

# RULES

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

### PART IX MATERIALS AND WELDING

ND No. 2-020101-157-E



**St. Petersburg  
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# **RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SHIPS CARRYING LIQUEFIED GASES IN BULK**

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Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk of Russian Maritime Register of Shipping (RS, the Register) have been approved in accordance with the established approval procedure and come into force on 1 January 2022.

The present edition of the Rules is based on the 2021 edition taking into account the amendments developed immediately before publication.

The Rules establish requirements, which are specific for ships carrying liquefied gases in bulk, and supplement the Rules for the Classification and Construction of Sea-Going Ships and Rules for the Equipment of Sea-Going Ships of Russian Maritime Register of Shipping.

The Rules are published in the following parts:

Part I "Classification";

Part II "Ship Arrangement";

Part III "Stability. Subdivision. Freeboard";

Part IV "Cargo Containment";

Part V "Fire Protection";

Part VI "Systems and Piping";

Part VII "Electrical Equipment";

Part VIII "Instrumentation and Automation Systems";

Part IX "Materials and Welding";

Part X "Special Requirements".

**REVISION HISTORY**

(purely editorial amendments are not included in the Revision History)

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

## **1 GENERAL**

**1.1** The requirements of this Part of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk<sup>1</sup> 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<sup>2</sup>, 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 ultimate 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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<sup>1</sup> Hereinafter referred to as "the LG Rules".

<sup>2</sup> 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 <sup>1</sup> ), sections and forgings for cargo tanks and process pressure vessels for design temperatures not lower than 0 °C	
<b>Chemical composition</b>	
Carbon-manganese steel. Fully killed. Fine grain steel. Chemical composition of the steel shall comply with the requirements of national/international standard or manufacture's specification approved by the Register	
<b>Heat treatment</b>	
Normalized, or quenched and tempered <sup>2</sup>	
<b>Tensile and Charpy V-notch impact tests</b>	
Plates	Each piece shall be tested
Sections and forgings	Each batch shall be tested
Tensile properties	Specified minimum yield stress not exceeding 410 MPa <sup>3</sup>
<b>Charpy V-notch impact test</b>	
Plates	Transverse test pieces Minimum average impact energy value (KV) 27 J
Sections and forgings	Longitudinal test pieces Minimum average impact energy value (KV) 41 J
<b>Impact test temperature</b>	
Thickness S, in mm	Test temperature, in °C
S ≤ 20	0
20 < S ≤ 40	–20
<sup>1</sup> 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.	
<sup>2</sup> A controlled rolling procedure or TMCP may be used as an alternative provided the properties specified in the Rules are guaranteed by the manufacturer.	
<sup>3</sup> Hardness of the weld and heat affected zones shall meet the approved international and/national standards and norms.	

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Table 2.1-2

Plates, sections and forgings <sup>1</sup> for cargo tanks, secondary barriers and process pressure vessels for design temperatures below 0 °C and down to –55 °C. Maximum thickness <sup>2</sup> 25 mm						
<b>Chemical composition</b>						
Carbon-manganese steel. Fully killed. Aluminium treated fine grain steel. Chemical composition (ladle analysis):						
C	Mn	Si		S		P
0,16 max <sup>3</sup>	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
<b>Heat treatment</b>						
Normalized or quenched and tempered <sup>4</sup>						
<b>Charpy V-notch impact test</b>						
Plates	Each piece shall be tested					
Sections and forgings	Each batch shall be tested					
Tensile properties	Specified minimum yield stress not exceeding 410 MPa <sup>5</sup>					
<b>Impact tests</b>						
Plates	Transverse test pieces.					
	Minimum average impact energy value (KV) 27 J					
Sections and forgings <sup>1</sup>	Longitudinal test pieces.					
	Minimum average impact energy value (KV) 41 J					
<b>Impact test temperature</b>						
5 °C below design temperature or –20 °C, whichever is lower						
<sup>1</sup> Chemical composition of forgings shall comply with the specification approved by the Register.						
<sup>2</sup> For material thickness more than 25 mm thick, Charpy V-notch impact tests shall be conducted as follows:						
Material thickness S, in mm		Test temperature, in °C				
25 < S ≤ 30		5 °C below design temperature or –20 °C, whichever is lower				
30 < S ≤ 35		15 °C below design temperature or –20 °C, whichever is lower				
35 < S ≤ 40		20 °C below design temperature				
The Charpy V-notch impact energy value shall be in accordance with the table for 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.						
<sup>3</sup> Carbon content may be increased to 0,18 % maximum provided the design temperature is not lower than –40 °C.						
<sup>4</sup> A controlled rolling procedure or TMCP may be used as an alternative to normalizing or quenching and tempering, provided the properties specified in the 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 <a href="#">Table 2.1-3</a> shall be stipulated by the LG Rules.						
<sup>5</sup> Hardness of the weld and heat affected zones shall meet the approved international and/national standards and norms.						

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Table 2.1-3

Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures <sup>1</sup> below –55 °C and down to –165 °C. Maximum thickness <sup>2</sup> 25 mm										
Minimum design temperature, in °C	Chemical composition <sup>3</sup> and heat treatment	Charpy V-notch impact test temperature, °C								
–60	1,5 % nickel steel N or N+T or Q+T or TMCP	–65								
–65	2,25 % nickel steel N or N+T or Q+T or TMCP <sup>4</sup>	–70								
–90	3,5 % nickel steel N or N+T or Q+T or TMCP <sup>4</sup>	–95								
–105	5 % nickel steel N or N+T or Q+T or TMCP <sup>4, 5</sup>	–110								
–165	9 % nickel steel N+N+T or Q+T	–196								
–165	Austenitic steels such types* 304, 304L, 316, 316L, 321 and 347 Solution treated	–196								
–165	Aluminium alloys type* 5083, 1550, 1565ch	Not required								
	Annealed									
–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) 27J									
Sections and forgings	Longitudinal test pieces									
	Minimum average energy value (KV) 41J									
<sup>1</sup> The requirements for materials use at design temperatures below –165 °C shall comply with the values specified in the national/ international standards.										
<sup>2</sup> For steel 1,5 %; 2,25 %; 3,5 % and 5 % Ni, with thickness greater than 25 mm, the test temperature shall be corrected as follows:										
<table><tr><td>Thickness S (in mm)</td><td>Test temperature, in °C</td></tr><tr><td>25 &lt; S ≤ 30</td><td>10 °C below design temperature</td></tr><tr><td>30 &lt; S ≤ 35</td><td>15 °C below design temperature</td></tr><tr><td>35 &lt; S ≤ 40</td><td>20 °C below design temperature</td></tr></table>			Thickness S (in mm)	Test temperature, in °C	25 < S ≤ 30	10 °C below design temperature	30 < S ≤ 35	15 °C below design temperature	35 < S ≤ 40	20 °C below design temperature
Thickness S (in mm)	Test temperature, in °C									
25 < S ≤ 30	10 °C below design temperature									
30 < S ≤ 35	15 °C below design temperature									
35 < S ≤ 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.										
<sup>3</sup> The chemical composition limits shall comply with the approved specification.										
<sup>4</sup> A lower minimum design temperature for quenched and tempered steels may be permitted.										
<sup>5</sup> A specially heat treated, e.g. 5 % nickel steel, 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.										
* In compliance with the international and national standards.										



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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 <sup>1</sup> and heat treatment	Impact test	
		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 <sup>3</sup>	-70	34
-90	3,5 % nickel steel N, N +T, Q +T <sup>3</sup>	-95	34
-165	Steel of 9 % Ni <sup>4</sup> N, N +T, Q +T	-196	41
-165	Austenitic steel types* 304, 304L, 316, 316L, 321 и 347 Solution treated <sup>8</sup>	-196	41
	Aluminium alloys type* 5083 Annealed		Not required
<b>Tensile and charpy V-notch impact test</b> Each batch shall be tested			
<b>Charpy V-notch impact test</b> Longitudinal specimens			
<sup>1</sup>	The chemical composition limits shall comply with the specification approved by the Register.		
<sup>2</sup>	The test temperature should shall be 5°C below the design temperature or -20°C whichever is lower.		
<sup>3</sup>	A lower minimum design temperature may be permitted for quenched and tempered materials.		
<sup>4</sup>	This chemical composition is not suitable for castings.		
<sup>*</sup>	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
0 and above <sup>1</sup> –5 and above <sup>2</sup>	In accordance with 1.4, Part II "Hull" of the Rules for the Classification						
down to –5	15	25	30	50	25	45	50
down to –10	*	20	25	50	20	40	50
down to –20	*	*	20	50	*	30	50
down to –30	*	*	*	40	*	20	40
Below –30	In accordance with <a href="#">Table 2.1-2</a> except that the thickness limitation given in Footnote 2 to the Table does not apply						
<sup>1</sup>	For cases specified in 19.2.3, Part IV "Cargo Containment".						
<sup>2</sup>	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 primary and secondary barriers, including the inner hull where this forms the secondary barrier.

The requirements of this Section are those generally employed for carbon, carbon-manganese, nickel alloy and austenitic steels, and may form the basis for acceptance testing of other material.

On agreement with the Register, impact testing of stainless steel and aluminium alloy weldments may be omitted.

The Register may demand other types of testing for any material.

#### **3.2 Welding consumables.**

**3.2.1** Welding consumables intended for welding of cargo tanks shall be recognized 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.

The results obtained from tensile and Charpy V-notch impact tests shall meet the Register requirements. The chemical composition of the deposited weld metal is subject to agreement with the Register.

#### **3.3 Welding procedure tests for cargo tanks, process pressure vessels and secondary barriers.**

##### **3.3.1 Number and location of test assemblies.**

**3.3.1.1** Welding procedure tests shall be conducted for all butt welds of:  
each base material;  
each type of consumable and welding process;  
each welding position.

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 on agreement with the Register.

Radiographic or ultrasonic testing may be performed at the discretion of the manufacturer or the Register.

Procedure tests for consumables intended for fillet welding shall be performed in accordance with the requirements of Part XIV "Welding" of the Rules for the Classification; in such cases welding consumables shall ensure the required impact energy value in the impact test.

##### **3.3.2 Test scope.**

**3.3.2.1** The selected welding procedures for cargo tanks and process pressure vessels specified in this para shall meet the requirements of [1.2](#).

The following welding procedure tests are specified for each test assembly:

- .1** cross-weld tensile tests;
- .2** longitudinal all-weld tensile testing shall comply with the requirements of national or international standard;
- .3** transverse bend tests. However, longitudinal bend tests may be required in lieu of transverse bend tests where base material and bend metal have different strength levels;

.4 one set of three Charpy V-notch type specimens for the impact test shall be selected from the following locations ([Fig. 3.3.2.1.3](#)):

centerline of the weld (1);

fusion line (FL) (2);

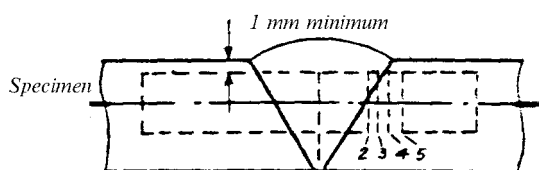
1 mm from the FL (3);

3 mm from the FL (4);

5 mm from the FL (5);

.5 macrosection analysis. The Register may also require the microsection analysis and hardness determination.

*Single V-butt weld*



*Double V-butt weld*

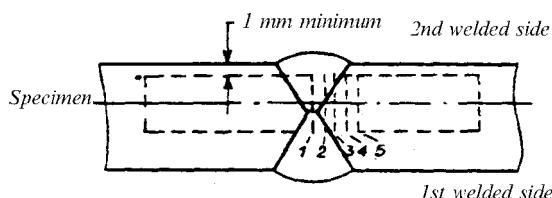


Fig. 3.3.2.1.3  
Orientation of weld test specimen

### 3.4 Tests.

#### 3.4.1 Tensile tests.

3.4.1.1 Tensile strength in testing of welded joints shall not be less than required for the base metal. The tensile strength of the weld metal below the tensile strength of the parent metal is allowed on a special agreement with the Register, unless in the tensile test of the transverse weld specimen, the tensile strength is less than that specified for the weld metal. In every case, the position of fracture shall be reported for information.

#### 3.4.2 Bend tests.

3.4.2.1 No fracture is acceptable after 180° bend over a former diameter of  $4t$  where  $t$  is the thickness of the test pieces.

#### 3.4.3 Charpy V-notch impact tests.

3.4.3.1 Charpy tests shall be conducted at the temperature prescribed for the base materials being joined. In impact tests of the weld metal, 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 Rules for the Classification.

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, and for subsize specimens, similarly to specified in 1.3.

**3.5 Fillet Welding Procedure Tests.**

**3.5.1** The requirements for fillet welding procedure tests are given in Section 6, 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. In such cases, welding consumables shall be selected which exhibit Charpy V-notch impact properties complying with the Register requirements.

**3.6 Welding Procedure Tests for Secondary Barriers.**

**3.6.1** Welding procedure tests for secondary barriers shall be carried out.

**3.7 Welding procedure tests for piping welded joints.**

**3.7.1** Welding procedure tests for piping welded joints similar to the tests specified in [3.2](#) shall be conducted.

The test requirements shall be in accordance with [3.4](#) unless provided otherwise.

**3.8 Production weld tests.**

**3.8.1** For all cargo tanks and process pressure vessels except integral and membrane tanks, production weld tests are generally to 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 [3.8.2 to 3.8.4](#), may be required for cargo tanks or secondary barriers at the discretion of the Register.

Test requirements shall comply with [3.4](#). The test program shall be based on the technical documentation of the manufacture and shall be approved by the Register.

**3.8.2** The production tests for types A and B independent tanks and semi-membrane tanks shall include the following tests.

**3.8.2.1** Bend tests and impacts test where required for procedure tests. One set 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). For austenitic stainless steel, all notches shall be in the centre of the weld.

**3.8.3** In addition to the tests for type C independent tanks and process pressure vessels, transverse weld tensile tests are also to be performed.

**3.8.4** Production weld tests for integral and membrane cargo tanks shall be performed in accordance with [3.3.2](#).

**3.9 Non-destructive testing.**

**3.9.1** For type A independent tanks and semi-membrane tanks where the design temperature is  $-20^{\circ}\text{C}$  or less, and for type B independent tanks regardless of temperature, 100 % of full penetration butt welds of the shell plating of cargo tanks shall be subjected to radiographic testing.

**3.9.1.1** Where the design temperature is higher than  $-20^{\circ}\text{C}$ , all full penetration butt welds in way of intersections and at least 10 % of the remaining full penetration welds of tank structures shall be subjected to radiographic testing.

**3.9.1.2** In each case the welds of other cargo tank structures including the welding of stiffeners and other fittings and attachments shall be subjected to non-destructive testing on agreement with the Register.

**3.9.2** For type C independent tanks and process pressure vessels, the extent of non-destructive testing shall be total or partial according to RS recognized manufacture quality standards, but the controls to be carried out shall not be less than those specified in [3.9.2.1](#) and [3.9.2.2](#).

**3.9.2.1** Total non-destructive testing referred to in 23.2.1, Part IV "Cargo Containment":

**.1** radiographic testing:

all butt welds over their full length;

**.2** non-destructive testing for surface crack detection:

all welds over 10 % of their length;

reinforcement rings around holes, nozzles, etc., over their full length.

As an alternative, ultrasonic testing as described in [3.9.7](#) may be accepted as a partial substitute for the radiographic testing. In addition, total ultrasonic testing on welding of reinforcement rings around holes, nozzles, etc may be required.

**3.9.2.2** Partial non-destructive testing referred to in 23.2.1, Part IV "Cargo Containment":

**.1** radiographic testing:

all butt-welded crossing joints and at least 10 % of the full length of butt welds at selected positions uniformly distributed;

**.2** non-destructive testing for surface crack detection:

reinforcement rings around holes, nozzles, etc., over their full length;

**.3** ultrasonic testing:

the controls to be carried out shall be approved by the Register.

**3.9.3** Non-destructive testing of welded joints of the inner hull or the independent tank structures supporting internal insulation tanks shall take into account the design criteria specified in 23.2.1, Part IV "Cargo Containment". The non-destructive testing scope and methods shall be agreed with the Register.

**3.9.4** For integral and membrane cargo tanks, special weld non-destructive testing methods and acceptance criteria are subject to agreement with the Register.

**3.9.5** Non-destructive testing of piping shall be carried out in accordance with the requirements of Part VI "Systems and Piping".

**3.9.6** The welds of secondary barrier structures are subject to radiographic testing 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 radiographic testing.

**3.9.7** All test procedures of non-destructive testing and acceptance standards shall be in accordance with Section 3, Part XIV "Welding" of the Rules for the Classification.

A non-destructive ultrasonic testing procedure in lieu of radiographic testing may be conducted. However, supplementary radiographic testing at selected locations shall be carried out to verify the results.

The manufacturer shall submit to the Register for the review a program of non-destructive testing and the documentation of the firm quality assurance system to ensure the required extent of non-destructive testing of the firm's products.

The relevant records of the testing results shall be submitted to the Register.

Russian Maritime Register of Shipping

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