.1.2** These Rules include the requirements amending or supplementing those of the Rules for the Classification and Construction of Sea-Going Ships[2] and other RS rules for ships specified in 1.1.1. Unless expressly provided otherwise in the text of these Rules, the requirements of the RS Rules/C and other RS rules applying to such ships shall be appropriately met where they do not contradict with the requirements of these Rules.

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[2] Hereinafter referred to as "the RS Rules/C.".

1.1.3 The requirements of these Rules applied to ships intended for the carriage of liquefied hydrogen in bulk shall be subject to the provisions of IMO resolution MSC.565(108).

1.1.4 If a ship is intended for the carriage of several specific cargoes, the requirements of these Rules are specified proceeding from the combination of properties of the most dangerous cargoes carried.".

Para 1.2.1. Before definition "Upper flammable limit" new definition "LG barge" is introduced:

"L G b a r g e in an LG barge as defined in Section 6 of Appendix 1 to Part I "Classification" of the RS Rules/C. Unless otherwise specified, the requirements of these Rules applicable to LG carriers also apply to LG barges."

Para 1.2.1. Definition "LG carrier" is replaced by the following text:

"L G c a r r i e r is an LG carrier as defined in Section 3 of Appendix 1 to Part I "Classification" of the RS Rules/C.".

Para 1.2.1. Footnote 1 to definition "Thermal oxidation method" is amended as follows:

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

Para 1.2.1. After definition "LNG" new definition "LNG bunkering ship" is introduced reading as follows:

"LNG bunkering ship is a gas carrier engaged in transportation of liquefied natural gas (LNG) and intended to ensure the transfer of LNG on board the ships using LNG as a fuel.".

2 CLASS NOTATION

New **paras 2.2** — **2.2.6** are introduced reading as follows:

"**2.2 Distinguishing marks in the class notation.**

2.2.1 Where a ship is fitted with a regasification unit for cargo export to shore and provided the requirements of 3.24 of Part VI "Systems and Piping" are met, the distinguishing mark **RGU** (Regasification unit) shall be added to the ship's character of classification. In addition, the requirements of 2.2.5.5 of Part VII "Electrical Equipment" and Part V "Fire Protection" shall be met.

2.2.2 Where a ship is fitted with a reliquefaction unit for cargo vapours complying with 4.2 of Part VI "Systems and Piping", the distinguishing mark **RLU** (Reliquefaction unit) shall be added to the ship's character of classification. The documentation specified in 3.2.8 of this Part shall be submitted to confirm the fulfillment of the requirements applying to ships with the distinguishing mark **RLU**.

2.2.3 Where a ship is fitted with a gas combustion unit complying with 4.3 of Part VI "Systems and Piping", the distinguishing mark **GCU** (Gas combustion unit) shall be added to the ship's character of classification.

2.2.4 If membrane LNG cargo tanks are capable to withstand vapour pressure exceeding 25 kPa but not more than 70 kPa, the distinguishing mark **highPRESS(pressure)** shall be added to the ship's character of classification where a maximum allowable vapour pressure in kPa is indicated in brackets, for example, **highPRESS(50)**. In order to assign **highPRESS(pressure)** mark to the ship, the documentation shall be submitted in accordance with 3.1 of this Part confirming fulfillment of the requirements specified in 24.1.4 and 24.4 of Part IV "Cargo Containment", 3.16.6 of Part VI "Systems and Piping" and 4.1 of Part VIII "Instrumentation and Automation Systems".

2.2.5 Ships carrying liquefied natural gas (methane), using cargo as fuel and complying with the requirements of both the LG Rules and the IGC Code, are assigned the distinguishing mark **GFS** (Gas fuelled ships) added to the character of classification.

2.2.6 LNG bunkering ships that met the requirements of these Rules and Section 11 of Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" of the RS Rules/C, the distinguishing mark **BUNKER LNG** shall be added to the class notation.

When the additional features related to ships servicing are provided on board the LNG bunkering ship using LNG as fuel, the distinguishing marks **RE, IG-Supply, BOG** (refer to 2.2.66.1 — 2.2.66.3 of Part I "Classification" of the RS Rules/C) shall be added to the ship's character of classification after the distinguishing mark **BUNKER-LNG**.".

Existing **paras 2.2** — **2.2.2**, **2.2.3** and references thereto are renumbered **2.3** — **2.3.2**, **2.3.4**, respectively.

Para 2.3 is amended as follows:

"~~**2.2**~~ **2.3 Descriptive and additional notations~~, distinguishing marks~~ in the class notation.**".

New **para 2.3.3** is introduced after **para 2.3.2** reading as follows:

"**2.3.3** Ships, for which **type 1G** or **2G/2PG** is assigned as per 2.3.2 shall be subject to the following additional requirements for cargo stowage:

.1 when cargo tanks contain products, for which a type **1G** ship is required, neither flammable liquids having a flashpoint of 60 °C or less, nor flammable products listed in Annex 1 to these Rules shall be carried in tanks located within the protective zones described in 2.4.1 of Part II "Ship Arrangement";

.2 when cargo tanks contain products, for which a type **2G/2PG** ship is required, the flammable liquids as described in 2.3.3.1 of this Part shall not be carried in tanks located within the protective zones described in 2.4.2 of Part II "Ship Arrangement";

.3 in each case, for cargo tanks loaded with products, for which a type **1G** or **2G/2PG** ship is required, the restriction applies to the protective zones within the longitudinal extent of the hold spaces for those tanks;

.4 the flammable liquids and products described in 2.3.3.1 may be carried within these protective zones when the quantity of products retained in the cargo tanks, for which a **type 1G** or **2G/2PG** ship is required, is solely used for cooling, circulation or fuelling purposes.".

In **para 2.3.4** a reference to para 2.2.1 is replaced by a reference to para 2.3.1.

Existing **paras 2.2.4 — 2.2.13** are deleted.

3 CLASSIFICATION SURVEYS

Section 3 is deleted.

4 TECHNICAL DOCUMENTATION

Existing **Section 4**, existing **Chapters 4.1** — **4.3** and references thereto are renumbered **3** and **3.1** — **3.3**, respectively.

Existing paras **4.1.1, 4.1.2, 4.2.1** — **4.2.8, 4.3.1** — **4.3.2.3** and references thereto are renumbered **3.1.1, 3.1.2, 3.2.1** — **3.2.8** and **3.3.1** — **3.3.2.3**, respectively.

Para 3.2.8 is amended as follows:

"~~**4.2.8**~~ **3.2.8 Documentation on reliquefaction unit for cargo vapours (distinguishing mark RLU).**".

PART IV. CARGO CONTAINMENT

19 MATERIALS

Chapter 19.3 is amended as follows:

"**19.3 Materials of primary and secondary barriers.**

19.3.1 Metallic materials used in the construction of primary and secondary barriers not forming the hull, shall be suitable for the design loads that the barriers may be subjected to ~~that they may be subjected to~~, and shall be in accordance with Tables 2.1-1 — 2.1-3, Part IX "Materials and Welding". The application of high manganese austenitic steel for cargo tanks shall meet the requirements of Annex 7 "Guidelines on the Application of High Manganese Austenitic Steel for Cryogenic Service"[1].

19.3.2 Materials, either non-metallic or metallic but not covered by Tables 2.1-1 — 2.1-3, Part IX "Materials and Welding", used in the primary and secondary barriers may be approved by the Register, considering the design loads ~~that they may be subjected to~~ applied to barriers~~, their~~ and properties ~~and their intended use~~ of materials.

19.3.3 ~~Where non-metallic materials, including composites, are used for, or incorporated in the primary or secondary barriers, they shall be tested for the following properties, as applicable, to ensure that they are adequate for the intended service~~ Non-metallic materials of primary and secondary barriers, including composites, shall be tested to confirm their operational reliability and to confirm the following properties as applicable:

.1 compatibility with the ~~cargoes~~ cargo;

.2 ageing rate;

.3 mechanical properties;

.4 characteristics of thermal expansion and contraction;

.5 abrasion resistance;

.6 cohesion strength;

.7 ~~resistance to vibrations~~vibration resistance;

.8 resistance to fire and flame spread; and

.9 ~~resistance to fatigue failure and crack propagation~~ fatigue life and crack resistance.

19.3.4 ~~The above properties~~Parameters specified in 19.3.3~~, where applicable~~, shall be tested for the range between the expected maximum temperature in service and +5 °C below the minimum design temperature, but not lower than –196 °C.

19.3.5 ~~Joining of the primary and secondary barriers~~Guidance on the use of non-metallic materials.

19.3.5.1 ~~Where non-metallic materials, including composites, are used for the primary and secondary barriers, the joining processes shall also be tested as described above~~The joints of non-metallic materials, including composites, shall be tested in accordance with the requirements of 19.3.3 and 19.3.4.

19.3.5.2 ~~Guidance on~~Additional requirements for the use of non-metallic materials in the construction of primary and secondary barriers ~~is~~are provided in Annex 3.

19.3.6 ~~Consideration may be given to the use of materials in~~ For the primary and secondary ~~barrier~~barriers, materials which are not resistant to fire and flame spread may be used, provided ~~they are protected by a suitable system~~ that special protective systems are used, ~~such as such as a permanent inert gas environment, or are provided with a fireretardant barrier~~ such as an inert gas system or a fireretardant barrier.

[1] Additional requirements are in accordance with IMO Circular Letter No. MSC.1/Circ.1599/Rev.3.".

Para 19.4.8 is deleted.

New Chapter 19.5 is introduced reading as follows:

"**19.5 Alternative metallic materials.**

19.5.1 When using metal materials not listed in Tables 2.1-2 — 2.1-4, Part IX "Materials and Welding" in the cargo containment system, the provisions of Annex 6 "Guidelines for the Acceptance of Alternative Metallic Materials for Cryogenic Service in Ships Carrying Liquefied Gases in Bulk" shall be followed.

[1] Additional requirements are in accordance with IMO Circular Letters No. MSC.1/Circ.1622 and MSC.1/Circ.1648.".

PART V. FIRE PROTECTION

Section 4 is renamed as follows:

"4 FIRE-FIGHTING OUTFIT".

Para 4.3 is replaced by the following text:

"**4.3** Additional requirements for personnel protective equipment are specified in Section 2, Part X "Special Requirements".".

Paras 4.4 — 4.10 and references thereto are deleted.

PART VI. SYSTEMS AND PIPING

2 PIPING

Para 2.1.1 is amended as follows:

"**2.1.1** The piping and valves used at a working temperature from 0 to –165 °C shall be made of the materials mentioned in Table 2.1-4, Part IX "Materials and Welding". The choice and testing of materials used in piping systems shall comply with the requirements of Section 2, Part IX "Materials and Welding" taking into account the minimum design temperature. However, some relaxation may be permitted in the quality of material of open-ended vent piping, provided that the temperature of the cargo at the pressure relief valve (PRV) setting is not lower than -55 °C, and that no liquid discharge to the vent piping can occur. Similar relaxations may be permitted under the same temperature conditions to open-ended piping inside cargo tanks, excluding discharge piping and all piping inside membrane and semi-membrane tanks.

When using metallic materials not listed in Table 2.1-4, Part IX "Materials and Welding", the provisions of Annex 6 "Guidelines for the Acceptance of Alternative Metallic Materials for Cryogenic Service in Ships Carrying Liquefied Gases in Bulk" shall be followed.".

Para 2.2.1 is amended as follows:

"**2.2.1** Cargo piping systems and process piping systems, as well as single-walled piping systems for gas fuel shall meet the applicable requirements to Class I piping in compliance with Part VIII "Systems and Piping" of the Rules for the Classification, unless otherwise specified in the IGC Code or this Part.

The wall thickness of pipes operating under the internal pressure shall be not less than that determined by Formula ~~(2.3.1), Part VIII "Systems and Piping" of the Rules for the Classification with due regard for the following values involved in the formula.~~ (2.2.1)

$$S = (S_0 + b + c)/(1 - |a|/100), \qquad (2.2.1)$$

where $S_0 = dp/(2\sigma\varphi + p)$;

S_0 = theoretical wall thickness, mm;

d = outside diameter of the pipe, mm;

p = design pressure determined in accordance with 2.2.1.1 — 2.2.1.2.1, MPa;

φ = weld efficiency factor taken in accordance with 2.2.1.4;

b = allowance for a reduction of pipe wall thickness because of bending taken in accordance with 2.3.4, Part VIII "Systems and Piping" of the Rules for the Classification, mm;

σ = permissible (normal) stress determined in accordance with 2.2.1.5, MPa;

c = corrosion addition taken in accordance with Table 2.3.1-1 (for steel pipes) and Table 2.3.1-2 (for pipes of nonferrous metals), Part VIII "Systems and Piping" of the Rules for the Classification, mm;

a = negative manufacturing tolerance for pipe wall thickness, % (when pipes without negative allowance are used, a = 0).".

Para 2.2.1.4 is amended as follows:

"**2.2.1.4** ~~The remaining values involved in the formula shall meet the requirements of 2.3.1, Part VIII "Systems and Piping" of the Rules for the Classification;~~ In calculations weld efficiency factor φ is taken equal to 1 for seamless pipes and for longitudinally or spirally welded pipes, delivered by approved manufacturers of welded pipes that are considered equivalent to seamless pipes when non-destructive testing on welds is carried out in accordance with the standards agreed with the Register.

For other welded pipes, the value of weld efficiency factor φ shall be assigned considering the requirements in 2.1.6.1-1, Part X "Boilers, Heat Exchangers and Pressure Vessels" of the Rules for the Classification.

~~n~~No reduction of the safety factors is allowed.".

Para 2.2.1.5 is amended as follows:

"**2.2.1.5** The minimum material ultimate strength and yield stress safety factors ~~accepted~~ for the cargo ~~pipeline~~ piping systems ~~shall be specified in the Certificate~~:

for pipes made of steel, including corrosion-resistant steel, permissible (normal) stress, σ in Formula (2.2.1), shall be taken equal to the minimum value of the following:

$$\sigma = \min\left(\frac{R_m}{2{,}7}, \frac{R_e}{1{,}8}\right)$$

where R_m = minimum tensile strength at room temperature, MPa;

R_e = minimum yield stress at room temperature, MPa. If the stress-strain curve does not show a defined yield stress, the 0,2 % proof stress $R_{p0.2}$ applies.

For pipes made of materials other than steel, permissible stresses shall be taken in accordance with the standards agreed with the Register.".

Para 2.2.2. The first paragraph is amended as follows:

"**2.2.2** The minimum pipe wall thickness ~~shall~~ may be taken in accordance with Table 2.3.8, Part VIII "Systems and Piping" of the Rules for the Classification or standards agreed with the Register.".

9 USE OF CARGO AS FUEL

New para 9.1.1 is introduced reading as follows:

"**9.1.1** The use of cargoes requiring carriage in type 1G ships, as identified in column 4 of the table in Annex 1, shall not be permitted. Upon agreement with the Register and Maritime Administration, cargoes identified as toxic products in column 7 which are required to be carried in type 2G/2PG ships may be used as fuel, provided that the same level of safety as methane is provided in compliance with the requirements of these Rules, including provisions in Section 1.3 of the IGC Code, and taking into account the guidelines developed by IMO.".

PART X. SPECIAL REQUIREMENTS

Section 2 is replaced by the following text:

"2 PERSONNEL PROTECTION

2.1 Protective equipment.

2.1.1 Suitable protective equipment, including eye protection to a recognized national or international standard, shall be provided to protect crew members involved in normal loading and discharging operations, with due regard for the characteristics of the products being carried.

2.1.2 The personal protective equipment shall be kept in clearly marked lockers located in readily accessible places.

2.2 Safety equipment.

2.2.1 Sufficient, but not less than three complete sets of safety equipment in addition to the fireman's outfit required by 4.1, Part V "Fire Protection" each permitting personnel to enter and work in gas-filled spaces, shall be provided.

2.2.2 One complete set of safety equipment required by 2.1.1 shall consist of:

.1 one self-contained positive pressure air-breathing apparatus incorporating full face mask, not using stored oxygen and having a capacity of at least 1,200 l of free air. Each set shall be compatible with that required by 4.1, Part V "Fire Protection";

.2 protective clothing, boots and gloves to a recognized standard;

.3 steel-cored rescue line with belt; and

.4 explosion-proof lamp.

2.2.3 An adequate supply of compressed air for the air-breathing apparatus required in 2.2.2.1 shall be provided and shall consist of:

.1 at least one fully charged spare air bottle for each breathing apparatus;

.2 an air compressor of adequate capacity capable of continuous operation, suitable for the supply of high-pressure air of breathable quality; and

.3 a charging manifold capable of dealing with sufficient spare breathing apparatus air bottles for the breathing apparatus.

2.2.4 Safety equipment required in 2.2.1 — 2.2.3 shall be kept in special clearly marked lockers located in readily accessible places.

2.3 Requirements for personal protection.

2.3.1 Suitable respiratory and eye protection for emergency escape purposes shall be provided for every person on board, subject to the following:

.1 filter-type respiratory protection is unacceptable;

.2 self-contained breathing apparatus shall have at least a duration of service of 15 min; and

.3 emergency escape respiratory protection shall not be used for firefighting or cargo handling purposes and shall be marked to that effect.

2.3.2 One or more suitably marked decontamination showers and eyewash stations shall be available on deck, taking into account the size and layout of the ship. The showers and eyewashes shall be operable in all ambient conditions.

2.3.3 Protective clothing specified in 2.2.2.2 shall be gastight during carriage of cargoes for which it is required under Chapter 19 of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

2.4 First-aid equipment.

2.4.1 A stretcher that is suitable for hoisting an injured person from spaces below deck shall be kept in a readily accessible location.

2.4.2 The ship shall have onboard medical first-aid equipment, including oxygen resuscitation equipment, based on the requirements of the Medical First Aid Guide (MFAG) on rendering first-aid in accidents associated with dangerous cargoes as well as considering the characteristics of the cargoes being carried.".

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

ANNEX 6

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

Para 3.2.4 is amended as follows:

"**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" of the LG Rules. 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. If a waiver of requirements for post-weld heat treatment is sought, additional welded samples with the required post-weld heat treatment shall be provided for comparison purposes.".

Para 4.1.10 is amended as follows:

"**4.1.10** Corrosion test for ammonia compatibility.
The test shall be carried out in accordance with the requirements of 4.3.".

Paras 4.1.10.1 and **4.1.10.2** are deleted.

Para 4.2.10 is amended as follows:

"**4.2.10** Corrosion test for ammonia compatibility.
The test shall be carried out in accordance with the requirements of 4.3."

Paras 4.2.10.1 and **4.2.10.2** are deleted.

New para 4.3 is introduced reading as follows:

"**4.3 Procedure of corrosion testing for ammonia compatibility.**

4.3.1 The test shall be carried out in accordance with an agreed standard, such as ASTM B858. The provisions of ASTM B85 standard, despite it being applicable to copper alloys, may be applied to the testing taking into account the requirements of 4.3.1.1 — 4.3.1.3 and 4.3.2 — 4.3.5.

4.3.1.1 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.

4.3.1.2 Three base metal and three welded specimens shall each be immersed in the following ammonia environments (6 types) for a period of 30 days:

liquid phase ammonia environments, obtained by cooling of ammonia at slightly lower temperature than the boiling temperature of ammonia, i.e., –33,5 °C and at atmospheric pressure 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 (+25 °C) and atmospheric pressure with the following gas ammonia compositions:

pure ammonia (≥ 99,99 %) (type 3) and

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

gas phase ammonia environments at –20 °C and atmospheric pressure with the following gas ammonia compositions:

pure ammonia (≥ 99,99 %) (type 5) and

0,9 % volume of oxygen and 99,1 % volume of ammonia (type 6).

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

4.3.1.3 The test report shall contain all test procedures, test results, information about the environment in accordance with standard ISO 16540 and include the information on:

the orientation, types, and dimensions of specimens;

material description: chemistry and tensile properties of base metal; chemistry and tensile properties of welding consumables; type of welding, hardness of the weld metal and heat affected zones (HAZ);

four points bending test;

target stress and applied deflection;

strain measurement procedures;

loading procedures; and

test environment (temperature, water and oxygen content, pH).

4.3.2 A test acceptance criterion is availability of stress corrosion cracking under an optical microscope with proper magnification. The location and the number of cracks shall be specified, and a fluorescent penetration test performed to confirm the results as necessary. For welded joints, the location of cracks shall be described as located in the base metal, weldment 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. Test results shall be agreed with the Register.

4.3.3 Loading jig made of corrosion resistant alloys with spacing between outer rollers of 85 mm shown in Fig. 4.3.3, is to be used to apply a constant deflection to the specimen. The specimen is electrically isolated from the ceramic rollers in order to avoid undesirable galvanic corrosion.

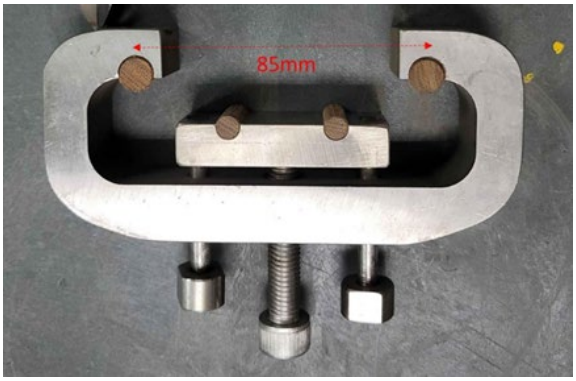

Fig. 4.3.3
Four-point bend loading jig design

4.3.4 The specimens are machined from a 40 mm thick hot rolled plate and are not subjected to post-weld heat treatment. The outer radius of the specimen subject to bending is the original surface of the hot rolled plate. They are bent prior to testing. The surface subject to ammonia exposure in a tank is not machined.

Four-point bend specimens are flat strips of uniform rectangular cross section and uniform thickness except in the case of testing welded specimens with one face in the as-welded condition as shown in Fig. 4.3.4. The original (measured) surface from a 40 mm plate (cap bead in case of welded specimen) is the one to be observed. For weldments, the weld bead to be tested is the weld cap.

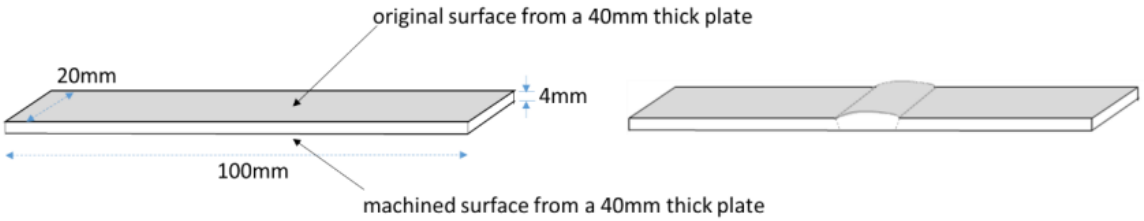

Fig. 4.3.4
Four-point bend specimens (base specimen and as-welded specimen)

4.3.5 Dial gauge will be attached for measurement of deflection at the centre of the face in tension. The loading of the specimen is such that it reaches to the required yield strength level and then the specimen is constrained to maintain its form during testing.

The amount of deflection, *y*, is set as the formula below complying with ISO 16540:

$$Y = \frac{(3H^2 - 4A^2)\sigma}{12Et},$$

where σ is the yield strength;
E is the modulus of elasticity;
t is the specimen thickness;
A is the distance between the inner and outer supports;
H is the distance between the outer supports.

Uniaxial tensile test of a 40 mm thick plate will be performed to determine the yield strength to be applied for the calculation of the amount of deflection required.

During welded specimen testing, the same amount of the deflection as for the base plate is to be set out.".

New Annex 7 is introduced reading as follows:

"ANNEX 7

GUIDELINES ON THE APPLICATION OF HIGH MANGANESE AUSTENITIC STEEL FOR CRYOGENIC SERVICE

1 GENERAL

1.1 These Guidelines on the application of high manganese austenitic steel for cryogenic service[1] shall be applied during design and construction of cargo tanks using high manganese austenitic steel for cryogenic service, to comply with the Design Conditions defined in Section 18, Part IV "Cargo Containment" of the LG Rules.

[1] Hereinafter referred to as "these Guidelines".

2 APPLICATION

2.1 These Guidelines are not intended to replace any requirements of the LG Rules and contain additional requirements for cargo tanks made of high manganese austenitic steel subject to limitations specified in 2.1.1 and 2.1.2.

2.1.1 The requirements cover the following cargo and/or fuel types regulated by the LG Rules:

ammonia, anhydrous;
butane (all isomers);
butane-propane mixture;
carbon dioxide (high purity);
ethane;
ethylene;
methane (LNG);
pentane (all isomers);
propane.

2.1.2 The requirements are applied to hot rolled plates between 6 up to 40 mm thick.

2.1.3 The post-weld stress relief heat treatment referenced in 19.2.2, Part X "Special Requirements" of the LG Rules is waived for ammonia cargo and/or fuel tanks containing ammonia.

2.2 The application of high manganese austenitic steel for cargo and fuel tanks is limited by the requirements of these Guidelines.

3 DEFINITIONS

For the purpose of these Guidelines, the following additional definitions have been adopted

High manganese austenitic steel is steel with a high amount of manganese in order to retain austenite as its primary phase at atmospheric and service temperature.

Under-matched weld is a welded joint where the weld metal has lower yield or tensile strength than the base metal.

4 SPECIFICATIONS

4.1 Steel specifications shall be submitted to the Register for approval. The test requirements and acceptance criteria for steel are provided in Section 11.

4.2 The steel shall be fully killed and fine-grained. The condition of supply for steel shall be hot rolled with subsequent controlled cooling as necessary. The reduction ratio of slab to finished product thickness shall not be less than 3:1. Other conditions of supply shall be in accordance with those agreed with the Register.

4.3 The use of high manganese austenitic steel is limited to steel plates with a thickness between 6 mm and 40 mm. Thicknesses greater than 40 mm shall be subject to special consideration by the Register.

5 CHEMICAL COMPOSITION

5.1 The chemical composition for high manganese austenitic steel shall meet the requirements of an agreed standard, such as ASTM A1106/A1106M-17 as shown in Table 5.1, or ISO 21635:2018.

Table 5.1

Chemical composition
(standard ASTM A1106/A1106M-17)

Chemical composition, %								
C	Si	Mn	P	S	Cr	Cu	B	N
0,35 — 0,55	0,10 — 0,50	22,5 — 25,5	<= 0,03	<= 0,01	3,0 — 4,0	0,30 — 0,70	<= 0,005	<= 0,05
Note: Silicon (Si) may be less than 0,10%, provided total aluminium is 0,03 % or higher, or provided acid soluble aluminium is 0,025 % or higher.								

6 MECHANICAL PROPERTIES

6.1 Mechanical properties for the base metal shall meet the applicable requirements of Part IX "Materials and Welding", as well as agreed standards applied to chemical composition, such as ISO 21635, as shown in Table 6.1-1, or ASTM A1106/A1106M-17. Mechanical properties of welded joints metal are listed in Table 6.1-2. A test report shall contain the information specified in Section 11.

Table 6.1-1

Mechanical properties for base metal
(standard ISO 21635)

Yield strength (0,2 % offset), MPa	Tensile strength, MPa	Elongation, % at $5,65\sqrt{S_0}$
>= 400	800 — 970	>= 22,0
Note. Impact test requirements are listed in Table 2.1-3, Part IX "Materials and Welding" of the LG Rules, as applicable.		

Table 6.1-2

Mechanical properties for welded joint metal

Yield strength (0,2 % offset), MPa	Tensile strength, MPa	Elongation, % at $5,65\sqrt{S_0}$
>= 400	>= 660	>= 22,0
Note. Impact test requirements are listed in Table 2.1-3, Part IX "Materials and Welding" of the LG Rules, as relevant.		

7 WELDING AND NON-DESTRUCTIVE TESTING

7.1 Welding of metallic materials and non-destructive testing shall meet the requirements of Part IX "Materials and Welding" of the LG Rules and metal testing requirements and acceptance criteria specified in Section 11. Mechanical properties of a welded joint are listed in Table 6.1-2.

8 TESTING AND ACCEPTANCE CRITERIA

8.1 Metal testing requirements and acceptance criteria shall meet the requirements of Part IX "Materials and Welding" of the LG Rules and metal testing requirements and acceptance criteria specified in Section 11. A test report shall contain the information specified in Section 11.

9 MANUFACTURER APPROVAL SCHEME

9.1 Approval of the manufacturer shall be carried out in accordance with 1.2, Part IX "Materials and Welding" of the LG Rules.

10 CARGO TANKS DESIGN APPLICATION

10.1 General.

10.1.1 The relevant loading conditions and design conditions shall be established in accordance with Section 18, Part IV "Cargo Containment" of the LG Rules.

10.1.2 For the selection of relevant safety factors for high manganese austenitic steels, the safety factor specified in Sections 21 — 23, Part IV "Cargo Containment" of the LG Rules for "austenitic steels" shall be applied both for the base metal and for the welded joint metal.

10.2 Ultimate design condition.

10.2.1 High manganese austenitic steels shall normally have under-matched welds. Therefore, it is of great importance that the design values of the yield strength and tensile strength are based on the "minimum mechanical properties" for the base metal and as welded joint metal in accordance with the requirements of Section 6. The limitation for under-matched welds defined in 18.2.4.1.2, Part IV "Cargo Containment" of the LG Rules shall also be taken into account.

10.3 Buckling strength.

10.3.1 Buckling strength analysis for cargo containment shall be approved by the Register. Design loads shall be defined according to 3.4, Part IV "Cargo Containment" of the LG Rules. Design tolerances shall be considered where relevant and be included in the strength assessment as required in 6.6.2.1 of the IGC Code.

10.3.2 It shall be noted that the acceptance criteria for the flooding load cases are different from other buckling load cases during buckling strength analysis.

10.4 Fatigue design condition.

10.4.1 *S* — *N* curves, designed based on test results of steel specimens under "in air" condition, are shown in Table 10.4.1. *S* — *N* curves for steel welded joints as per standard IIW 1823-07 are shown in Fig. 10.4.1. These curves may be used as fatigue design curves for the base metal and welded joint metal with regard to the following:

the parameters of high manganese austenitic steel comply with *S* — *N* curve of *D*-curve for a welded joint without stress concentration from any structural details according to Table 10.4.1;

a reference *S* — *N* curve to high manganese austenitic steel is the FAT 90 curve for a welded joint without stress concentration from any structural details according to Fig. 10.4.1;

the application of other *S* — *N* curves is subject to the Register agreement.

When constructing *S* — *N* curves, the requirements of 18.3.4, Part IV "Cargo Containment" of the LG Rules shall be taken into account.

Table 10.4.1

S — N curves in air

S — N curve	$N \le 10^7$ cycles		$N > 10^7$ cycles $\log \bar{a}_2$, $m_2 = 5,0$	Fatigue limit at 10^7 cycles, MPa	Thickness exponent k	Structural stress concentration embedded in the detail (S — N *class*)
	m_1	$\log \bar{a}_1$				
B1	4,0	15,117	17,146	106,97	0	
B2	4,0	14,885	16,856	93,59	0	
C	3,0	12,592	16,320	73,10	0,05	
C1	3,0	12,449	16,081	65,50	0,10	
C2	3,0	12,301	15,835	58,48	0,15	
D	3,0	12,164	15,606	52,63	0,20	1,00
E	3,0	12,010	15,350	46,78	0,20	1,13
F	3,0	11,855	15,091	41,52	0,25	1,27
F1	3,0	11,699	14,832	36,84	0,25	1,43
F3	3,0	11,546	14,576	32,75	0,25	1,61
G	3,0	11,398	14,330	29,24	0,25	1,80
W1	3,0	11,261	14,101	26,32	0,25	2,00
W2	3,0	11,107	13,845	23,39	0,25	2,25
W3	3,0	10,970	13,617	21,05	0,25	2,50

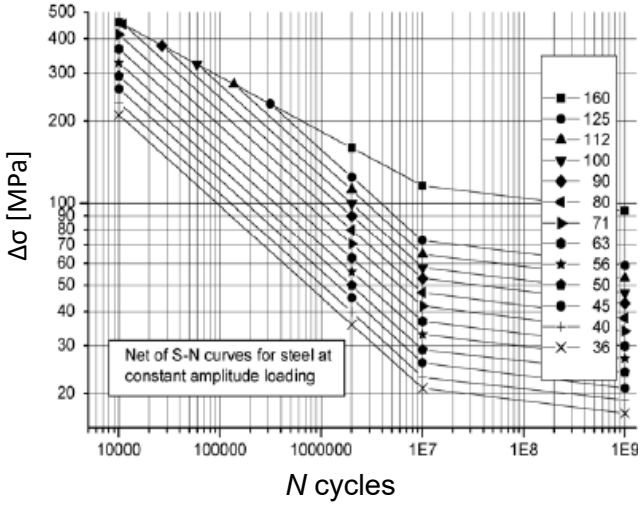

Fig. 10.4.1
S — N curves according to standard IIW 1823-07

10.5 Fracture mechanics analyses.

10.5.1 For a cargo tank with reduced secondary barrier applied, fracture mechanics analysis shall be carried out.

10.5.2 Fracture toughness properties shall be expressed using the Register approved standards. Fracture toughness properties shall be determined based on the cargo tank loading condition.

The fatigue crack propagation rate properties shall be documented for the tank metal and its welded joints for the relevant service conditions taking into consideration the fatigue crack propagation rate and variation in stress intensity, ΔK, at the crack tip. The effect of stresses produced by static loads shall be taken into account when establishing the choice of fatigue crack propagation rate parameters.

10.5.3 Note that for the application where very high static load utilization is relevant, alternative methods such as ductile fracture mechanic analyses shall be considered.

10.5.4 An example of a typical Crack Tip Opening Displacement (*CTOD*) value at cryogenic condition is given in Table 10.5.4.

Table 10.5.4

***CTOD* Test Report**

			REPORT No.		
Test method standard	ISO 12135/15653 Specimen No.		FCAW-2	Test date	
Specimen configuration	Square cross-section 3 point bend *(W = B)*			Crack plane orientation	*L — T*
Specimen dimensions		1	2	3	Average
	Thickness, *B* (mm)	40	40	40	40
	Width, *W* (mm)	80	80	80	80
	Span, *S* (mm)	320	Knife edge thickness, *z* (mm)		0
Test material	Young's modulus of elasticity, *E* (MPa)			182,000	
	YS (0,2 % proof), σ_{YSP} (MPa)			474	
	TS, σ_{TSP} (MPa)			780	
	YS (0,2 % proof), σ_{YS} (MPa)			655	
	Machined notch (mm)	Width, *N*	Length, L_{mc}	Root radius	
		4,7	32,4	0,1	
Test condition	Temperature (°C)			–165	

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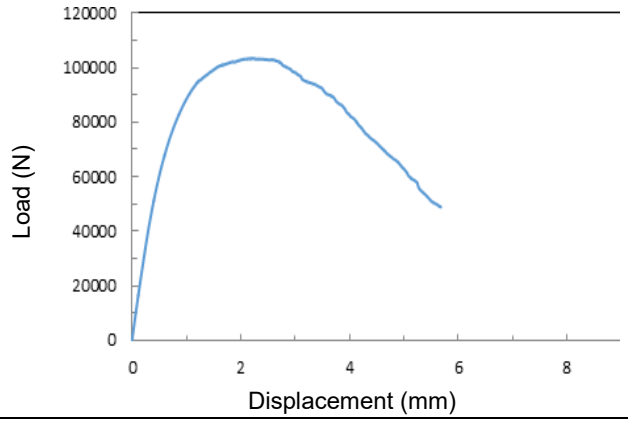
<tr><td rowspan="10">Test result</td><td colspan="10"> 
</td></tr>
<tr><td colspan="10">Crack length to tip of fatigue pre crack (mm)</td></tr>
<tr><td>a_1</td><td>a_2</td><td>a_3</td><td>a_4</td><td>a_5</td><td>a_6</td><td>a_7</td><td>a_8</td><td>a_9</td><td>a_0</td></tr>
<tr><td>37,62</td><td>39,28</td><td>39,36</td><td>38,95</td><td>39,24</td><td>38,27</td><td>38,55</td><td>38,67</td><td>37,21</td><td>38,72</td></tr>
<tr><td colspan="2">a_0/W</td><td colspan="2">0,54</td><td colspan="4">Plastic component V, Vp (mm)</td><td colspan="2">1,53</td></tr>
<tr><td colspan="10">Critical *CTOD* (mm)</td></tr>
<tr><td colspan="4">Type of *CTOD*</td><td colspan="6">Total *CTOD*</td></tr>
<tr><td colspan="4">δ_m</td><td colspan="6">0,53</td></tr>
</table>

10.5.5 A fracture mechanics analysis is required for type B tanks where a reduced secondary barrier is applied, as specified in 22.4, Part IV "Cargo Containment" of the LG Rules. Fracture mechanics analysis may also be required for other tank types as found relevant to show compliance with fatigue and crack propagation properties.

10.6 Welding.

10.6.1 Welding shall be carried out in accordance with provisions of Section 3, Part IX "Materials and Welding" of the LG Rules.

When carrying out welding:

.1 for reducing the heat input during production, reduced amperage shall be considered during arc welding of the first root pass when applying flux-cored arc welding (FCAW), at that welding heat input of maximum 30 kJ/cm shall be used as guidance for vertical-upward position (PF), as that has less heat input for downhand position (PA);

.2 distance between the nozzle and weld shall be kept to a minimum to reduce the oxygen content at the vicinity of the weld pool;

.3 FCAW weld gas composition shall normally be a mix of argon (80 %) and carbon dioxide (20 %);

.4 appropriate ventilation shall be provided to reduce exposure to hazardous welding fumes.

10.7 Non-destructive testing.

The scope of non-destructive testing (NDT) shall meet the requirements of 3.6, Part IX "Materials and Welding" of the LG Rules. For high manganese austenitic steel suitable NDT procedures normally applicable for austenitic steels shall be used.

10.8 Corrosion resistance.

Appropriate measures shall be taken with respect to corrosion protection. For example, filling cargo tanks with inert gas or dry air when not in use.

11 MATERIAL TESTING REQUIREMENTS AND ACCEPTANCE CRITERIA FOR HIGH MANGANESE AUSTENITIC STEEL

11.1 Test of base material.

11.1.1 Chemical composition shall be in accordance with an agreed standard, such as ASTM A1106/A1106M-17 or ISO 21635:2018.

Test acceptance criteria shall be in accordance with the agreed standard.

11.1.2 Micrographic examination.

The examination shall be carried out in accordance with 1.9, Part IX "Materials and Welding" of the LG Rules and agreed standards, such as ASTM E112.

A test acceptance criterion is microstructure, including grain size and non-metallic inclusions. A test report shall be submitted to the Register for reference.

11.1.3 Tensile test.

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

Test acceptance criteria are yield, tensile and elongation strength. Criteria shall be in accordance with the agreed standard applied for chemical composition according to 11.2.1, such as ASTM A1106/A1106M-17 or ISO 21635:2018.

11.1.4 Charpy impact test.

The test shall be carried out in accordance with 1.3, Part IX "Materials and Welding" of the LG Rules.

Test acceptance criteria are specified in Table 2.1-3, Part IX "Materials and Welding" of the LG Rules.

11.1.5 Charpy impact test on strain aged specimens.

The test shall be carried out in accordance with an agreed standard, such as ASTM E23.

Test acceptance criteria are specified in Table 2.1-3, Part IX "Materials and Welding" of the LG Rules.

11.1.6 Drop weight test.

The test shall be carried out in accordance with an agreed standard, such as ASTM E208, at the temperature of –196°C.

A test acceptance criterion is no break at test temperature as defined by the applied standard.

11.1.7 Fatigue test (*S* — *N* curve).

The basis for establishing S-N curves shall be in accordance with 18.3.4.2, Part IV "Cargo Containment" of the LG Rules.

A test acceptance criterion is the compliance of test results with parameters of *S* — *N* curves (fatigue life shall be not lower), accepted in accordance with standards IIW.

11.1.8 *CTOD* (crack tip opening displacement) test.

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

A test acceptance criterion is a *CTOD* minimum value which shall be in accordance with the Register approved design specification for testing at room and cryogenic temperatures as per design conditions. A minimum *CTOD* value is 0,2 mm.

11.1.9 Corrosion test.

The test shall be carried out in accordance with an agreed standard as specified in 11.1.9.1 — 11.1.9.4.

Test acceptance criteria shall be in accordance with the agreed standard.

11.1.9.1 Intergranular corrosion test.

The test shall be carried out in accordance with an agreed standard, such as ASTM A262.

Test acceptance criteria shall be in accordance with the agreed standard.

11.1.9.2 General corrosion test.

The test shall be carried out in accordance with an agreed standard, such as ASTM G31.

Test acceptance criteria shall be in accordance with the agreed standard.

11.1.9.3 Stress corrosion cracking test.

The test shall be carried out in accordance with agreed standards, such as ASTM G36 and ASTM G123.

Test acceptance criteria shall be in accordance with the agreed standard.

11.1.9.4 Corrosion test for ammonia compatibility.

The test shall be carried out in accordance with 11.3.

11.2 Tests of welded joints (including HAZ).

11.2.1 Micrographic examination.

Micrographic examination shall be carried out in accordance with 1.9, Part IX "Materials and Welding" of the LG Rules and agreed standards, such as ASTM E112.

A test acceptance criterion is microstructure, including grain size, precipitations. The test report shall be submitted to the Register for reference.

11.2.2 Hardness test.

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

A test acceptance criterion is a hardness value. The test report shall be submitted to the Register for reference.

11.2.3 Cross-weld tensile test.

The test shall be carried out in accordance with 3.3.5.1, Part IX "Materials and Welding" of the LG Rules, 4.2.2.2, Part XIV "Welding" of the RS Rules/C and agreed standards, such as ASTM E8/E8M, for under-matched welds.

Test acceptance criteria shall be in accordance with 18.2.4.1.2, Part IV "Cargo Containment" of the LG Rules.

11.2.4 Charpy impact test.

The test shall be carried out in accordance with 1.3 and 3.3.5.3, Part IX "Materials and Welding" of the LG Rules.

Test acceptance criteria shall be in accordance with 3.3.5.3, "Materials and Welding" of the LG Rules.

11.2.5 *CTOD* (crack tip opening displacement) test.

The test shall be carried out in accordance with an agreed standard, such ASTM E1820 or BS 7448, or ISO 15653.

A test acceptance criterion is a *CTOD* minimum value, which shall be in accordance with the Register approved design specification for testing at room and cryogenic temperatures as per design conditions. Minimum *CTOD* value is 0,2 mm.

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

The test shall be carried out in accordance with an agreed standard, such as ASTM E1820 or ISO 15653. The ductile fracture toughness test may be omitted upon the agreement with the Register.

Test acceptance criteria shall be in accordance with the agreed standard.

11.2.7 Bending test.

The test shall be carried out in accordance with 1.5, Part IX "Materials and Welding" of the LG Rules.

A test acceptance criterion is no fracture acceptable after a 180° bend as required for welded material according to 3.3.5.2, Part IX "Materials and Welding" of the LG Rules.

11.2.8 Fatigue test.

The basis for establishing S-N curves shall be in accordance with the requirements of 18.3.4.2, Part IV "Cargo Containment" of the LG Rules.

A test acceptance criterion is the compliance of test results with parameters of *S* — *N* curves (fatigue life shall be not lower), accepted in accordance with standards IIW.

11.2.9 Corrosion test.

The test shall be carried out in accordance with an agreed standard as specified in 11.1.9.1 — 11.1.9.4.

Test acceptance criteria shall be in accordance with the agreed standard.

11.2.9.1 Intergranular corrosion test.

The test shall be carried out in accordance with an agreed standard, such as ASTM A262.

Test acceptance criteria shall be in accordance with the agreed standard.

11.2.9.2 General corrosion test.

The test shall be carried out in accordance with an agreed standard, such as ASTM G31.

Test acceptance criteria shall be in accordance with the agreed standard.

11.2.9.3 Stress corrosion cracking test.

The test shall be carried out in accordance with agreed standards, such as ASTM G36 and ASTM G123.

Test acceptance criteria shall be in accordance with the agreed standard.

11.2.9.4 Corrosion test for ammonia compatibility.

The test shall be carried out in accordance with 11.3.

11.3 Procedure of corrosion testing for ammonia compatibility.

11.3.1 The test shall be carried out in accordance with an agreed standard, such as ASTM B858. The provisions of the standard, despite it being applicable to copper alloys, may be applied to high manganese austenitic steel taking into account the requirements of 11.3.1.1 — 11.3.1.3 and 11.3.2 — 11.3.5.

11.3.1.1 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.

11.3.1.2 Three base metal and three welded specimens shall each be immersed in the following ammonia environments (6 types) for a period of 30 days:

liquid phase ammonia environments, obtained by cooling of ammonia at slightly lower temperature than the boiling temperature of ammonia, i.e., –33,5 °C and at atmospheric pressure 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 (+25 °C) and atmospheric pressure with the following gas ammonia compositions:

pure ammonia (≥ 99,99 %) (type 3) and

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

gas phase ammonia environments at –20 °C and atmospheric pressure with the following gas ammonia compositions:

pure ammonia (≥ 99,99 %) (type 5) and

0,9 % volume of oxygen and 99,1 % volume of ammonia (type 6).

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

11.3.1.3 The test report shall contain all test procedures, test results, information about the environment in accordance with standard ISO 16540 and include the information on:

the orientation, types, and dimensions of specimens;

material description: chemistry and tensile properties of base metal; chemistry and tensile properties of welding consumables; type of welding, hardness of the weld metal and heat affected zones (HAZ);

four points bending test;

target stress and applied deflection;

strain measurement procedures;

loading procedures; and

test environment (temperature, water and oxygen content, pH).

11.3.2 A test acceptance criterion is availability of stress corrosion cracking under an optical microscope with proper magnification. The location and the number of cracks shall be specified, and a fluorescent penetration test performed to confirm the results as necessary. For welded joints, the location of cracks shall be described as located in the base metal, weldment 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. Test results are subject to the Register approval.

11.3.3 Loading jig made of corrosion resistant alloys with spacing between outer rollers of 85 mm shown in Fig. 11.3.3 is to be used to apply a constant deflection to the specimen. The specimen is electrically isolated from the ceramic rollers in order to avoid undesirable galvanic corrosion.

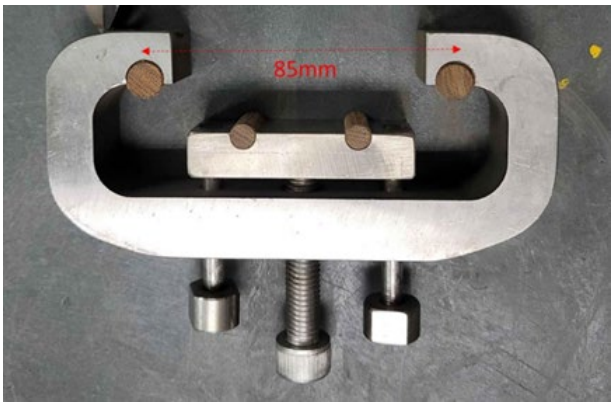


Fig. 11.3.3
Four-point bend loading jig design

11.3.4 The specimens are machined from a 40 mm thick hot rolled plate and are not subjected to post-weld heat treatment. The outer radius of the specimen subject to bending is the original surface of the hot rolled plate. They are bent prior to testing. The surface subject to ammonia exposure in a tank is not machined.

Four-point bend specimens are flat strips of uniform rectangular cross section and uniform thickness except in the case of testing welded specimens with one face in the as-welded condition as shown in Fig. 11.3.4. The original surface from a 40 mm hot rolled plate (cap bead in case of welded specimen) is the one to be observed. For weldments, the weld bead to be tested is the weld cap.

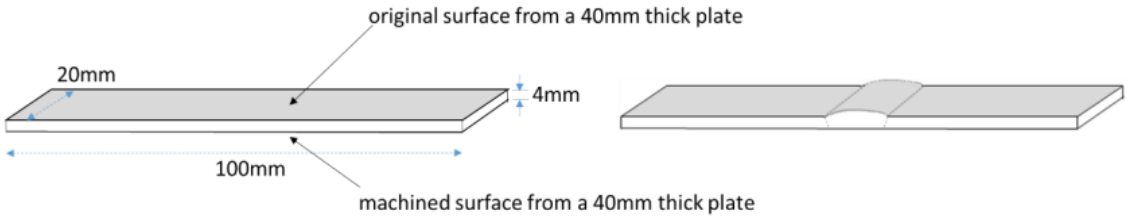


Fig. 11.3.4
Four-point bend specimens (base specimen and as-welded specimen)

11.3.5 Dial gauge will be attached for measurement of deflection at the centre of the face in tension. The loading of the specimen is such that it reaches to the required yield strength level and then the specimen is constrained to maintain its form during testing. The amount of deflection, *y*, is set as the formula below complying with ISO 16540:

$$\mathrm{Y} = \frac{(3H^2 - 4A^2)\sigma}{12Et},$$

where
σ is the yield strength;
E is the modulus of elasticity,
t is the specimen thickness;
A is the distance between the inner and outer supports;
H is the distance between the outer supports.

Uniaxial tensile test of a 40 mm thick plate will be performed to determine the yield strength to be applied for the calculation of the amount of deflection required.

During welded specimen testing, the same amount of the deflection as for the base plate is to be set out.".

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