RUSSIAN MARITIME REGISTER OF SHIPPING

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# RULES

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

## PART IX

### MATERIALS AND WELDING

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# RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SHIPS CARRYING LIQUEFIED GASES IN BULK (PART IX)

The present version of Part IX "Materials and Welding" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk of Russian Maritime Register of Shipping (RS, the Register) has been approved in accordance with the established approval procedure and comes into force on 1 January 2026.

The present version is based on the version dated 1 July 2025 and Rule Change Notice No. 25-251415 taking into account the amendments and additions developed immediately before publication (refer to the Revision History).

## REVISION HISTORY[1]

For this version, there are no amendments to be included in the Revision History.

[1] With the exception of amendments and additions introduced by Rule Change Notices (RCN), as well as of misprints and omissions.

## 1 GENERAL

**1.1** The requirements of this Part of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk[1] apply to plates, sections, pipes, forgings and castings used in the construction of cargo tanks, cargo process pressure vessels, cargo and process piping, secondary barriers, as well as to welded joints of the above products.

The requirements also cover hull structural steel plates and sections according to 3.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships[2], which are used for manufacture of structures subjected to low temperatures, but of other than parts of the secondary barrier.

The requirements for rolled materials, forgings and castings are given in Tables 2.1-1 — to 2.1-5, and for welded structures, in Section 3.

**1.2** The manufacture, testing, survey and documentation shall meet the requirements of Part XIII "Materials" of the Rules for the Classification, the approved standards and the requirements of this Part.

**1.3** Unless otherwise required by the Register, the impact tests in accordance with 2.2.3, Part XIII "Materials" of the Rules for the Classification on the specimens according to Fig. 2.2.3.1-2 and Table 2.2.3.1-2 of the above Part shall be carried out; in addition, the standards for the minimum impact energy KV are established according to 2.2.3.1 and Table 2.2.3.1-4 of the above Part.

For base metal, the largest size specimens possible for the material thickness shall be machined. The requirements for tests of metal thickness less than 5 mm shall comply with the national and/or international standards. In the case where the material thickness is 40 mm or below, the test specimens shall be cut with their edge within 2 mm from the "as rolled" surface with their longitudinal axes parallel to the final direction of rolling of the material, and the surfaces shall be machined. For steel thickness over 40 mm the specimens shall be cut with their longitudinal axes located as near as practicable to a point midway between the surface and the centre of the thickness and the length of the notch perpendicular to the surface. V-notches shall be made perpendicular to the surface.

On agreement with the Register, in addition to or instead of impact tests other tests may be carried out to determine brittle fracture resistance (crack resistance), e.g. the drop weight test.

In case of unsatisfactory results for bending impact test the re-testing shall be conducted in compliance with 1.3.2, Part XIII "Materials" of the Rules for the Classification.

**1.4** The tensile strength, yield stress and elongation of a specific material shall be given in the documentation to be approved by the Register.

**1.5** The bend test may be omitted for a base material, but is required during testing of welded joints.

Longitudinal bend tests may be required in lieu of transverse bend tests in cases where the base material and weld metal have different strength levels.

**1.6** The Register may accept materials with alternative chemical composition and/or mechanical properties.

**1.7** Where post-weld heat treatment is specified, the properties of the base material shall be determined in the heat-treated condition in accordance with Tables 2.1-1 — 2.1-5, and the weld properties shall be determined in the heat-treated condition according to the requirements of Section 3.

In cases where a post-weld heat treatment is applied, the test requirements may be modified on agreement with the Register.

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

**1.8** Steels with A, B, D, E, AH, DH, EH and FH grades shall comply with 3.2 and 3.5 of Part XIII "Materials" of the Rules for the Classification accordingly.

**1.9** During the initial survey and in case of discrepancies between the results of the acceptance tests and the requirements specified in an appropriate section of the Rules, macrosection, microsection observations and hardness tests shall be performed in accordance with 3.2 of Part XIII "Materials" of the Rules for the Classification.

**1.10** Aluminium alloys applied in the cargo containment structures of gas carriers shall comply with the requirements for aluminium alloys of Section 5, Part XIII "Materials" of the Rules for the Classification, as well as of Section 10, Part XIII "Materials" of the Rules for the Classification.

## 2 MATERIAL REQUIREMENTS

**2.1** The requirements for materials of construction are shown in the tables as follows:

Table 2.1-1: plates, pipes (seamless and welded), sections and forgings for cargo tanks and process pressure vessels for design temperatures not lower than 0 °C;

Table 2.1-2: plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below 0 °C and down to –55 °C;

Table 2.1-3: plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below –55 °C and down to –165 °C;

Table 2.1-4: pipes (seamless and welded), forgings and castings for cargo and process piping for design temperatures below 0 °C and down to –165 °C;

Table 2.1-5: plates and sections for hull structures subjected to lowered cargo temperatures.

**2.2** Castings and forgings intended for cargo and process piping for design temperature above 0 °C shall comply with the requirements of the recognized national and/or international standards.

Table 2.1-1

| **Plates, pipes (seamless and welded[1]), sections and forgings for cargo tanks, fuel tanks and process pressure vessels for design temperatures not lower than 0 °C** | |
|---|---|
| **Chemical composition**<br>Carbon-manganese steel. Fully killed. Fine grain steel.<br>Chemical composition of the steel shall comply with the requirements of national/international standard or manufacture's specification approved by the Register. | |
| **Heat treatment**<br>Normalized, or quenched and tempered[2] | |
| **Tensile and charpy V-notch impact test** | |
| Plates | Each piece shall be tested |
| Sections and forgings | Each batch shall be tested |
| Tensile properties | Specified minimum yield stress not exceeding 410 MPa[3] |
| **Charpy V-notch impact test** | |
| Plates | Transverse specimens |
| | Minimum average energy value (KV) 27 J |
| Sections and forgings | Longitudinal specimens |
| | Minimum average energy value (KV) 41 J |
| **Impact test temperature** | |
| Thickness *t*, in mm | Test temperature, in °C |
| $t \leq 20$ | 0 |
| $20 < t \leq 40$ | –20 |
| $40 < t \leq 50$[4] | –20[5] |
| $40 < t \leq 50$[4] | –30[6] |

[1] For seamless pipes and fittings in compliance with the requirements of the Rules for the Classification and Construction. Charpy V-notch impact tests are not required for pipes.

[2] A controlled rolling procedure or TMCP may be used as an alternative provided the properties specified in the Rules are guaranteed by the manufacturer.

[3] Hardness of the weld and heat affected zones shall meet the approved international and/national standards and norms.

[4] For semi-finished products of $t > 40$ mm in thickness, testing of a further set of samples taken from mid-thickness is required. This requirement does not apply to normal, higher and high strength rolled steel complying with the requirements of the RS rules and specified in 3.2 and 3.13, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

[5] Applies to independent tanks of C type and process pressure vessels. Post-weld stress relief heat treatment shall be performed. Exemption to post-weld stress relief heat treatment based on an alternative approach (e.g., engineering-critical assessment) shall be to agreed standards or may be individually agreed with the Register.

[6] Applies to cargo or fuel tanks except of those of C type.

Table 2.1-2

**Plates, sections and forgings[1] for cargo tanks, secondary barriers and process pressure vessels for design temperatures below 0 °C and down to –55 °C. Maximum thickness[2] 25 mm**

**Chemical composition**
Carbon-manganese steel. Fully killed. Aluminium treated fine grain steel. Chemical composition (ladle analysis), %:

| C | Mn | Si | S | P |
|---|---|---|---|---|
| 0,16 max[3] | 0,70 — 1,60 | 0,10 — 0,50 | 0,025 max | 0,025 max |

Alloys and grain refining elements may be generally in accordance with the following, %:

| Ni | Cr | Mo | Cu | Nb | V | Al |
|---|---|---|---|---|---|---|
| 0,80 max | 0,25 max | 0,08 max | 0,35 max | 0,05 max | 0,10 max | 0,02 min |

**Heat treatment**
Normalized or quenched and tempered[4]

**Tensile and Charpy V-notch impact test**

| | |
|---|---|
| Plates | Each piece shall be tested |
| Sections and forgings | Each batch shall be tested |
| Tensile properties | Specified minimum yield stress not exceeding 410 MPa[5] |

**Charpy V-notch impact test**

| | |
|---|---|
| Plates | Transverse specimens |
| | Minimum average impact energy value *KV* 27 J |
| Sections and forgings[1] | Longitudinal specimens |
| | Minimum average impact energy value *KV* 41 J |

**Charpy V-notch impact test temperature**
5 °C below design temperature or –20 °C, whichever is lower

[1] Chemical composition of forgings shall comply with the specification approved by the Register.

[2] For material thickness more than 25 mm thick, Charpy V-notch impact tests shall be conducted as follows:

| Material thickness *t*, in mm | Test temperature, in °C |
|---|---|
| 25 < *t* ≤ 30 | 10 °C below design temperature or –20 °C, whichever is lower |
| 30 < *t* ≤ 35 | 15 °C below design temperature or –20 °C, whichever is lower |
| 35 < *t* ≤ 40 | 20 °C below design temperature |

The Charpy V-notch impact energy value shall be in accordance with the table for the applicable type of test specimen.

Materials for tanks and parts of tanks which are completely thermally stress relieved after welding may be tested at a temperature 5 °C below design temperature or – 20 °C, whichever is lower.

For thermally stress relieved reinforcements and other fittings, the test temperature shall be the same as that required for the adjacent tankshell thickness.

[3] Carbon content may be increased to 0,18 maximum provided the design temperature is not lower than –40 °C.

[4] A controlled rolling procedure or TMCP may be used as an alternative to normalizing or quenching and tempering, provided the properties specified in the LG Rules are guaranteed by the manufacturer. For materials exceeding 25 mm in thickness for which the test temperature is –60 °C or lower, the application of specially treated steel or steels in accordance with Table 2.1-3 shall be stipulated by the LG Rules.

[5] Hardness of the weld and heat affected zones shall meet the approved international and/national standards and norms.

**Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below 0 °C and strictly down to –10 °C. Thickness above 40 mm.**
**Requirements for Charpy V-notch impact bend testing.**

| | Thickness t, in mm | Test temperature, in °C |
|---|---|---|
| Test temperature | 40 < *t* ≤ 50[6] | 5 °C below design temperature or – 20 °C, whichever is lower[7] |
| | 40 < *t* ≤ 50[6] | 25 °C below design temperature[8] |
| | 40 < *t* ≤ 50[6] | 30 °C below design temperature[8] |

[6] For semi-finished products of *t* > 40 mm in thickness testing of a further set of samples taken from mid-thickness is required. This requirement does not apply to normal, higher and high strength rolled steel complying with the requirements of the RS rules and specified in 3.2 and 3.13, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

[7] Applies to independent tanks of C type and process pressure vessels. Post-weld stress relief heat treatment shall be performed. Exemption to post-weld stress relief heat treatment based on an alternative approach (e.g., engineering-critical assessment) shall be to agreed standards or may be individually agreed with the Register.

[8] Applies to cargo or fuel tanks except of those of C type.

| **Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below –10 °C and down to –55 °C. Thickness above 40 mm. Requirements for Charpy V-notch impact bend testing.** | | |
|---|---|---|
| Test temperature | Thickness *t*, in mm | Test temperature, in °C |
| | 40 < *t* ≤ 50[9] | 5 °C below design temperature or –20 °C, whichever is lower[10] |
| | 40 < *t* ≤ 50[9] | 25 °C below design temperature[11] |
| | 40 < *t* ≤ 50[9] | 30 °C below design temperature[11] |

[9] For semi-finished products on *t* > 40 mm in thickness, testing of a further set of samples taken from mid-thickness is required. This requirement does not apply to the rolled steel of normal, higher and high strength complying with the requirements of the RS rules and specified in 3.2 and 3.13, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

[10] For post-weld stress relief heat treatment requirements of 6.6.2.2 of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk shall apply Post-weld stress relief heat treatment shall be performed. Exemption to post-weld stress relief heat treatment based on an alternative approach (e.g., engineering-critical assessment) shall be to agreed standards or may be individually agreed with the Register.

[11] Applies to cargo or fuel tanks except of those of C type.

Table 2.1-3

| **Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures[1] below –55 °C and down to –165 °C. Maximum thickness[2] 25 mm** | | |
|---|---|---|
| Minimum design temperature, in °C | Chemical composition[3] and heat treatment | Charpy V-notch impact test temperature, °C |
| –60 | 1,5 % nickel steel<br>N or N+T or Q+T or TMCP | –65 |
| –65 | 2,25 % nickel steel<br>N or N+T or Q+T or TMCP[4] | –70 |
| –90 | 3,5 % nickel steel<br>N or N+T or Q+T or TMCP[4] | –95 |
| –105 | 5 % nickel steel<br>N or N+T or Q+T[4, 5] | –110 |
| –165 | 9 % nickel steel N+N+T or Q+T | –196 |
| –165 | Austenitic steels such types* 304, 304L, 316, 316L, 321 and 347<br>Solution treated | –196 |
| –165 | High manganese austenitic steel — hot rolling and controlled cooling[6, 7] | –196 |
| –165 | Aluminium alloys type* 5083, 1550, 1565ch<br>Annealed | Not required |
| –165 | Austenitic Fe – Ni alloy (36 % Ni) | Not required |

| **Tensile and Charpy V-notch impact test** | |
|---|---|
| Plates | Each piece shall be tested |
| Sections and forgings | Each batch shall be tested |

| **Charpy V-notch impact test** | |
|---|---|
| Plates | Transverse specimens |
| | Minimum average energy value *KV* 27 J |
| Sections and forgings | Longitudinal specimens |
| | Minimum average energy value *KV* 41 J |

[1] The requirements for materials use at design temperatures below –165 °C shall comply with the values specified in the national/ international standards.

[2] For steel 1,5 %; 2,25 %; 3.5% and 5% Ni, with thickness greater than 25 mm, the Charpy V-notch impact test temperature shall be corrected as follows:

| Material thickness *t*, in mm | Test temperature, in °C |
|---|---|
| $25 < t \le 30$ | 10 °C below design temperature |
| $30 < t \le 35$ | 15 °C below design temperature |
| $35 < t \le 40$ | 20 °C below design temperature |

The Charpy V-notch impact energy value shall be in accordance with the table for the applicable type of test specimen.

[3] The chemical composition limits shall comply with the approved specification.

[4] A lower minimum design temperature for quenched and tempered steels may be permitted.

[5] A specially heat treated, for example triple heat treated 5 % nickel steel may be used down to –165 °C, provided that the Charpy V-notch impact tests are carried out at –196 °C.

[6] Use of the material shall be subject to the required operational conditions based on the provisions of IMO circular MSC.1/Circ.1599/Rev.3.

[7] The impact test may not be omitted for high manganese austenitic steel.

* In compliance with the international and national standards.

| **Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures[1] below –55 °C and down to –165 °C. Thickness above 40 mm Requirements for Charpy V-notch impact bend testing.** | |
|---|---|
| $40 < t \le 45$[8] mm | 25 °C below design temperature |
| $45 < t \le 50$[8] mm | 30 °C below design temperature |

[8] For semi-finished products of $t > 40$ mm in thickness, testing of a further set of samples taken from mid-thickness is required. This requirement does not apply to normal, higher and high strength rolled products complying with the requirements of the RS rules and specified in 3.2 and 3.13, Part XIII "Materials" of the RS Rules/C.

Table 2.1-4

| Pipes (seamless and welded), forgings and castings for cargo and process piping for design temperatures below 0 °C and down to –165 8C. Maximum thickness 25 mm. | | | |
|---|---|---|---|
| Minimum design temperature, in °C | Chemical composition[1] and heat treatment | Impact tes | |
| | | Test temperature, in °C | Minimum average impact energy value (KV), in J |
| –55 | Carbon-manganese steel. Fully killed. Fine grain steel. N or treated. | –2 | 27 |
| –65 | 2,25 % nickel steel N or N + T or Q + T[3] | –70 | 34 |
| –90 | 3,5 % nickel steel N, N +T, Q +T[3] | –95 | 34 |
| –165 | Steel of 9 % Ni[4] N, N +T, Q +T | –196 | 41 |
| –165 | Austenitic steel types* 304, 304L, 316, 316L, 321 и 347 Solution treated[8] | –196 | 41 |
| | Aluminium alloys type* 5083 Annealed | | Not required |
| **Tensile and charpy V-notch impact test** Each batch shall be tested | | | |
| **Charpy V-notch impact test** Longitudinal specimens | | | |
| [1] The chemical composition limits shall comply with the specification approved by the Register. [2] The test temperature should shall be 5°C below the design temperature or –-20°C whichever is lower. [3] A lower minimum design temperature may be permitted for quenched and tempered materials. [4] This chemical composition is not suitable for castings. | | | |
| * In compliance with the international and national standards. | | | |

Table 2.1-5

| Plates and sections for hull structures receiving lower cargo temperature | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Minimum design temperature of hull structure, in °C | Maximum thickness, in mm, for steel grades | | | | | | | |
| | A | B | D | E | A32 A36 A40 | D32 D36 D40 | E32 E36 E40 | F32 F36 F40 |
| 0 and above[1] –5 and above[2] | In accordance with 1.4, Part II "Hull" of the Rules for the Classification | | | | | | | |
| down to –5 | 15 | 25 | 30 | 50 | 25 | 45 | 50 | 50 |
| down to –10 | * | 20 | 25 | 50 | 20 | 40 | 50 | 50 |
| down to –20 | * | * | 20 | 50 | * | 30 | 50 | 50 |
| down to –30 | * | * | * | 40 | * | 20 | 40 | 50 |
| Below –30 | In accordance with Table 2.1-2 except that the thickness limitation given in Footnote 2 to the Table does not apply | | | | | | | |
| [1] For cases specified in 19.2.3, Part IV "Cargo Containment". [2] For cases specified in 19.2.2, Part IV "Cargo Containment". | | | | | | | | |
| * This steel grade shall not be used. | | | | | | | | |

## 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*);

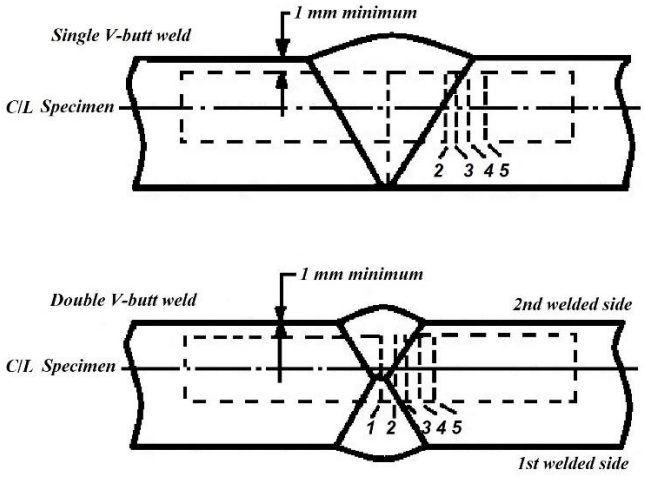


Fig. 3.3.4.4
Location of V-notch on specimens for impact test

**.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.

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

**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 this 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.

Russian Maritime Register of Shipping

**Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk**
**Part IX**
**Materials and Welding**

FAI "Russian Maritime Register of Shipping"
7, Litera A, Millionnaya Ulitsa
St. Petersburg, 191186,
Russian Federation
www.rs-class.org/en/