PART XIV. WELDING

1. GENERAL

1.1 APPLICATION

1.1.1 The requirements of the present Part of the Rules apply to the following items, which are subject to survey by the Register:

.1 ship hulls;

.2 machinery and machinery installations;

.3 steam boilers, heat exchangers and pressure vessels;

.4 piping;

.5 ship equipment and arrangements.

1.1.2 The requirements of the present Part shall establish requirements for welding consumables manufacture, welding procedures, and testing of welded structures stated in 1.1.1.

1.1.3 The requirements of the present Part shall be applied when designing, building and manufacturing items stated in 1.1.1.

1.1.4 The requirements of the present Part may be applied when carrying out repairs of structures stated in 1.1.1 as well, to an extent, which is deemed necessary and advisable.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 Definitions and explanations pertaining to the general terminology of the Rules shall be found in the General Regulations for the Classification and Other Activity and in Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships[1].

Besides, in this Part the following definitions have been adopted.

High temperature brazing (hard brazing) is a brazing method, at which the melting temperature of the solder is above 450 °C.

Welding consumables include electrode, welding wire, flux, shielding gases and other materials used in welding.

Heat-affected zone (HAZ) is the layer of the base metal adjacent to a weld (or to the deposited metal) where structural changes were caused by the welding heat.

Weld metal is the metal obtained by the merging of the fused base metal and the deposited metal, or by fusion of the base metal only.

Deposited metal is the metal obtained by melting of electrodes or welding wire and containing no appreciable admixture of the base metal.

Base metal is the metal of items being welded.

Penetration is the merging of the base metal into the deposited one or the merging of the fused metal of both the components being welded.

[1] Hereinafter referred to as Part I " Classification".

1.3 GENERAL

1.3.1 Welding of items stated in 1.1.1 shall be effected by certified welders (operators) and Register- approved welding works (shops, bays) using welding consumables and welding processes approved by the Register.

The application of each of the welding processes (or its variant) at a particular works shall be backed up by the results of testing conducted in accordance with a program agreed with the Register according to Section 6, Part II "Technical Supervision during Manufacture of Materials" of Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

Welding consumables shall be approved by the Register in compliance with the requirements of Section4.

1.3.2 Welding operation on structures subject to survey by the Register shall be performed by those welders only who stood the tests prescribed by Section 5.

1.4 SCOPE OF SURVEYS

1.4.1 General provisions concerning survey during manufacture of materials and equipment shall be found in General Regulations for the Classification and Other Activity.

1.4.2 As far as structures stated in 1.1.1 are concerned, the following is subject to survey by the Register:

.1 welding consumables;

.2 welding procedures (choosing of welding consumables, preparation of parts for welding assembly, pre- and post-heating, heat treatment);

.3 methods and scope of non-destructive testing and criteria for evaluation of welded joints.

1.5 TECHNICAL DOCUMENTATION

1.5.1 The scope of technical documentation on welding, which shall be agreed as part of the ship design, is set out in Part I "Classification".

Technical documentation on items specified in 1.1.1 shall include information on welding required by those parts of the Rules, which cover the items concerned.

1.5.2 The composition of technical documentation for welding consumables being approved shall be determined proceeding from 4.1.2.1.

2. TECHNOLOGICAL REQUIREMENTS FOR WELDING

2.1 GENERAL

2.1.1 The present technological requirements shall be applied when welding structures mentioned in 1.1.1.

To effect welding operations and non-destructive testing of welded joints in structures subject to survey by the Register the works shall have adequate equipment.

2.1.2 Where welding is performed at low temperature, working conditions shall be provided to enable the welder to produce sound welds.

The welding site shall be protected from draught and precipitation.

2.1.3 Where welding is performed at low ambient temperature, welds shall be

protected from fast cooling, as far as practicable.

2.1.4 On condition proper quality of welded joints is ensured, welding and all related operations on the structures stated in 1.1.1 and made of hull structural steel of normal and higher strength up to 20 mm in thickness are generally permitted at ambient temperature up to -25 °C, provided that welding consumables used have been tested at this temperature in accordance with 4.2.2.4.

Otherwise, the minimum permissible ambient temperature for unheated welding shall be established in accordance with applicable standards or on agreement with the manufacturer of welding consumables, and recorded at welding procedures approval after respective tests have been carried out.

In the following cases the edges of parts to be welded shall be preheated at least to +20°C over a width of 75 mm to both sides of the weld at ambient temperature:

.1 below -15 °C for forgings and castings used for ship hull;

.2 below -10 °C for parts of joints made of semi-killed steel;

.3 below -5 °C for low alloy boiler steel and during manufacture of boilers and pressure vessels.

2.1.5 The welding of piping made of low alloy steel, piping of the steam main as well as piping, which shall operate at temperatures above 350 °C, shall not be conducted at temperatures below zero.

2.1.6 The structural requirements for welds aimed at ensuring their strength shall be found in the relevant parts of the Rules.

2.1.7 The edge preparation of the parts to be welded shall be effected in conformity with standards or with drawings approved by the Register.

2.1.8 The edges of parts to be welded shall be prepared by methods, which ensure the required quality of welded joints in accordance with the requirements of the Rules.

2.1.9 From the edges of the parts to be welded, oil, moisture, scale, rust, paint and other contaminating substances shall be removed.

Steel parts coated with a primer may be welded without removing it; in this case, the primer shall be of a type approved by the Register after testing in accordance with Procedure for Determining the Influence upon Weldability of Protective Primers not Removed before Welding (refer to Collection of Regulating Documents of the Register of the USSR, Book 4).

2.1.10 When welding of structures is effected at temperatures below zero the edges being welded shall be free from snow, hoar-frost, ice and be dry.

2.1.11 When structures are welded, the sequence of welding operations shall be such as to ensure the absence of excessive residual stresses or distortions.

2.1.12 When it is necessary to preheat the parts to be welded, the preheating temperature shall be determined taking into account chemical composition of metal, welding process, thickness of parts to be welded, level of weld stresses and conditions of heat transfer through the structure from the weld zone.

When complex structures are welded, the preheating temperature is, in each case, subject to special consideration by the Register.

2.1.13 Instances of welding and cutting under water as well as welding operations on structures, on the reverse side of which water is present during welding, shall be specially considered by the Register.

2.1.14 When plates, sheets and the like shall be welded into a rigid contour, technological measures shall be taken to reduce the stresses caused by welding.

An opening with closed perimeter is considered to have the rigid contour if any of its dimensions is less than 60 plate thicknesses in the considered spot. For complex structures a contour may be regarded as rigid even at greater ratios of opening dimensions.

2.1.15 Dressing of welded structures is permitted within reasonable limits only. Hot dressing with mechanical effect and without one is permitted. When doing this, no damage to the joint or plate surface is admissible.

For hot dressing, the temperature shall not exceed 650 °C, but in no case shall the heating involve changes in the metal structure.

2.1.16 Postweld heat treatment is required to eliminate residual stresses.

The type of heat treatment shall be determined by the Manufacturer proceeding from the properties of material, and it shall be agreed upon with the Register.

2.1.17 Welding of components made of cold-bent hull structural steel may be effected without any heat treatment if the inner radius of bending complies with standards.

In case no such standards are available the said radius shall be equal to at least the triple thickness of the plate.

2.1.18 Welding consumables with controllable hydrogen content in the deposited metal shall be stored and calcinated before use in compliance with the manufacturer's recommendations.

2.2 WELDING OF SHIP HULL AND EQUIPMENT

2.2.1 The parts shall be assembled in such a way that the stresses arising during assembly and welding are as low as possible.

Tack welding shall be performed only by persons possessing the necessary qualifications. Tack welding shall be carried out using welding consumables of the grades required for welding structural components. Tack welds shall be free from any defects, which could impair the quality of welded joints.

If required by the surveyor to the Register, the tack welds shall be checked for freedom from cracks or other defects. When cracks occur in way of tack welds, they shall be cut out to sound metal and rewelded.

Temporary fittings used for assembly shall be kept to a minimum and be welded and tack-welded in conformity with the requirements stated above.

Excessive cutouts and other damage to the base metal that occurs while removing temporary fittings shall be rewelded and the rectified areas dressed to ensure gradual transition to the base metal. In doing so, the reduction of the base metal thickness shall not exceed the permissible tolerances for plate thickness specified in the standards.

Protruding remainders of welds used for the attachment of temporary fittings to the hull structure parts listed below shall be removed and then dressed (the permissible reinforcement shall not exceed the tolerances for butt weld reinforcement for the structures concerned):

.1 strength deck (plating and longitudinal framing members including continuous side coamings of cargo hatches);

.2 bottom (plating and longitudinal framing members);

.3 sides;

.4 sheerstrake and bilgestrake (plating and longitudinal framing members);

.5 bulkheads forming boundaries of tanks;

.6 deep framing members in tanks;

.7 structures in areas of intensive vibration.

For other structures the necessity of dressing the welds after removal of temporary fittings shall be determined by the customer.

2.2.2 When butt joints are being assembled, mutual misalignment of plates up to 0.1 of their thickness but not over 3 mm is admissible.

2.2.3 When it is necessary to deposit metal on the edges to eliminate the inaccuracies of machining or assembly of the parts to be joined, this improvement may be carried out only on agreement with a surveyor to the Register.

On agreement with the Register, undercuts in excess of values stated in Tables 3.3.2-1 and 3.3.2-2 may be rewelded or grounded.

2.2.4 Choice of welding consumables grades for welding of normal and higher strength steel structures.

Welding consumables shall be employed for welding those steel grades, for which they were permitted by the Register in accordance with Table 2.2.4.

Besides the following requirements shall be followed:

.1 when joining normal to higher strength hull structural steel, welding consumables of the lowest acceptable grade, according to Table 2.2.4 and this paragraph, for either steel being joined may be used (for instance, for welded joint of Grades D and E32 steels, the welding consumables of Grade 2 may be used);

.2 when joining steels of the same strength level but with different requirements for impact test temperature, welding consumables of the lowest acceptable grade, according to Table 2.2.4 and this paragraph, for either steel being joined may be used (for instance, for welded joint of Grades D and E32 steels, the welding consumables of Grade 2Y may be used);

.3 when joining higher strength hull structural steel to the same or normal strength hull structural steel, controlled diffusible hydrogen type welding consumables, according to Table 4.2.1.4, shall be used.

Other welding consumables may be used only on the special permission of the Register for steels having the carbon equivalent (refer to 3.2.2, Part XIII "Materials") $C_e \leq 0.41$ following tests according to the program agreed with the Register;

Table 2.2.4

Grade of welding consumables	Hull structural steel											
	Normal strength				Higher strength							
	A	B	D	E	A32, A36	D32, D36	E32, E36	F32, F36	A40	D40	E40	F40
1, 1S, 1T, 1M, 1TM, 1V	+	–	–	–	–	–	–	–	–	–	–	–
1YS, 1YT, 1YM, 1YTM, 1YV	+	–	–	–	+[1]	–	–	–	–	–	–	–
2, 2S, 2T, 2M, 2TM, 2V	+	+	+	–	–	–	–	–	–	–	–	–

2Y, 2YS, 2YT, 2YM, 2YTM, 2YV	+	+	+	–	+	+	–	–	–	–	–	–
2Y40, 2Y40S, 2Y40T, 2Y40M, 2Y40TM, 2Y40V	Refer to 2.2.4.4				+	+	–	–	+	+	–	–
3, 3S, 3T, 3M, 3TM, 3V	+	+	+	+	–	–	–	–	–	–	–	–
3Y, 3YS, 3YT, 3YM, 3YTM, 3YV	+	+	+	+	+	+	+	–	–	–	–	–
3Y40, 3Y40S, 3Y40T, 3Y40M, 3Y40TM, 3Y40V	Refer to 2.2.4.4				+	+	+	–	+	+	+	–
4Y, 4YS, 4YT, 4YM, 4YTM, 4YV	+	+	+	+	+	+	+	+	–	–	–	–
4Y40, 4Y40S, 4Y40T, 4Y40M, 4Y40TM, 4YV	Refer to 2.2.4.4				+	+	+	+	+	+	+	+

[1]Refer to 2.2.4.5

.4 the welding consumables approved for steel Grades A40, D40, E40 and/or F40 may also be used for welding of the corresponding Grades A, B, D, E of normal strength steels subject to the special permission of the Register for particular welding consumables grades;

.5 when joining higher strength steels using Grades 1YS, 1YT, 1YM, 1YTM, 1YV grade welding consumables, the material thickness shall
not exceed 25 mm;

.6 the welding consumables in Table 2.2.4 may also be used for welding of steel other than that shown in Table if the mechanical properties and chemical composition of such a steel are equivalent to the same of the steel, for which the given welding consumable was approved;

.7 rutile electrodes shall not be used for welding the following joints:

mounting butt joints of ship sections;

all butts and seams of the ice belt of shell plating;

butt joints of longitudinal members;

butt joints of hull structure more than 20 mm thick;

solid structures (sternframe, stem, etc.), as well as butt joints to be welded in a rigid contour (a contour is considered rigid when the ratio of its minimal dimension to the plate thickness is less than 60);

.8 oxide-coated electrodes shall not be used for welding of structures regulated by Part II "Hull".

2.2.5 Choice of welding consumables grades for welding of high strength steel structures.

Welding consumables shall be employed for welding those high strength steel grades, for which they were permitted by the Register according to Tables 2.2.5-1 and 2.2.5-2.

Besides, the following restrictions and requirements shall be followed:

.1 in some cases the Register may limit the scope of application of the particular welding consumable grade only to one base metal strength grade and not extend the approval to the high strength steel lowest grades according to Table 2.2.5-2;

.2 when joining high strength hull structural steel to the same and also joining high strength steel to higher or normal strength hull structural steel, controlled diffusible hydrogen type welding consumables, having the classification indices H5 or H10, according to Table 4.2.1.4, shall be used;

.3 the use of a single-run and two-run welding procedure for high strength steel welded joints is not recommended. It may be approved by the Register only when based on additional tests according to the special program agreed with the Register;

.4 the use of an electroslag and electrogas welding for high strength steel welded joints is not recommended. It may be approved by the Register only when based on additional tests according to the special program agreed with the Register;

.5 the use of a multi-arc and one-side welding on backs of different types for high strength steel welded joints is not recommended. It may be approved by the Register only when based on additional tests according to the special program agreed with the Register;

.6 rutile and oxide-coated electrodes shall not be used for high strength steel structures welding;

.7 the use of all grades welding consumables, tested according to requirements in 4.6, for high strength steel welding is permitted only for base metal joints up to 70 mm thick.

The use of welding consumables for welding of steel over 70 mm thick is subject to special consideration by the Register and demands additional tests according to the special program agreed with the Register.

Table 2.2.5-1

Identification of welding consumables grades by test temperature	Identification of high strength steel grades by impact test temperature			
	A (420/690)	D (420/690)	E (420/690)	F (420/690)
3Y (42/69)	+	+	–	–
4Y (42/69)	+	+	+	–
5Y (42/69)	+	+	+	+

Table 2.2.5-2

Identification of welding consumables grades by strength level	Identification of high strength steel grades by strength level					
	(A/F) 420	(A/F) 460	(A/F) 500	(A/F) 550	(A/F) 620	(A/F) 690
(3Y/5Y) 42	+	–	–	–	–	–
(3Y/5Y) 46	+	+	–	–	–	–
(3Y/5Y) 50	+	+	+	–	–	–

(3Y/5Y) 55	–	–	+	+	–	–
(3Y/5Y) 62	–	–	–	+	+	–
(3Y/5Y) 69	–	–	–	–	+	+

2.2.6 Choice of welding consumables grades for welding of hull structural steel structures operating at low temperatures.

Welding consumables for welding of hull steel structures operating at low temperatures shall be used in accordance with requirements in Table 2.2.6.

Besides, when grades of welding consumables for welding of higher strength steels with the index F are specified, the requirements listed in 2.2.4 shall be followed including the following additions:

.1 depending on the function and operational conditions of structures, the Register may specify the higher grade of welding consumables (for instance, 5Y instead of 4Y and 5Y40 instead of 4Y40);

.2 the use of Grades 4Y46 and 5Y46 welding consumables, intended for high strength steel welding, is subject to additional agreement with the Register.

Table 2.2.6

Grade of welding consumables	Grade of hull structural steel		
	F32	F36	F40
4Y, 4YS, 4YT, 4YTM, 4YV	+	+	–
4Y40, 4Y40S, 4Y40T, 4Y40M, 4Y40TM, 4Y40V	+	+	+
5Y, 5YS, 5YT, 5YM, 5YTM, 5YV [1]	+	+	–
5Y40, 5Y40S, 5Y40T, 5Y40M, 5Y40TM, 5Y40V [1]	+	+	+
4Y42, 4Y42S, 4Y42M	–	+	+
5Y42, 5Y42S, 5Y42M [1]	–	+	+
4Y46, 4Y46S, 4Y46M	–	+[2]	+
5Y46, 5Y46S, 5Y46M [1]	–	+[2]	+

[1]Refer to 2.2.6.1.
[2]Refer to 2.2.6.2

2.2.7 Assignment of welding consumable grades for welding of hull structural aluminium alloys.

2.2.7.1 Welding consumables for welding hull structural aluminium alloys depending on their grade shall be used in compliance with the requirements in Table 2.2.7.1-1.

The practical areas of application for the most common international and national filler materials, which shall be followed in their approval, are given in Table 2.2.7.1-2.

Table 2.2.7.1-1

Grade of welding consumables	Hull structural aluminium alloys										
	International						National				
	5754	5086	5083	5383 5456	5059	6061 6005A, 6082	1530	1550	1561	1575	(AlSiMgMn)
RA/WA (5754)	+	–	–	–	–	–	+	–	–	–	–
RB/WB (5086)	+	+	–	–	–	–	+	–	–	–	–
RC/WC (5083)	+	+	+	–	–	+	+	+	–	–	+
RC/WC (5383)	+	+	+	+	–	+	+	+	–	–	+
RC/WC (5456)	+	+	+	+	–	+	+	+	–	–	+
RC/WC (5059)	+	+	+	+	+	+	+	+	+	–	+
RD/WD (6061)	–	–	–	–	–	+	–	–	–	–	+
RD/WD (6005A)	–	–	–	–	–	+	–	–	–	–	+
RD/WD (6082)	–	–	–	–	–	+	–	–	–	–	+
R1/W1 (1530)	+	–	–	–	–	–	+	–	–	–	–
R2/W2 (1550)	+	+	+	–	–	+	–	–	–	–	+
R3/W3 (1561)	+	+	+	+	+	+	+	+	+	–	+
R4/W4 (1575)	–	–	–	–	+	–	–	–	+	+	–
R4/W4 (AlSiMgMn)	–	–	–	–	–	+	–	–	–	–	+

Table 2.2.7.1-2

Grade of welding consumable		Hull structural aluminium alloys										
		International						National				
Designation	Code of chemical composition	5754	5086	5083	5383 5456	5059	6061 6005A, 6082	1530	1550	1561	1575	(AlSiMgMn)
International materials[1]												
–	AlMg3	+	–	–	–	–	–	+	–	–	–	–
5356	AlMg5	+	+	+	–	–	+	+	+	–	–	+
5183	AlMg4,5Mn	+	+	+	+	–	+	+	+	–	–	+
–	AlMg6Mn1	+	+	+	+	+	+	+	+	+	–	+
National materials[2]												
СвАМг3	AlMg3	+	–	–	–	–	–	+	–	–	–	–
СвАМг5	AlMg5	+	+	+	–	+	+	+	+	–	–	+
СвАМг61	AlMg6Mn1	+	+	+	+	+	+	+	+	+	–	+
Св01597	–	–	–	–	–	+	–	–	–	+	+	–

[1] Designations of the most common filler materials for welding international aluminium alloys (welding processes 141 – TIG and 131 – MIG) in accordance with ISO 18273.

[2] Designations of welding wire brands for welding national aluminium alloys used in shipbuilding in accordance with the Russian standard GOST 7871 (welding processes 141 – TIG and 131 – MIG).

2.3 WELDING IN SHIP MACHINERY CONSTRUCTION

2.3.1 The present requirements apply to the welding of ship machinery structures manufactured using base materials and welding consumables, which are in accordance with Part XIII "Materials" and the present Part.

Manufacturing of structures from materials not regulated by the Rules shall be effected on agreement with the Register.

2.3.2 Welding consumables for machinery and machinery installations shall be chosen on the basis of steel grades used for the manufacture bearing the requirements of 2.2.4 to 2.2.6 in mind.

2.3.3 When structures are intended for operation at high temperatures or in a chemically aggressive medium, those conditions shall be taken into account, when selecting the welding consumables.

2.3.4 For welding of steel parts 30 mm and more in thickness used in ship machinery construction, welding consumables shall be applied, which would guarantee the cold cracking resistance of the weld, or the manufacturer shall take technological measures (pre-heating, heat treatment, limiting of ambient air temperature during welding, etc.) to eliminate cold cracking.

2.3.5 The welds in structures, which shall be exposed to dynamic loads, shall be executed with full penetration.

The transition from the base metal to the weld shall be smooth.

2.3.6 When shafts for ship shafting or crankshafts are fabricated, the application of welding shall be specially considered by the Register in each case.

For this purpose, the necessary conditions are that all the welds were subjected to non-destructive testing and the fatigue strength of welded joints adopted in the calculations were guaranteed.

The amount of experimental welding necessary and the test program shall be agreed with the Register before welding is commenced.

2.3.7 The application of welding including building-up, metal pulverization and other similar methods, when manufacturing or repairing ship machinery items, may be permitted if tests carried out in accordance with the procedure agreed with the Register and confirming the possibilities of applying the method in question at a particular works yield good results.

Repairs to ship shafts of carbon steel (with up to 0.45 per cent carbon content), which are worn or have surface cracks, may be performed by building-up, provided the amount of wear or the depth of cracking does not exceed 5 per cent of the shaft diameter, but it shall not be over 15 mm.

2.4 WELDING OF STEAM BOILERS AND PRESSURE VESSELS

2.4.1 Welded joints of boilers shall be so marked as to make it possible to identify the operator having performed the welding.

Longitudinal and circumferential welds of boiler shells shall be made with a back-sealing run except when the efficiency factor of welded joints φ according to Table 2.1.6.1-1, Part X "Boilers, Heat Exchangers and Pressure Vessels" is adopted to be 0,7 or less.

Cuts and openings in the boiler shell shall not, as far as possible, cross circumferential or longitudinal joints in the shell.

The possibilities of fixing, by welding, any fastenings, catches and the like parts for erecting purposes on the

boiler shell shall be specially considered by the Register in each case.

The longitudinal and circumferential joints of headers, boiler shells and pressure vessels shall be butt-welded. If butt welding cannot be applied, the type of weld shall be specially considered by the Register.

2.4.2 Welding consumables for boilers and pressure vessels shall be chosen on the basis of steel grades used for the manufacture bearing the requirements of 2.2.4 to 2.2.6 in mind.

2.4.3 Rutile and oxide-coated electrodes are not permitted for the welding of boilers and pressure vessels of Class I (refer to 1.3.1.2, Part X "Boilers, Heat Exchangers and Pressure Vessels"). They are permitted for boilers and pressure vessels of Class II and Class III, provided those structures are manufactured of carbon steel and the thickness of parts to be welded is not in excess of 20 mm.

2.4.4 The heat treatment of boilers and pressure vessels shall be determined according to standards or by the data presented by steel works.

The welded joints in parts, which cannot be heat treated as a whole for stress relieving because of their dimensions or inappropriate structure, may be subjected to local heat treatment on agreement with the Register. Such a treatment shall be per formed by uniform warming-up of a sufficiently wide area along the weld (for a distance about 6 times the plate thickness on both sides of the joint) so as to prevent the spread of thermal stresses to other areas of the parts involved.

Local treatment by means of a welding torch is prohibited.

2.4.5 When openings in boilers are closed up by means of plugs fixed by welding, the requirements of national standards shall be met.

2.4.6 Worn-out shell plates of boilers and pressure vessels may be repaired by building-up only on agreement with the Register.

The built-up area shall not exceed 500 cm^2, and its depth shall not be over 30 per cent of the plate thickness. If these conditions cannot be met, the faulty area shall be repaired by inserting a new plate.

2.4.7 When manufacturing boilers, heat exchangers and pressure vessels belonging to Class I or Class II (refer to 1.3.1.2, Part X "Boilers, Heat Exchangers and Pressure Vessels"), test samples shall be prepared to check up the mechanical properties of welded joints in the case of unique products being manufactured, serial production, on the prototype product, alterations in the structure of main units and parts, application of new materials and welding processes.

Test samples for products belonging to Class III shall be prepared, if required by the Register.

2.4.8 The test samples shall be attached to the longitudinal joint of a boiler or pressure vessel in such a way that the test plate joint is a continuation of the joint of the boiler or pressure vessel. The welding procedure shall be the same as employed in the welding of the boiler or pressure vessel joint.

A test assembly thus prepared shall provide one transverse tensile test piece, two transverse bend test pieces, three impact test pieces cut out according to Fig. 4.2.4.2.

Specimens for structures belonging to Class III shall be prepared, if required by a surveyor to the Register. The requirements for cutting specimens from the test assembly and for testing them shall be in accordance with the requirements of 4.2.3.2 and 4.2.3.3.

2.5 WELDING OF PIPELINES

2.5.1 The type of welded joints in pipes shall comply with standards.

2.5.2 Welding consumables for pipelines shall be chosen on the basis of steel grades used for the manufacture bearing the requirements of 2.2.4 to 2.2.6 in mind.

2.5.3 In the welded butt joints of pipes full root penetration shall be provided. Welding with the use of removable backing rings is permitted.

2.5.4 The use of the remaining backing rings in butt joints is permitted in pipelines where those rings do not adversely affect the performance.

The remaining backing rings shall not be used for flange-to-pipe butt joints.

2.5.5 The welded joints in pipes shall be heat treated in the case of pipes of low-alloyed steels and in the case of gas welding of main steam pipelines operating at temperatures above 350 °C.

2.5.6 When welding pipes of chrome-molybdenum steel containing 0.8 per cent or more of chromium and more than 0.16 per cent of carbon, the edges to be welded shall be preheated to a temperature 200 to 230 °C. This temperature shall be maintained during welding.

2.5.7 Before welding, the edges of copper pipes with a wall thickness 5 mm and over shall be heated to a temperature 250 to 350 °C.

Nickel-copper pipes shall be welded without preheating.

For connecting of nickel-copper pipelines the use of brazing is not permitted.

2.5.8 The repair of pipelines by welding of damaged areas is in each case subject to special consideration by the Register.

2.6 WELDING OF CASTINGS AND FORGINGS

2.6.1 Regardless of ambient air temperature, the welding of steel castings and forgings shall be effected with preheating, or other technological measures shall be taken to guarantee that the requirements for welded joints are satisfied in the following cases:

.1 for steel castings and forgings with carbon content exceeding 0.25 per cent;

.2 for steel castings and forgings with carbon content exceeding 0,23 per cent when those castings and forgings are part of the hull structure of ships with the ice categories **Arc4** to **Arc6** (castings and forgings of sternframes, stems, propeller shaft brackets, etc.).

2.6.2 The temperature of preheating and the heat treatment procedure for castings and forgings shall be determined depending on the design, size and service conditions of the structure concerned in accordance with 2.1.4, 2.1.12, 2.1.16.

2.6.3 The faults in castings and forgings may be repaired by welding only when the steel in question has been previously checked for weldability with due regard to the service conditions of the cast or forged part.

Repairs of faults by welding shall generally be undertaken prior to the final heat treatment. After it, rewelding is permitted only by way of exception.

Repetitive faults in castings and forgings are not permitted for repair by welding.

2.6.4 The rewelding of faults in castings shall be made after sprues and heads have been removed and the castings thoroughly cleaned of sand, scale and extraneous inclusions.

The surface subject to repair shall be ground to sound metal so as to provide for penetration throughout the welded area.

The surfaces of areas to be rewelded shall be gently sloped and shall not have sharp comers.

2.7 WELDING OF CAST IRON

2.7.1 Repair of cast iron by welding is permitted on agreement with a surveyor to the Register using a welding process approved by the Register and proceeding from the results of testing by a program agreed with the Register.

2.8 WELDING OF CLAD STEELS

2.8.1 Welding processes for clad steel shall be approved in accordance with Section 6, for the welding consumables – in accordance with Section 4.

The edge preparation for welding shall be in accordance with national standards or drawings approved by the Register.

Preparation of the edges shall be effected by machining or grinding. The edges of parts to be assembled shall fit each other closely and shall not be out of alignment on the clad surface.

2.8.2 The corrosion resistance of weld metal on the clad side shall be equal to that of the cladding.

The thickness of the corrosion-resistant layer of the weld shall not be less than that of the cladding.

The chemical composition of weld metal on the clad size (except the root zone) shall correspond to the chemical composition of the cladding metal.

2.8.3 As a rule, the weld shall be made first on the plate surface, which is opposite to the clad surface and then on the clad side.

Welding on the non-clad side shall be so done that no melting of the cladding layer occurs.

Prior to welding on the clad side the root of an unalloyed weld shall be cut out to sound metal by machining or grinding.

The cladding layer shall be welded so as to reduce, as far as possible, the interpenetration of alloyed and unalloyed materials.

For welding the cladding layer, welding electrodes and wires of the smallest diameter possible shall be used. The welding shall be carried out, as far as possible, at a low rate of energy input. The weld on the clad surface shall be made up of two layers at least.

In welding the cladding layer, transverse weaving of electrode is not permitted. Besides, a deposition of high alloy materials providing for freedom from cracks shall be previously made of the surface of edges to be welded through all the thickness of the base layer.

Where the top layer width is such that it shall be deposited in several runs, the last run shall be made along the middle of the weld.

2.8.4 In welding pipes of clad steel, where welding on both sides is not feasible, the entire joint shall be welded with the use of welding consumables suitable for the cladding material.

When welding clad plate steel, the entire joint shall also be welded with the use of welding consumables suitable for the cladding material.

2.9 BRAZING

2.9.1 Brazed joints in structures specified in 1.1.1 are subject to survey by the Register. They shall be executed in conformity with standards or technical documentation agreed with the Register.

2.10 WELDING OF ALUMINIUM AND ITS ALLOYS

2.10.1 Welding operations shall be performed by the most expedient method, which would ensure good quality joints of required strength with their chemical composition similar to that of the base metal and having sufficient corrosion resistance.

2.10.2 Wherever possible, welded joints shall be located in areas exposed to the lowest stresses.

As a rule, welding shall be effected in the down-hand position.

Weld reinforcement may be removed only subject to the special approval of the Register.

2.10.3 Immediately before welding (tack welding) the edges of aluminium or aluminium alloy components shall be degreased with special solvents (acetone, alcohol, etc.) and then cleaned with wire brushes. Jacked spots are also to be cleaned with a steel wire brush before welding.

In the case of multirun welding, each run of deposit shall be brushed before the next run is applied.

2.10.4 Welding consumables of aluminium and aluminium alloys shall have their surfaces cleaned from dirt and oxide film.

2.10.5 For aluminium alloys, welding on remaining or removable backings is permitted.

The backings to be removed after welding shall be of stainless steel.

The backings that are not removed shall be made of the same kind of alloy as that used for the parts to be welded.

2.10.6 In the case of a double-welded joint, before a sealing run is applied to the back of the weld, a groove shall be made by root-run chipping, planning or milling to clean metal.

Cutting out of the root by means of abrasive disks is not permitted.

2.10.7 Hot straightening of structures made of aluminium and aluminium alloys is permitted.

The heating temperature range for straightening shall be within the limits corresponding to the properties of the alloy.

2.10.8 Where a flux is used, it shall, as a rule, be neutral. If, by way of an exception, the flux used was not neutral, it shall be carefully removed after welding.

2.11 On riveted structures made of aluminium alloys, all major welding operations shall be completed before riveting.

2.12 WELDING OF COPPER AND COPPER ALLOYS, HEAVY METALS AND OTHER NON-FERROUS METALS

2.12.1 Welding of copper and copper alloys as well as of heavy metals and other non-ferrous metals shall be carried out according to national standards, and if those standards are not available, it will be specially considered by the Register.

2.12 WELDING OF HIGH STRENGTH STEELS

2.12.1 The welding consumables designed for welding of high strength steels shall be approved in accordance with 4.7, and the welding processes – in accordance with Section 6.

2.12.2 The process and procedure of welding shall be approved by the Register after fabrication testing by an agreed program. For this, the manufacturer of welded structures shall submit the documented preheating temperature, linear power consumption during welding, postweld heat treatment, and temperature between runs.

The manufacturer shall use a welding condition recording system including the temperature between runs and submit the inspection results to the Register upon request.

2.12.3 Welded joints shall be made by multirun welding.

Single-run welding may be permitted only on agreement with the Register. Each run shall be continuous with minimum arc fluctuations.

2.12.4 Arc firing outside the edges prepared for welding is not permitted.

Welding-on of temporary mounting

fittings may be permitted on special agreement with the Register with the requirements being fulfilled for consumable materials and the local heating temperature.

As a rule, temporary fittings are removed by machining with subsequent dressing flush with the base metal surface.

Preliminary gas cutting shall be followed by the machining of the remaining part and by dressing.

The edges prepared by gas cutting shall be machined after such cutting.

Roots shall be removed by machining only.

The heating temperature for straightening is subject to approval by the Register in each case. The required properties of the base metal and welded joint shall be ensured.

3. TESTING OF WELDED JOINTS

3.1 GENERAL

3.1.1 Non-destructive testing methods.

3.1.1.1 Non-destructive testing of welded joints may be effected by the following methods:

.1 visual testing (VT);

.2 magnetic particle testing (MT);

.3 penetrant testing, including dye penetrant testing, fluorescent penetrant testing and fluorescent-dye penetrant testing (PT);

.4 radiographic testing, including X-ray testing and gamma-ray testing (RT);

.5 ultrasonic testing (UT);

.6 tightness testing.

3.1.1.2 The scope of applicability of various non-destructive testing methods for various types of welded joints is specified in Tables 3.1.1.2-1 and 3.1.1.2-2. It is necessary to consider that radiographic and ultrasonic testing have different detectability characteristics for defects of various types and location.

Radiographic testing is the most effective for detecting and classification of three-dimensional inner discontinuities like pores, slags, metallic inclusions and lack of fusion in the weld's root and it is less effective for detection of plane (two dimensional) discontinuities like cracks and poor fusion.

On the contrary, ultrasonic testing is the most effective for the detection of plane (two-dimensional) defects which are the most dangerous and impermissible in welded structures irrespective of their linear dimensions and location. Ultrasonic testing enables to determine the depth of the detected defects location which is essential for extraction and repair of defective weld parts. It is necessary to consider that this non-destructive testing method has limited capability for the classification of three-dimensional discontinuities and they are assessed in conditional numeric values.

Table 3.1.1.2-1 **Generally accepted methods for detection of accessible surface imperfections for all types of welds, including fillet welds according to ISO 17635**

Materials	Testing method
Ferritic steel	VT, VT and MT, VT and PT
Austenitic steel	VT, VT and PT
Aluminium alloys	VT, VT and PT
Copper and nickel alloys	VT, VT and PT
Titanium alloys	VT, VT and PT

Table 3.1.1.2-2 **Generally accepted methods of detection of internal imperfections for butt and T-joints with full penetration in compliance with ISO 17635**

Materials and type of joint	Nominal thickness of base metal t, mm		
	$t \leq 8$	$8 < t \leq 40$	$t > 40$
Ferrite butt joints	RT or (UT)	RT or UT	UT or (RT)
Ferrite T-joints and fillet joints	(UT) or (RT)	UT or (RT)	UT or (RT)
Austenitic butt joints	RT	RT or (UT)	RT or (UT)
Austenitic T-joints and fillet joints	(UT) or (RT)	(UT) and/or (RT)	(UT) or (RT)
Aluminium butt joints	RT	RT or UT	RT or UT
Aluminium T-joints and fillet joints	(UT) or (RT)	UT or (RT)	UT or (RT)
Nickel and copper alloy butt joints	RT	RT or (UT)	RT or (UT)
Nickel and copper alloy T-joint and fillet joints	(UT) or (RT)	(UT) or (RT)	(UT) or (RT)
Titanium butt joints	RT	UT or (RT)	
Titanium T-joints and fillet joints	(UT) or (RT)	UT or (RT)	

Note:

Methods in parenthesis are only applicable with:

the lower boundary of the base metal thickness for ultrasonic testing method is determined with the applied equipment and standards. In accordance with normative documents applied in shipbuilding ultrasonic testing for thicknesses of under 8 mm is not applied;

for radiographic testing the upper boundary of its application of the base metal thickness is determined as per the capabilities of radiation sources and exposure time (refer to 3.2.4);

the capability of using radiographic testing for T-joints and fillet joints is calculated by the ratio of thickness of the welded metal in the radiographic testing direction to the total thickness of the base and welded metal in the radiographic testing direction (the use of radiographic testing is not feasible with a decrease in this ratio of less than 0.3);

for materials with high degradation of the signals (austenitic steels, nickel and copper alloys) the use of ultrasonic testing method requires the use of special procedures.

3.1.2 Requirements for testing laboratories and personnel.

3.1.2.1 It is necessary to consider that this non-destructive testing method has limited capability for the classification of three-dimensional discontinuities and they are assessed in conditional numeric values.

Non-destructive testing and quality assessment of welded joints shall be performed by testing laboratories (centres) which competence and status comply with the requirements for accreditation in accordance with national or international standards. The Recognition (Accreditation) Certificate issued by the Register or by other authorized national body is a document confirming competence of the testing laboratory.

Requirements for testing laboratories and the procedure of their recognition by the Register comply with the provisions of Section 9, Part I "Accreditation of Testing Laboratories" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

3.1.2.2 Non-destructive testing and quality assessment of welded joints shall be performed by specialists with the relevant training, certification and practical experience in the specific non-destructive testing method which shall be proved by documents.

Assessment of the qualification level and certification of personnel in non-destructive testing shall be performed in accordance with the national standards (GOST ISO 9712) unified with ISO 9712 or EN 473 as well as other documents recognized by the Register.

Bodies performing personnel certification in non-destructive testing shall comply with general requirements of the international standard ISO/IEC 17024.

3.1.2.2.1 Certification levels.

A person certified in accordance with ISO 9712 or EN 473, may be certified in one or more of the following three levels.

Level I.

The person certified by Level I shall be competent to implement the non-destructive testing in accordance with the NDT instructions and under the supervision of personnel of Level II or III.

As part of the scope executed covered by the Certificate, Level I personnel can be qualified by the employer to perform the following steps in accordance with the instructions of non-destructive testing and in the field of competence, specified in the Certificate:

installation of non-destructive testing equipment;

implementation of control;

keep records and assess testing results;

draw a report on the results.

The personnel certified by Level I shall not bear responsibility for the choice of method or testing procedures, nor of assessment of results.

Level II.

The person certified by Level II, shall have the competence to implement the non-destructive testing in accordance with established procedures.

Within the scope of the Certificate, Level II personnel may be entitled by the employer to:

select the non-destructive testing method to implement non-destructive testing procedure;

determine the limitations on the application of the testing method;

the use of sets of regulations (codes of practice), standards, specifications and procedures for non-destructive testing to make up practical instructions adapted to the actual operating conditions;

implementation of parameters set-up and check of the equipment tuning;

performance monitoring and supervision of control;

interpretation and assessment of results in accordance with the relevant legal regulations, standards, specifications and procedures;

preparation of NDT instructions;

execution and control of all the tasks of Level II or below Level II;

ensure personnel management as per Level H or below Level II;

preparation of a report on the results of non-destructive testing (NDT).

Level III.

The person certified by Level III, shall show competence to implement and implement directly the non-destructive testing for which he is certified.

Within the scope of the Certificate, Level III personnel may be entitled by the employer to:

accepting full responsibility for the day premises (spaces) for testing or examination centre and personnel;

framework, review of editorial and technical correctness and approval of NDT instructions and procedures;

interpretation of sets of regulations (codes of practice), standards, specifications and procedures;

assignment of specific testing methods, procedures and instructions used by non-destructive testing;

performance and control of all the tasks of all the levels;

provision of management at all levels;

taking part in commissions on certification exams for non-destructive testing specialists of all levels in compliance with the requirements of the applicable standard and in agreement with the certification body.

Level III personnel shall show:

competence in the assessment and interpretation of the results in the framework of the existing sets of regulations, standards, specifications and procedures;

sufficient working knowledge of the materials, technology and manufacturing process to select the method of non-destructive testing and render assistance in setting assessment criteria, where they do not exist;

general knowledge of other NDT methods.

In view of the above the following qualification requirements for personnel allowed to perform non-destructive testing of welded joints shall be adhered:

.1 the scope of the Register recognition of the qualification of specialists in ultrasonic testing is, as a rule, limited by the normative documents (standards) used for their special and practical testing during certification;

.2 specialists of at least Level I qualification are approved for radiographic testing (without the right to issue conclusions) and of at least Level II qualification – for other non-destructive testing methods;

.3 issue of conclusion on the specific non-destructive testing method, check of the equipment operability, as well as drawing up of non-destructive testing charts in accordance with valid normative documents shall be performed by specialists of at least Level II qualification;

.4 agreement of non-destructive testing charts, assignment of specific testing methods, procedures and used NDT instructions as well as interpretation of code of practice, standards, specifications and procedures shall be performed by specialists of at least Level III qualification.

3.1.3 Testing plan and records.

3.1.3.1 As a rule (provided otherwise is not agreed with the Register), the testing plan for welded joints of hull structures and pipelines, as well as for particular products manufactured under the Register technical supervision shall be prepared and submitted to the Register for approval.

In the latter case the necessary information may be provided on the relevant drawings without drawing up a separate document.

The testing plan shall contain the following information:

.1 details and welded joints subject to testing during the acceptance of welded structures;

.2 scope and methods of testing;

.3 testing locations determined in advance;

.4 requirements for quality assessment of welded joints;

.5 testing standards or written specifications.

3.1.3.2 Upon completion of welding operations on a structure the inspection authority of the manufacturer determines non-destructive testing locations (areas) according to the testing plan approved by the Register.

The Register reserves a right to change location of some non-destructive testing areas or enlarge the scope of inspections.

3.1.3.3 Records on the performed non-destructive testing of welded joints shall be prepared for all types of testing (initial, additional and repeated after repair) and submitted to the Register surveyor together with the volumetric test reports confirming ultrasonic and radiographic testing results.

Conclusion on non-destructive testing results of welded joints shall contain all the necessary information according to the Register requirements for specific non-destructive testing methods.

3.1.3.4 Results of repeated testing (after repair) shall be separated in records.

Conclusion on non-destructive testing results shall be signed by a person having performed testing (non-destructive testing operator) and by a person responsible for testing duly authorized by the testing laboratory.

3.1.3.5 Records on the welded joints non-destructive testing results shall be kept at the firm for at least 5 years and be submitted, if necessary, upon the Register request.

3.1.4 Non-destructive testing specification.

Non-destructive testing of welded joints shall be performed in accordance with the approved specifications

(procedures) which shall contain at least the following information (if applicable):

.1 applied testing standards;

.2 materials and size;

.3 welding process and type;

.4 reference to the welding procedure specification;

.5 type of joint and size;

.6 main and auxiliary equipment;

.7 conventional sensitivity of testing and tuning methods with indication of applied calibration blocks and/or standard specimens;

.8 necessity and method of sensitivity correction;

.9 specification of parameters of detected defects (discontinuities, wrong size or shape) subject to assessment;

.10 requirements for tuning and calibration of applied equipment;

.11 forms of records issued upon test results;

.12 requirements for personnel qualification in accordance with the international or national standards;

.13 quality assessment criteria for the product acceptance.

3.1.5 Requirements for acceptance non-destructive testing of welded joints.

3.1.5.1 Acceptance non-destructive testing of welded joints shall be carried out (unless specified otherwise) after completion of all welding and straightening prior to painting or priming, or prior to application of galvanic and other coverings.

During welding of higher strength steels structures at least 48 h shall pass between completion of welding and start of acceptance testing.

Notes: 1. If a manufacturer can submit a documentary evidence of resistance to cracking for the applied materials and welding procedure, the time between the completion of welding and start of testing may be reduced upon agreement with the Register for A/F40 grade steels and lower as per thicknesses up to 40 mm inclusive.

2. This requirement doesn't cover operational technical testing performed during manufacture of products in accordance with the requirements of technical regulation (e.g., the layer testing of welded joints by visual testing ,testing of welded joints with partially filled groove etc.)

3. Time required before final acceptance testing of high strength steels is agreed with the Register in each particular case.

3.1.5.2 All welded joints shall be initially subjected to acceptance based upon results of visual testing of 100 per cent length on both sides of joint (if this is technically feasible). All impermissible defects and deficiencies as per form and size of joint as well as other defects preventing non-destructive testing by other methods shall be eliminated, and locations of repair shall be repeatedly accepted by the welding structures manufacturer’s control body.

The Register reserves a right to require additional testing areas by relevant methods in those locations where visual testing detected defects witnessing serious breach of the welding procedure.

3.1.5.3 If welded joints are subjected to heat treatment the final acceptance testing shall be performed upon its completion.

3.1.5.4 The Register may require a repeated non-destructive testing prior to the welded structures commissioning (handling to the customer) or at their final acceptance if these structures were subjected to loads not provided for normal operation (e. g. during transportation to the place of assembly,

proof load testing or testing by pressure exceeding design operating values).

Methods and scope of such testing is a matter of a special consideration by the Register in each particular case.

3.1.5.5 Impermissible defects detected at any tinting stage of welded joints are subject to mandatory repair. A repeated repair of same area of the welded joint is allowed only upon agreement with the Register surveyor.

Repair of internal defects on the same weld length is usually not allowed more than twice.

3.1.5.6 If cracks are detected during testing of welded joints the following measures shall be taken:

.1 the whole length of the technologically independent welded joint made by the welder having performed a rejected weld shall be tested. All short welds (less than 1 m) in a block or assembly performed following the similar (to the rejected) welding procedure shall be tested;

.2 welding following the similar welding procedure specification shall be suspended;

.3 reasons for cracking shall be revealed and eliminated and the measures taken for their elimination shall be reported to the Register surveyor.

If necessary, the welding procedure specification shall be corrected to be repeatedly submitted for the Register approval.

Notes: 1. Technologically independent welded joint is a continuous joint with the same section and edge preparation performed according to the same welding procedure specification in one or continuously changing welding position.

2. Butt welds of flat bulb and T-section steel parts as well as T-joints with full penetration of branches with plating, decks or bulkheads are considered as short welds.

3.1.5.7 If defects other than cracks (refer to 3.1.5.6.) are detected during testing of welded joints the following actions shall be taken:

.1 testing shall be continued in areas adjacent to the rejected one from both sides until satisfactory results are gained;

.2 additional testing of two new areas shall be performed according to 3.1.5.8 per one rejected area;

Note: This requirement doesn't cover testing areas adjacent to the rejected one and specified to detect the weld defective area according to 3.1.5.7.1.

.3 four similar welds performed by the same welder following the same welding procedure specification: two antecedent and two consecutive, shall be additionally tested as per short welds;

.4 if results of additional testing according to 3.1.5.7.2 and 3.1.5.7.3 witness of the systematic character of impermissible defects, then all technologically independent welded joints or short welds in a block performed by one welder following one welding procedure specification shall be tested along the whole length;

.5 if during initial and additional testing 50 per cent and more of the technologically independent welded joint length or of the number of similar short welds in a block are tested and it is established that further testing is required, then the whole length of the joint shall be tested or all similar short welds in a block shall be tested.

3.1.5.8 When specifying additional testing areas according to 3.1.5.7.2 the following shall be followed:

.1 for circular butt joints between blocks and assembly butt joints additional testing areas shall be located

somewhere in the middle between the areas tested earlier and assessed "fit";

.2 for intrablock welded joints additional testing areas shall be located on joints of which initial radiographic and ultrasonic testing was not carried out;

.3 if during initial testing at least one area was tested on all intrablock joints, additional testing shall be carried out on the welded joint with the defective area;

.4 if an area with intersection of welded joints was tested, additional testing areas shall be located on the weld with impermissible defect.

3.1.5.9 If during additional radiographic or ultrasonic testing the welded joint area quality is assessed "fit", the testing is stopped.

If the additional testing area quality is assessed "unfit", the testing shall be continued according to 3.1.5.7 until satisfactory results are gained.

3.1.5.10 The following shall be observed during testing of welded joints after repair of impermissible defects:

.1 testing after repair of the whole technologically independent joint

.2 rejected upon the results of radiographic or ultrasonic testing shall be carried out in full scope by all testing methods provided by technical documentation for the acceptance testing of this joint;

.3 testing of separate areas of the welded joint rejected upon the results of radiographic or ultrasonic testing shall be performed after repair along the whole length by the same methods which were used for detection of repaired defects;

.4 quality assessment and acceptance of repaired welded joints shall be carried out following the same criteria as during the initial testing;

.5 if no impermissible defects are detected in the welded joint after repair, it is assessed "fit";

.6 if defects are detected in the welded joint after repair — refer to 3.1.5.5.

3.1.5.11 When shell plating welds are tested, the radiograph shall be located at the intersection of the weld axes so as to partially cover also the seam as shown in Fig. 3.1.5.11-1.

In ultrasonic testing areas wider than 100 mm shall be tested on each side of the butt as shown in Fig. 3.1.5.11-2.

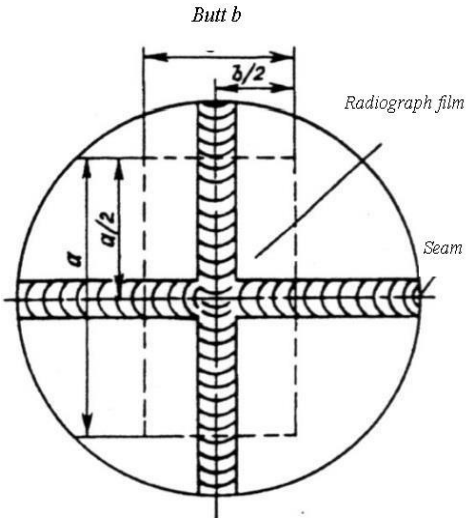


Fig. 3.1.5.11-1:
a – length of radiograph equal to ≈ 500 mm;
b – width of radiograph equal to ≈ 100 mm

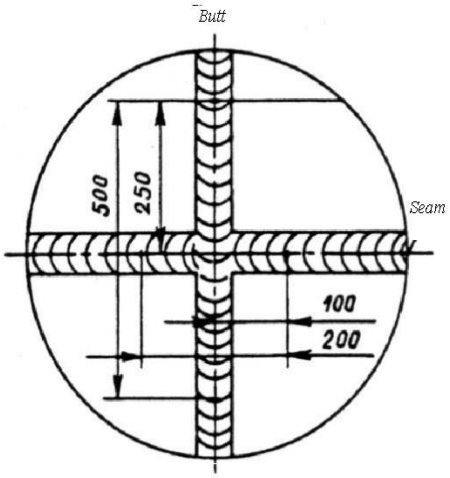


Fig. 3.1.5.11-2

3.1.6 Carrying out and basic parameters of non-destructive testing of welded joints.

3.1.6.1 Visual and measuring testing of welded joints (visual examination and measurement).

3.1.6.1.1 Visual and measuring testing of welded joints shall be performed in compliance with ISO 17637 or other international and national standards recognized by the Register.

3.1.6.1.2 Visual testing of welded joints shall be performed to reveal the weld surfaced imperfections and affected zone including (marking as per ISO 6520):

cracks (100, 104); undercuts (5011, 5012, 5013);

unfilled craters, sags, runs, unfilled bevel (2025, 506, 509, 511);

surfaced blowholes (2016);

lacks of fusion in the root of a single-sided weld, concave deformation-shrinkage grooves in the weld root as well as excessive penetration-sagging in the weld root (4021, 515, 504);

surfaced pores and poor fusion (2017, 401);

root porosity (516);

arc bums – stains of short circuits (601);

wrong weld section modulus – non-smoothness of conjunction with the base metal (505);

exceeding weld reinforcement (502, 503);

pimpling and scaling (514);

melted metal spatter (602);

correctness of the seal welding of crossing welds and free edges.

3.1.6.1.3 Visual testing of welded joints and affected zone shall be performed along the entire weld length on both sides accessible for examination (testing) before they can become inaccessible during further structure assembly except for absence of access to the weld reverse side in one-side welded joints.

3.1.6.1.4 Prior to visual testing weld and affected zone surface shall be cleaned from metal spatter, slag, soot and other and kept clear of protective coatings.

3.1.6.1.5 Visual testing shall be usually carried out without use of special optical instruments.

Magnifying glasses with not more than 10X magnification may be used.

The illumination of the surface under control shall be at least 350 lux with the recommended value of 500 lux.

To perform visual and measurement examination an access to the controlled welded joint shall be provided at a distance of about 600 mm at the angle of examination of at least 30° (refer to Fig. 3.1.6.1.5). In case when for the places which are not easily accessible the accessibility of the item under control (tested surface) in compliance with Fig. 3.1.6.1.5 cannot be implemented, it is necessary to use mirrors, borescopes, flexible fibre optic cables or video cameras.

To increase the contrast between the imperfections and the background additional sources of illumination can be used.

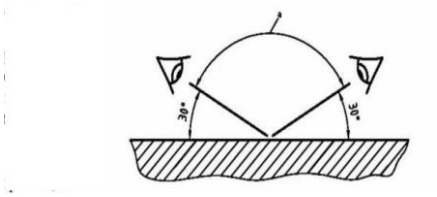


Fig. 3.1.6.1.5 Access for testing the surface at the visual and measurement examination

3.1.6.1.6 Where the results of visual examination are inconclusive, for example, where serious doubts exist that cracks exist, one of the following methods shall be additionally used to detect surfaced imperfections:

magnetic particle method of testing; penetrant method of testing; grinding with abrasive tool with subsequent etching by reagent used for detecting macrostructure.

3.1.6.1.7 Measurement testing of welded joints shall be carried out to check (marking as per ISO 6520):

toe weld (505);

weld reinforcement (502, 503);

throut thickness fillet weld (5213, 5214);

fillet weld asymmetry (512);

height and extension of undercuts (5011, 5012, 5013);

pimpling and scaling heights as well as values of sinking between the weld beads (514);

diameter of surface pores (2017);

lacks of fusion and concave deformation (shrinkage) depths in the root of one-sided weld (4021, 515);

exceeding penetration heights (504);

depths and extensions of metal leaks as well as sizes of unfillings of the edges groove (509, 511);

sagging values if required (506);

linear deflection values (507);

length and pitch of interrupted (non-continuous) weld.

Measurement testing is applied to check the geometric dimensions of the prepared for welding joints, including assembly clearances, mismatch welded edges peaks, shapes and dimensions of the edge preparation.

3.1.6.1.8 The measurement testing of the welds shall be carried out after visual examination or simultaneously with it. Measurement of welds shall be made not less than every meter connection, but there shall be at least one measurement at each of technologically independent connections (refer to Note 1 to 3.1.5.6). At that the measurements of welded joints shall be first carried out at points where deviations from specified dimensions are suspected after a visual testing. Measuring the dimensions of connections with an intermittent weld shall be made on a sampling basis.

3.1.6.1.9 To perform measurement testing of welded joints there shall be applied measuring tools relevant to the Guidelines of Annex A to ISO 17637.

3.1.6.2 Welded joints penetrant testing.

3.1.6.2.1 Welded joints penetrant testing including dye penetrant testing, fluorescent penetrant testing and fluorescent-dye penetrant testing (PT), shall be applied and effected in accordance with the written specifications (procedures) developed on the basis of ISO 3452 (Parts 1 ÷ 6) or other international and national standards recognized by the Register.

3.1.6.2.2 Specifications for performing penetrant testing shall contain

at least the following details and requirements:

minimum testing sensitivity and applicable control (reference) specimens (calibration equipment);

requirements for the preparation of the surface tested;

degreasing and backing of the surface tested prior to the penetrant application;

instructions on the details of the method application according to the temperature-controlled surface or restrictions on the temperature range for particular developers;

type of indicator penetrant;

applicable purifier and developer;

coating and removal of indicator penetrant;

drying time (conditioning before removal) of indicator penetrant;

developer application and the development time;

illumination conditions for testing.

3.1.6.2.3 The tested surface shall be cleaned and clear of scale, rust, slag, dirt, oil and grease contamination, paint (indications).

Surface preparation shall include a weld and base metal at a distance at least 10 mm on either side of the seam borders or, as an alternative, the entire width of the HAZ, whichever is greater.

3.1.6.2.4 Temperature requirements the tested surface depend on the applicable developers used and they are specified in accordance with applicable standards.

As a rule, the temperature range is within the scope of+ 10 °C up to + 50 °C.

Outside this temperature range (for the lower and higher temperatures) special developers shall be applied (penetrants, purifiers and developers) as well as corrective calibration specimens (refer to ISO 3452-5 and ISO 3452-6 for temperatures above 50 °C and below 10 °C, respectively).

3.1.6.2.5 Exposure time of indicator penetrant on the testing surface shall meet the specifications of a manufacturer and/or the applicable standards and be, as a rule, at least 10 min.

Development time shall comply with the manufacturer's specifications and/or the applicable standards and be, as a rule, at least 10 min.

3.1.6.2.6 Record of the testing results may be performed by any of the methods or a combination thereof:

description in writing;

sketches;

photography;

video recording.

3.1.6.3 Magnetic particle testing of welded joints.

3.1.6.3.1 Magnetic particle testing of welded joints shall be applied and effected in compliance with the written specifications (procedures) developed on the basis of ISO 17638 or other international and national standards recognized by the Register.

3.1.6.3.2 Specifications for performing magnetic particle testing shall contain at least the following details and requirements:

requirements for the prepreparation of the surface tested;

magnetizing equipment;

sensitivity tuning method;

measuring equipment and its application;

surface conditions;

requirements and methods of demagnetization of the product after completion of the test.

3.1.6.3.3 The tested surface shall be cleaned and free from scale, rust, slag, dirt, oil and grease contamination, paint (indications). Furthermore, the weld surface shall be free from abrupt sinking between beads and scales as well as inadmissible undercut dimensions.

3.1.6.3.4 When the circular current magnetization flow through the product, care shall be taken to prevent burns from current electrodes. At the same time it is not allowed to use copper shoes (lugs) of electrical connections.

Metal lugs with a low fusion point (of lead or zinc) are recommended to be used as practicable since in this case the temperature in the contact zone is not above the metal electrical connection fusion point. It is also advised to apply shims of lead or aluminium-copper grid.

3.1.6.3.5 To ensure detection of imperfections of any orientation the welds shall be magnetized in about two mutually perpendicular directions with tolerances of at least 30°.

For lap joints testing of the whole surface shall be provided.

3.1.6.3.6 The magnetic suspension shall be applied in any manner ensuring free movement of magnetic particles on the tested surface (under testing): dry spraying, spray arc or suspension jet watering, immersion in a suspension bath. In this case a method of applying a continuous layer of wet suspension shall be used as practicable.

3.1.6.3.7 Examination of the tested surface shall be carried out immediately after processing it with magnetic

At the control method of applied field the examination is also carried out during processing the product with magnetic suspension.

3.1.6.4 Radiographic testing of the welded joints.

3.1.6.4.1 Radiographic testing of the welded joints shall be applied and carried out in compliance with written specifications (procedures) developed on the basis of ISO 17636 or other international and national standards recognized by the Register.

3.1.6.4.2 Specifications for performing radiographic testing shall contain at least the following details and requirements:

material of the tested product;

type of radiation source and the maximum size of the focal spot of the radiation source;

the X-ray tube voltage during X-ray examination;

X-rayed control areas penetrated radiation thickness (total thickness of the base and weld metal in the direction of the central ray of the radiation beam);

X-ray and control schemes (location and numbers of controlled areas);

the overlap of radiographs with continuous control;

type and location of the sensitivity standards;

class and testing sensitivity;

type (Class) of radiographic film and intensifying screens feature if required;

length and width of the radiographic films;

specifications for the terms of exposure;

requirements for processing radiographic films;

requirements for the optical density of exposures and conditions of their viewing (maximum brightness of the X-ray viewer illuminated field).

3.1.6.4.3 X-ray schemes of welded joints shall comply with international or national standards.

X-ray directions in these schemes shall be as such as during X-ray examination the maximum amount of the weld deposited metal is controlled (monitored) at a minimum radiation thickness of the welded joint controlled metal. Thus where practicable X-ray examination is carried out the next but one waft.

3.1.6.4.4 Labeling of radiograph shots shall enable to identify where applicable: the hull number (order), section number located on the outer shell plate (starboard/portside), location (or order number of a radiograph) and the control date.

3.1.6.4.5 The radiation sources for radiographic inspection of welded joints, X-ray devices shall be used as well as radioactive isotopes as follows: ytterbium-169, thulium-170, selenium-75, iridium-192, cobalt-60, electron accelerators with the energy of accelerated electrons up to 12 MeV. At the same time, where possible, X-ray source shall be given priority in relation to sources of gamma radiation.

Details on the application of radiation sources in accordance with ISO 17636 are given in Fig. 3.1.6.4.5 and in Tables 3.1.6.4.5-1, 3.1.6.4.5-2.

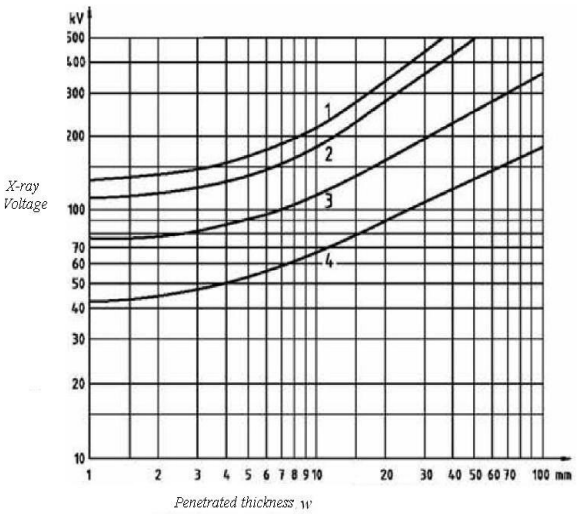


Fig.3.1.6.4.5 The maximum X-ray device tube voltage values depending on the penetrated thickness of the controlled metal: 1 – copper/nickel and alloys; 2 – steel; 3 – titanium and alloys; 4 – aluminium and alloys

Table 3.1.6.4.5-1 **Penetrated thickness range for gamma ray sources for steel, copper and nickel base alloys**

Radiation source	Penetration thickness *w*, mm	
	Test class A	Test class B
Thulium-170	$w \leq 5$	$w \leq 5$
Ytterbium-169[1]	$1 < w \leq 15$	$2 < w \leq 12$
Selenium-75[2]	$10 < w \leq 40$	$14 < w \leq 40$
Iridium-192	$20 < w \leq 100$	$20 < w \leq 90$
Cobalt-60	$40 < w \leq 200$	$60 < w \leq 150$

[1]For aluminium and titanium, the penetrated material thickness is 10 mm < *w* < 70 mm for control Class A and 25 mm < *w* < 55 for control Class B.

[2] For aluminium and titanium, the penetrated material thickness is 35 mm < *w* < 120 mm for Class A.

Table 3.1.6.4.5-2 **Permissible penetrated thickness of steel for electron accelerators**

Accelerated electrons energy, MeV	Penetration thickness *w*, mm	
	Test class A	Test class B
1 to 4	$30 < w \leq 200$	$50 < w \leq 180$
4 to 12	$w \geq 50$	$w \geq 80$
Over 12	$w \geq 80$	$w \geq 100$

3.1.6.4.6 The sensitivity of radiographic testing shall be determined by the image on the welded joint radiograph indicator of image quality indicator in compliance with international or national standards (ISO 19232-1, 19232-2, EN 462 and similar).

It is admitted to apply indicator of image quality of wire or step/hole type as well.

As a rule, indicator of image quality (the sensitivity standard) shall be installed on a tested welded joint in the centre of an X-rayed area on the radiation source side (end).

By way of exception, the installation of indicator of image quality on the film side shall be applied in the following cases:

during X-ray examination of piping welded joints at the next but two walls using an image of only the adjacent to the film seam area for the joint quality assessment;

during panoramic X-ray examination of piping welded joints.

3.1.6.4.7 The requirements to minimum sensitivity of radiographic inspection in compliance with ISO 17636 or EN 1435 shall comply with Class A or B (examination level) depending on the requirements for the quality of welded joints and they are specified as per ISO 10675-1, Table 3.5.1.4, shall be used.

The control sensitivity values complying with Classes A and B according to ISO 17636 or EN 1405 for wire-type indicator of image quality are shown in

Tables 3.1.6.4.7-1 ÷ 3.1.6.4.7-3.

Table 3.1.6.4.7-1 **The minimum sensitivity of radiographic inspection for flat components and during X-ray of piping welded joints at the next but one wall (indicator of image quality from the radiation source side) for X-ray devices and electron accelerators**[1]

Test sensitivity, mm	Penetration thickness *w*, mm	
	Test class A	Test class B
1	2	3
0.050	–	$0 < w \leq 1.5$
0.063	$0 < w \leq 1.2$	$1.5 < w \leq 2.5$
0.080	$1.2 < w \leq 2$	$2.5 < w \leq 4$
0.100	$2 < w \leq 3.5$	$4 < w \leq 6$
0.125	$3.5 < w \leq 5$	$6 < w \leq 8$
0.16	$5 < w \leq 7$	$8 < w \leq 12$
0.20	$7 < w \leq 10$	$12 < w \leq 20$
0.25	$10 < w \leq 15$	$20 < w \leq 30$
0.32	$15 < w \leq 25$	$30 < w \leq 35$
0.40	$25 < w \leq 32$	$35 < w \leq 45$
0.50	$32 < w \leq 40$	$45 < w \leq 65$
1	2	3
0.63	$40 < w \leq 55$	$65 < w \leq 120$
0.80	$55 < w \leq 85$	$120 < w \leq 200$
1.0	$85 < w \leq 150$	$200 < w \leq 350$
1.25	$150 < w \leq 250$	$350 < w$
1.60	$250 < w$	–

[1]During X-ray of welded joints by gamma radiation (Iridium-192) the values given in Table shall be lowered down (decreased) (reduce sensitivity):

Class A control:

two steps lower for thicknesses over 10 up to 24 mm inclusive;

two steps lower for thicknesses over 24 up to 30 mm inclusive;

Class B controls:

a step lower for thicknesses over 12 up to 40 mm inclusive.

Table 3.1.6.4.7-2 **The minimum sensitivity of radiographic inspection during X-ray of piping welded joints at the next but two walls (indicator of image quality from the radiation source side) during panoramic X-ray examination of piping**

welded joints for X-ray devices and electron accelerators (indicator of image quality on the film side)[1]

Test sensitivity, mm	Penetration thickness *w*, mm	
	Test class A	Test class B
1	2	3
0.050	–	$0 < w \leq 1.5$
0.063	$0 < w \leq 1.2$	$1.5 < w \leq 2.5$
0.080	$1.2 < w \leq 2$	$2.5 < w \leq 4$
0.100	$2 < w \leq 3.5$	$4 < w \leq 6$
0.125	$3.5 < w \leq 5$	$6 < w \leq 8$
0.16	$5 < w \leq 7$	$8 < w \leq 15$
0.20	$7 < w \leq 12$	$15 < w \leq 25$
0.25	$12 < w \leq 18$	$25 < w \leq 38$
0.32	$18 < w \leq 30$	$38 < w \leq 45$
0.40	$30 < w \leq 40$	$45 < w \leq 55$
0.50	$40 < w \leq 50$	$55 < w \leq 70$
0.63	$50 < w \leq 60$	$70 < w \leq 100$
0.80	$60 < w \leq 85$	$100 < w \leq 170$
1.0	$85 < w \leq 120$	$170 < w \leq 250$
1.25	$120 < w \leq 220$	$250 < w$
1.60	$220 < w \leq 380$	–
2.00	$380 < w$	–

[1]Refer to Note to Table 3.1.6.4.7-1

Table 3.1.6.4.7-3 **The minimum sensitivity of radiographic inspection during X-ray of piping welded joints at the next but two walls (indicator of image quality on the film side) during panoramic X-ray examination of piping welded joints for X-ray devices and electron accelerators[1]**

Test sensitivity, mm	Penetration thickness *w*, mm	
	Test class A	Test class B
1	2	3
0.050	–	$0 < w \leq 1.5$
0.063	$0 < w \leq 1.2$	$1.5 < w \leq 2.5$
1	2	3
0.080	$1.2 < w \leq 2$	$2.5 < w \leq 4$
0.100	$2 < w \leq 3.5$	$4 < w \leq 6$
0.125	$3.5 < w \leq 5$	$6 < w \leq 12$
0.16	$5 < w \leq 10$	$12 < w \leq 18$
0.20	$10 < w \leq 15$	$18 < w \leq 30$
0.25	$15 < w \leq 22$	$30 < w \leq 45$
0.32	$22 < w \leq 38$	$45 < w \leq 55$
0.40	$38 < w \leq 48$	$55 < w \leq 70$
0.50	$48 < w \leq 60$	$70 < w \leq 100$
0.63	$60 < w \leq 85$	$100 < w \leq 180$
0.80	$85 < w \leq 125$	$180 < w \leq 300$

1.0	$125 < w \leq 225$	$300 < w$
1.25	$225 < w \leq 375$	–
1.60	$375 < w$	–

[1]Refer to Note to Table 3.1.6.4.7-1

3.1.6.4.8 Geometric unsharpness of imperfections of images in radiographs shall not exceed one half of the minimum testing sensitivity according to 3.5.4.7.

3.1.6.4.9 Length of X-rayed flat cells weld areas per an exposure and the number of exposures(areas) during X-ray of piping welded joints shall be such that the ratio of radiation thickness of X-rayed metal at the inspected areas edges and centre shall not exceed 1,2 under Class A control and 1,1 under Class B control. In this case the optical density values at the radiograph edges and in the centre shall not go beyond the limits 3.1.6.4.11.

3.1.6.4.10 Types of radiographic films and relevant intensifying screens shall comply with the applicable international or national standards (ISO 17636, EN 1435 and the similar standards).

3.1.6.4.11 The optical density of radiographs shall be at least 2.0 at Class A control and at least 2.3 at Class B control.

The maximum value of the Image optical density is determined by the characteristics of the applied X-ray viewers and it is 4,0 for the relevant X-ray viewers of 3.1.6.4.12.

3.1.6.4.12 To interpret the welded joints radiographs X-ray viewers shall be used with adjustable size and brightness of the illuminated field in accordance with international standards, such as ISO 5580.

3.1.6.5 Ultrasonic testing of welded joints.

3.1.6.5.1 Ultrasonic testing of the welded joints shall be applied and carried out in compliance with written specifications (procedures) developed on the basis of ISO 17640 or other international and national standards recognized by the Register.

3.1.6.5.2 Ultrasonic testing of welded joints is carried out on the surface after rolling, shot-blasting or machining. The surface shall be free of dents and irregularities, metal spatter, soot, scale disbondment, rust and paint shall be removed from it.

Surface waviness shall provide a gap between the surface of scanning and contact surface of converters and transformers of at least 0.5 mm.

If necessary, an additional surface machining shall be performed to meet this requirement.

Local surfaced imperfections causing a gap increase below the contact surface up to 1 mm may be permitted only if additional scanning of this area/section is provided by the converter at a different entry angle.

3.1.6.5.3 Sizes of areas into which a welded joint is divided under control, and their marking-out shall comply with those accepted for radiographic control if possible.

Circumferential welded joints of pipes are divided into areas by analogy with the clock dial customizing if

possible to the working environment progress direction.

3.1.6.5.4 Deposited weld metal, merging zone and heat affected zone shall be subject to ultrasonic testing.

The base metal layer of thickness at least 10 mm, adjacent to the heat affected zone, shall be included in the controlled area and evaluated according to the criteria specified for the joint.

3.1.6.5.5 Specification for carrying out ultrasonic testing shall contain the following information and requirements at a minimum:

identification particulars on a controlled product: the hull number (order), section number located on the outer shell plate (starboard/portside), location (or order numbers of areas under control, drawings, etc.);

types (marks) of base material and welding consumables;

type of a welding consumable (rolled products, forgings, castings, etc.);

welding process;

product manufacturing stage in which control is performed (either before or after heat treatment, fully or partly welded seam) including the required heating time after the preceding control operation;

drawing of a controlled welded joint indicating edge preparations of the joint thickness, available weld reinforcement and its width, geometrical shape of input surface and roughness requirements;

level of control including sonic scheme showing scanning areas for each of the passageways, input PEC angles as well as the requirements for the identification of longitudinal and transverse imperfections, with reference to the relevant normative and technical document (standards, rules);

type of a used non-destructive testing (NDT) instrument and converters (including frequency, angle of entry, the size and shape of the piezoelectric element);

method for setting the sensitivity reference level indicating the used standard samples (or the manufacturer's (firm's) standard samples);

controlled and reported sensitivity levels as well as the requirements to an acceptable level of assessment of the imperfections identified with reference to the applicable standard, and, if necessary, additional requirements;

necessity and a way of adjusting the sensitivity taking into account the input surface state of ultrasonic oscillations;

the personnel's qualifications as per national or international standards.

3.1.6.5.6 To carry out ultrasonic testing the following shall be applied:

ultrasonic flaw pulse detectors of general purpose with piezoelectric transducers (probes) complying with the requirements of international and national standards (e.g., EN 12668 – all parts) and with technical characteristics as per the requirements of these rules and specifications to carry out monitoring of specific objects;

PEC straight dual, straight single-dual, inclined dual and single-dual search units providing a frequency range of at least 2 to 6 MHz;

national or international standard specimens (gauge blocks) to check the basic control characteristics and settings of working modes of non-

destructive testing (NDT) instruments (e.g., specimens of K-1 and K-2 of the International Institute of Welding for ISO 2400);

standard samples of the firm (gauge blocks) to set the reference sensitivity level of control that meet the requirements of the applicable standards;

devices for control of the mirror- like echo method as per schemes "straddle" and "tandem";

devices for stabilizing the acoustic coupling (bearings, nozzles) under the control by curved surfaces;

auxiliary arrangements and devices for evaluating the surface roughness and waviness, compliance with scanning parameters and measurement of parameters of the imperfections revealed;

DAC (distance-amplitude-curve) or DGS (distance gain size) of a diagram or scale;

specialized non-standard probes;

means of providing ultrasonic contact in accordance with the requirements of the applicable standards (e.g., EN 583-1).

3.1.6.5.7 Inclined PEC operating on transverse waves shall provide input angles from 35° till 75° (as a rule, 45°, 60° and 70°). In the case where the sonic scheme involves the use of PECs with two or more entry/input angles, the difference between the nominal input angles shall be at least 10°.

Admission to the angle shall be not more than + 2°.

3.1.6.5.8 Each converter shall have an identification number, files or other document, which shall also state its type, frequency, angle of entry (into steel), form and geometrical dimensions of piezoelectric elements.

3.1.6.5.9 When monitoring cylindrical and spherical surfaces, the gap between the scanning surface and the contact surface of PEC shall not exceed 0.5 mm.

This requirement is usually performed provided that $D \geq 15b$, where D is a diameter of the product in mm, b – a linear size of PEC contact surface in the control plane. If this requirement is not complied with, adaptation of the PEC contact surface is required to the product shape or ointment or application of coupling gaskets or supports fixing its position.

3.1.6.5.10 Equipment for ultrasonic testing shall provide the gain control setting (playing of standard level of sensitivity control) upon increment (maximum pitch) of at least 2 dB within the scope of at least 60 dB.

3.1.6.5.11 Prior to ultrasonic testing the basic parameters shall be checked out which affect its results.

The check shall include the identification of:

the angle of an ultrasonic beam entering into the metal; position of the exit point of the beam and inclined PEC boom;

dead area;

resolution capability on the beam;

deviation of the acoustic axis of straight and inclined PEC off the nominal direction.

Checks are carried out according to a firm's written procedure performing control.

3.1.6.5.12 In the case when estimation is performed in compliance with the admissible assessment levels

of the revealed imperfections based on the length and amplitude of the echo signal, such as ISO 11666, EN 1714 for initial testing the frequency shall be selected if possible closer to the lower limit within the recommended range of 2 to 6 MHz.

Higher speed values closer to the upper limit of the recommended range, can be used to improve the control resolution capability range in the case it is necessary to assess the readings for compliance with the acceptable levels based on the characteristics of imperfections, such as ISO 23279, EN 1713.

Frequencies within 1 MHz may be used for testing products with a longer sound channel where the signal attenuation level by the material is above average.

3.1.6.5.13 In accordance with the standards ISO 17640 and ISO 11666 during ultrasonic testing the following four levels of sensitivity and assessment of results are applied:

reference level is a sensitivity level used to set the initial level of the reference echo amplitudes;

evaluation level is a sensitivity level according to which or while exceeding it the assessment of the revealed imperfections shall be carried out (refer to Table 3.5.6.1);

recording level is a sensitivity level defined as complying with the admissible level of assessment minus 4 dB;

acceptance level is a level of assessment of the identified imperfections in compliance with the requirements for acceptance of products (refer to Table 3.5.6.1).

3.1.6.5.14 In accordance with ISO 17640 for setting the reference level of ultrasonic testing sensitivity one of the methods listed may be used:

method 1 – reference level is a DAC (distance-amplitude curve) chart drawn up using standard specimens of the firm with the side drilled hole of 3 mm diameter (refer to Table 3.1.6.5.14-1);

method 2 – to set the reference level for the longitudinal and transverse waves DGS (distance gain size) charts or scales are built using standard specimens with flat-bottom DSR – disc-shaped reflectors. Reference levels of sensitivity in accordance with ISO 17640 for inclined and straight PEC are shown in Tables 3.1.6.5.14-2 and 3.1.6.5.14-3.

method 3 – for the reference level DAC chart is taken drawn up with the use of the firm's reference materials (standard specimens) with a rectangular notch 1 mm in width and 1 mm in depth. This method of sensitivity settings can be used for inclined PEC with an input angle of over 70° and a range of thicknesses of $8 \text{ mm} \leq t \leq 15 \text{ mm}$,

method 4 – using sonic testing schemes "tandem" as a reference level signal is received from the flat-bottomed hole with a diameter of 6 mm (for all thicknesses) perpendicular to the surface scanned. This method only applies to the loop input angle of 45° and thickness $t \geq 15$ mm.

Table 3.1.6.5.14-1 **The requirements to the size of the firm's standard specimens (gauge blocks) to draw DAC-charts**

The material thickness to be inspected, mm	Standard specimen thickness, mm	Hole diameter, mm	Distance from the hole to one of the surfaces, mm
$10 \le t \le 50$	40 or t	Ø3 ±0,2	$t/2$ and $t/2$ Additional holes are permitted and recommended.
$50 \le t \le 100$	75 or t		
$100 \le t \le 150$	125 or t	Ø6 ±0,2	
$150 \le t \le 200$	175 or t		
$200 \le t \le 250$	225 or t		
T >250	275 or t		

Notes:

1. The calibration (gauge) block (arrangement) shall be made of actually tested material, it shall have approved dimensions and be checked in accordance with the established procedure.

2. In the case ultrasonic testing is used to control rolled steel structures as delivered CR (controlled rolling) or TM (thermo-mechanical rolling), relevant gauge blocks (arrangements) shall be made perpendicular and parallel to the rolling direction. Rolling direction shall be clearly identified both on the gauge blocks and on a controlled product (item).

3. The use of reference materials for the control of large thicknesses with a side hole diameter of 6 mm is recommended as it is not regulated by ISO 17640 and EN 1712.

Table 3.1.6.5.14-2 **Reference levels of sensitivity for inclined PEC with transverse waves using DGS method (method 2 of ISO 17640)**

Nominal PEC probe frequency, MHz	The metal thickness to be inspected, mm					
	$10 \le t \le 15$		$15 \le t \le 40$		$40 \le t \le 100$	
	AL 2	AL 3	AL 2	AL 3	AL 2	AL 3
1.5 to 2.5	–	–	DSR_{DSR} = 2.5 mm	DSR_{DSR} = 2.5 mm	DSR_{DSR} = 3.0 mm	DSR_{DSR} = 3.0 mm
3 to 5	DSR_{DSR} = 1.5 mm	DSR_{DSR} = 1.5 mm	DSR_{DSR} = 2.0 mm	DSR_{DSR} = 2.0 mm	DSR_{DSR} = 3.0 mm	DSR_{DSR} = 3.0 mm

DSR_{DSR} is the diameter of a flat-bottomed DSR – disc-shaped reflector.

AL2 and AL3 are admissible imperfections acceptance levels according to ISO 11666.

Table 3.1.6.5.14-3 **Reference levels of sensitivity for straight PEC with longitudinal waves using DGS method (method 2 of ISO 17640)**

Nominal PEC probe frequency, MHz	The metal thickness to be inspected, mm					
	$10 \le t \le 15$		$15 \le t \le 40$		$40 \le t \le 100$	
	AL 2	AL 3	AL 2	AL 3	AL 2	AL 3
1.5 to 2.5	–	–	DSR_{DSR} = 2.5 mm	DSR_{DSR} = 2.5 mm	DSR_{DSR} = 3.0 mm	DSR_{DSR} = 3.0 mm
3 to 5	DSR_{DSR} = 2.0 mm	DSR_{DSR} = 2.0 mm	DSR_{DSR} = 2.0 mm	DSR_{DSR} = 2.0 mm	DSR_{DSR} = 3.0 mm	DSR_{DSR} = 3.0 mm

DSR $_{DSR}$ is the diameter of a flat-bottomed DSR – disc-shaped reflector.
AL2 and AL3 are admissible imperfections acceptance levels according to ISO 11666.

3.1.6.5.15 Weld test scheme on the quantity of scanning directions and scan camera angles applied (PEC inclined input angle) shall comply with the applicable international or national standards, such as ISO 17640 or EN 1712.

Thus for welds of higher and high steel strength irrespective of applicable acceptable level, as well as for an applicable acceptable level "B" as per ISO 5217 (procedure and control level is not lower than "B" as per ISO 17640, acceptance level 2 as per ISO 11666, refer to Table 3.5.1.4) it is obligatory to perform sounding (scanning) to detect transverse imperfections (T-scan).

Note: If the manufacturer is able to provide documentary evidence of indisposition for cracking of the applied materials used and welding process, scanning cannot be implemented for high strength steels of categories A/F40 and lower in thicknesses up to 40 mm inclusive to detect transverse imperfections (T- scan) at the control level on acceptance level 3 as per ISO 11666 in agreement with the Register.

3.1.6.5.16 At the sensitivity setting possible difference in roughness and waviness of a specimen surface used to set the sensitivity, and the weld surface of a controlled weld in the scanning area shall be taken into account.

The necessity and method of adjusting the sensitivity shall be specified in a written procedure of a testing firm, and the actual correction value specification of inspection in accordance with the instructions set out below.

If the difference in sensitivity between the firm's standard specimen and the testing surface is less than 2 dB, sensitivity correction is not required.

If the difference in sensitivity between the firm's standard specimen and the testing surface is over 2 dB, but less than 12 dB, it shall be appropriately balanced.

If the difference in sensitivity between the firm's standard specimen and the testing surface is over 12 dB, the cause shall be found out and measures for further preparation of a scanned surface shall be taken if possible.

When the obvious reasons for high differences in sensitivity are not seen, degradation of a signal shall be measured from different places of a test item, and if it is found to be very significant, the appropriate corrective actions shall be considered.

Methods to correct sensitivity shall comply with the relevant standards (e.g., EN 583-2).

3.1.6.5.17 When testing circumferential piping welded joints by a single reflected beam adjustable for plane parallel specimens or reference signals received with a direct ray as well as at the direct PEC control the loss of signal amplitude shall be

considered on the inner cylindrical surface of the weld HAZ.

Method of correction reference shall be specified in a written procedure of a testing firm, and the actual correction value in an appropriate specification of inspection.

3.1.6.5.18 Before ultrasonic testing of the weld straight PEC control of base metal shall be made across the width of the scanning surface for detection and reporting of imperfections that may affect the ability to control the weld by the inclined PEC.

As a result of control of the base metal, if required, specifications to perform ultrasonic testing shall be corrected, and with the technical inability to control weld run in full – alternative methods of non-destructive testing (e.g., radiographic) are provided that shall be noted in the test report.

Note. The requirement to monitor the continuity of the base metal can also be confirmed by previous examinations (for example, during the production and control of the base metal).

3.1.6.5.19 The sensitivity of the PEC flaw detector shall be checked prior to the start of monitoring, after work breaks and completing testing, and periodically every 60 minutes during testing in accordance with the instructions set out below:

If the sensitivity is not changed for more than 4 dB, prior to continuation of testing equipment setting-up shall be adjusted.

If the sensitivity is reduced by more than 4 dB, the setting shall be corrected, and the control of welded joints made since the last adjustment correction shall be carried out completely again.

If the sensitivity is increased by more than 4 dB, the setting shall be adjusted, and all the detected and assessed "unfit" imperfections shall be monitored and reassessed.

3.1.6.6 Report on the results of non-destructive testing of welded joints.

3.1.6.6.1 Reports on non-destructive testing of welded joints shall be prepared by the manufacturer of welded structures and submitted to the Register surveyor.

3.1.6.6.2 Reports on non-destructive testing of welded joints shall contain general information for all control methods:

date of testing;

surname, name, qualifications level and of the person's signature performing the test;

identification of the tested item;

identification of tested welds;

category (type) of material, type of connection (joint), thickness of the base metal, method (procedure) of welding;

procedures and testing level as well as an acceptance level of the revealed discrepancies of welds;

applicable standards and rules;

applicable test equipment and devices;

restrictions on testing, testing conditions and temperature;

test results with reference to the relevant criteria, location and size of the imperfections to be considered;

assessment of testing results as per the alternative system of "fit-unfit" ("acceptance — non-acceptance");

quantity of corrections if one area of control was under repairs more than twice.

3.1.6.6.3 For dye penetrant control methods report on the tests shall include the following additional special items:

type of indicator penetrant; applicable purifier and developer; drying time (conditioning before removal) of indicator penetrant; development time.

3.1.6.6.4 For magnetic particle inspection report on tests shall include the following special items:

type of magnetization; total magnetic intensity; type of a magnetic suspension;

conditions for examination of the tested surface; product demagnetization procedure at the end of control if required.

3.1.6.6.5 For radiographic testing method report on tests shall include the following special items:

type of radiation source and the maximum size of the focal spot of the radiation source;

the X-ray tube voltage during X-ray examination;

type of a radiographic film;

type of intensifying screens;

X-raying scheme, exposure time and distance Item the focal spot of the radiation source to the radiographic film;

control sensitivity, type and location of an indicator of image quality;

optical density of the image;

geometric blur images.

3.1.6.6.6 For ultrasonic testing method report on tests shall include the following special items:

information on the used control instruments (type, model and serial number of the flaw detector, type, frequency, PEC angle of entry and registration number, couplant);

setting method and level of sensitivity;

correction method and actual value of the sensitivity allowance;

type and designations of used standard specimens (sample units) and standard specimens used for equipment settings;

type of the return (echo) signal used to detect imperfections.

3.2 SCOPE OF NON-DESTRUCTIVE TESTING

3.2.1 The scope of non-destructive testing of hull welds in the inspection plan approved by the Register shall be determined in accordance with Table 3.2.1.

The number of weld lengths in shell plating for 0.4*L* amidships to undergo radiographic or ultrasonic testing shall be determined by the following formula:

$$N = \frac{L(B+D)}{45}T, \qquad (3.2.1)$$

where N is number of controlled weld lengths;

L, B, D are length, breadth and height of ship respectively;

T is factor depending on ship type and manufacturing conditions and determined at the approval of the inspection plan.

Following are the maximum values of the factor *T* for various ship types:

up to 0.7 for ships having the length $L < 60$ m;

up to 0.9 for ships having the length $60 \le L < 80$ m;

up to 1.1 for dry cargo ships, bulk carriers, special purpose ships, supply vessels, fishing vessels and ro-ro ships;

up to 1.2 for ships for carriage of heavy bulk cargoes, ore carriers, ore or oil carriers and oil or bulk dry cargo carriers;

up to 1.3 for oil tankers and container ships.

For ships not listed above, the factor *T* is determined in agreement with the Register.

It is assumed in the calculation that the controlled weld length is 0.5 m.

The scope of the non-destructive testing of welded joints using the radiographic or ultrasonic testing for type ships (when applying the manufacture of new products, and also during repair, modification and conversion) may be increased as compared to the values determined by Formula (3.2.1) and given in Table 3.2.1 by the Register or designer's demand.

Where structural elements are welded into a rigid contour (cutouts with the ratio of the minimum dimension to a shell thickness of 60 and less), the fully penetrated butt and tee-joints of the hull plating shall be checked along their entire length, and the remaining structures, to the extent of at least 20 per cent of their length using the radiographic or ultrasonic testing.

The radiographic or ultrasonic testing of the welded joints of the structures subjected to treatment under pressure (bending, stamping, etc.) shall be executed along the entire length of the welded joints of these structures after treatment under pressure. When the structures are subjected to heat treatment after treatment under pressure, the radiographic or ultrasonic testing shall be carried out thereafter.

3.2.2 The welded joints of steam boilers, pressure vessels and heat exchangers shall be subjected to non-destructive testing within the scope specified in Table 3.2.2 depending on the class of structure (refer to 1.3.1.2, Part X "Boilers, Heat Exchangers and Pressure Vessels").

3.2.3 The welded joints of piping, depending on their class indicated in Table 1.3.2, Part VIII "Systems and Piping", shall be subjected to non-destructive testing within the scope specified in Table 3.2.3.

3.2.4 Besides, the structures specified in Tables 3.2.1, 3.2.2 and 3.2.3, such elements of machinery and gear as joints in cargo masts and posts, etc. are subject to non-destructive testing.

The controlled weld lengths in these structures shall be established upon agreement with the surveyor.

3.2.5 The survey or may determine a distribution of non-destructive testing weld lengths differing from that specified in the approved inspection plan depending on the particular conditions, under which welding is carried out.

3.2.6 The works shall determine, on the basis of radiographic and ultrasonic testing, the percentage of welded joint defects not less than once

in six months and report the results to the Register.

The percentage of defects in welded joints shall be determined by the following formula:

$$K = 100 l / s, \qquad (3.2.1)$$

where K is welded joint defects percentage;

l is total length of controlled welds found unsatisfactory, in m;

s is total weld length controlled, in m.

If the percentage of defects is more than 5, the Register is entitled to require, for every percent of rejected welds exceeding this value, an increase in the number of controlled weld lengths by 10 percent.

The number of controlled weld lengths may be reduced if the surveyor finds the general standard of welding operations satisfactory.

3.2.7 For the purpose of conversion and repair of ships and craft, the number of controlled weld lengths is determined by the Register proceeding from the scope of welding and the importance of structures bearing the above in mind.

Table 3.2.1

Ser. No.	Test location	Type of welded joint	Scope of testing		
			visual testing and measurement[1,2], %	radiographic and ultrasonic testing, number of radiographs	
			Ship area		
			fore-and-aft	within 0.4*L* amidships	outside 0.4*L* amidships
1	2	3	4	5	6
1	Plating butts (mainly intersections with seams): strength deck outside hatch line; sheerstrake (in area 0.1*D* below strength deck); bilges (in area 0.1*D* above bottom); bottom. Butts: of hatch side coamings; of thickened deck plates in way of hatchway corners and at ends of superstructures; of longitudinal bulkheads (in area 0.1*D* below strength deck)	Butt weld	100	About 0.60*N*	Random[3]

2	Hull plating butts – remaining[4] (mainly intersections with seams)	Butt weld	100	About 0.20*N*	Random[3]
3	Hull plating seams	Butt weld	100	About 0.20*N*	Random[3]
4	Welded joints of longitudinal stiffeners (in longitudinal framing): strength deck outside hatch line; sheerstrake (in area 0.1*D* below strength deck); bilges (in area 0.1*D* above bottom); of longitudinal bulkheads (in area 0.1*D* below strength deck); bottom.	Butt weld	100	1 radiograph per 5 butts (mainly mounting butts)	Random[3]

End of Table 3.2.1

1	2	3	4	5	6
5	Welded joints of longitudinal stiffeners (in longitudinal framing) in other places not specified under item 4	Butt weld	100	1 radiograph per 10 butts (mainly mounting butts)	Random[3]
6	Welded joints of transverse stiffeners (in transverse framing):	Butt weld	100	1 radiograph per 10 butts	Random[3]
7	Welded joints on sternframe	Butt weld	100		50 per cent of hull plating welded joints in way of sterntube[5]
8	Welded joints between deck stringer and sheerstrake[6] (in way of intersection with butt welds)	Fillet weld or T-joint, full penetration	100	4 controlled lengths along the 1st plate	Random[3]

[1] Where there are doubts as to the results of visual testing, penetrant or magnetic particle testing may be carried out on agreement with the surveyor to the Register.

[2] All welded joints (including those not specified in the table) shall undergo testing.

[3] The number of weld lengths undergoing testing shall be up to 20 per cent of the lengths specified for the area 0.41*L* amidships.

[4] Where ice strengthened, the ice belt butts shall mainly be tested.

[5] Intersections between seams and butts shall be tested.

[6] Ultrasonic testing is recommended.

Table 3.2.2

Class of structure (boilers, pressure vessels and heat	Type of welded joint	Scope of welded joint testing as percentage of total weld length

exchangers)		visual and measurement[1]	radiographic or ultrasonic
I	Longitudinal	100	100
II			25
III			On agreement with the Register
I	Circular		50
II			25
III			On agreement with the Register

End of Table 3.2.2

[1] Where there are doubts as to the results of visual testing and measurements, penetrant or magnetic particle testing may be carried out on agreement with the surveyor to the Register.

Table 3.2.3

Class of piping	Outer diameter of pipe, mm	Scope of welded joint testing as percentage of total weld length	
		visual and measurement[1]	radiographic or ultrasonic
I	≤ 75	100	10[2]
	> 75		100
II	≤ 100		Random
	> 100		10[2]
III	Any		Random

[1] Where there are doubts as to the results of visual testing and measurements, penetrant or magnetic particle testing may be carried out on agreement with the surveyor to the Register.

[2] But not less than one welded joint made by a particular welder.

3.3 ASSESSMENT OF WELDED JOINT QUALITY IN HULL STRUCTURAL STEEL.

3.3.1 General.

3.3.1.1 Assessment of welded joints quality shall be carried out in compliance with quality levels of the relevant requirements of ISO 5817 or other international and national standards recognized by the Register.

3.3.1.2 Quality level requirements in compliance with ISO 5817 for the hull structural steel shall be assigned in accordance with the instructions of Table 3.3.1.2.

3.3.1.3 Quality level requirements in compliance with ISO 5817 for boilers, heat exchangers and piping shall be assigned in accordance with the instructions of Table 3.3.1.3.

3.3.1.4 For specific non-destructive testing procedure acceptable levels of imperfection acceptance in accordance with the established quality levels as per ISO 5817, as well as the requirements for the class and procedure of control are specified by ISO 17635 and, as a rule, they shall be

assigned in accordance with Table 3.3.1.4.

Reduced acceptable levels of imperfection acceptance as well as the requirements for the class and procedure of control are the subject of the Register special consideration in each particular case.

3.3.1.5 Assessment of the welded joints quality within each level of assessment of imperfections shall be performed as per an alternative system of "fit-unfit" ("acceptance – non-acceptance") applying assessment criteria, according to 3.3.2, 3.3.3, 3.3.4, 3.3.5 and 3.3.6.

Table 3.3.1.2

Structural member category[1]	Type of welded joints	Minimum quality level in compliance with ISO 5817 for ships with the following length			
		$L \leq 250$ m		$L >250$ m	
		Within 0.4*L* amidships	Without 0.4*L* amidships[2]	Within 0.4*L* amidships	Without 0.4L amidships[2]
III	Butt joints	B	B	B	B
	Fillet joints, T-joints and cruciform joints with full penetration	B	B	B	B
	Fillet joints, T-joints and cruciform joints with beveling and lack of structural fusion	C	C	B	C
	Fillet joints, T-joints and cruciform joints made by a fillet weld without beveling	C	C	C	C
II	Butt joints	B	C	B	C
	Fillet joints, T-joints and cruciform joints with full penetration	C	C		C
	Fillet joints, T-joints and cruciform joints with beveling and lack of structural fusion	C	D	C	C
	Fillet joints, T-joints and cruciform joints made by a fillet weld without beveling	C	D	C	D
I	Butt joints	C	C	C	C
	Fillet joints, T-joints and cruciform joints with full penetration	C	C	C	C
	Fillet joints, T-joints and cruciform joints with beveling and lack of structural fusion	C	D	C	D
	Fillet joints, T-joints and cruciform joints made by a fillet weld without beveling	C	D	C	D

[1] In compliance with 1.2.3.7, Part II "Hull".
[2] For locations with high stresses or vibration the quality level may be increased.

Table 3.3.1.3

Class of structure[1]	Type of welded joints	Minimum quality level in compliance with ISO 5817	
		Boilers and heat exchangers	Piping
1	2	3	4
III	Butt joints	B	B
	Fillet joints, T-joints and cruciform joints with full penetration	B	B
	Fillet joints, T-joints and cruciform joints with beveling and lack of structural fusion	B	B
	Fillet joints, T-joints and cruciform joints made by a fillet weld without beveling	C	C
II	Butt joints	B	B
	Fillet joints, T-joints and cruciform joints with full penetration	B	B
	Fillet joints, T-joints and cruciform joints with beveling and lack of structural fusion	C	C
	Fillet joints, T-joints and cruciform joints made by a fillet weld without beveling	C	C
I	Butt joints	B	B
	Fillet joints, T-joints and cruciform joints with full penetration	C	C
	Fillet joints, T-joints and cruciform joints with beveling and lack of structural fusion	C	C
	Fillet joints, T-joints and cruciform joints made by a fillet weld without beveling	C	C

[1] In compliance with 1.3.2, Part VIII "Systems and Piping", and 1.3.1.2, Part X "Boilers, Heat Exchangers and Pressure Vessels".

Table 3.3.1.4

Quality level in accordance with ISO 5817	Radiographic testing requirements		Ultrasonic testing requirements[1]		Visual and inspection testing requirements		Magnetic particle testing requirements		Visual and testing requirements	
	Testing technique and level in accordance with ISO 17636	Acceptance level[2] in accordance with ISO 17636-1	Testing technique and level in accordance with ISO 17640	Acceptance level[2] in accordance with ISO 11666	Testing technique and level in accordance with ISO 17636	Acceptance level[2, 3]	Testing technique and level in accordance with ISO 17638	Acceptance level[2] in accordance with ISO 23278	Testing technique and level in accordance with ISO 3452	Acceptance level[2] in accordance with ISO 23277
1	2	3	4	5	6	7	8	9	10	11
B	B	1	At least B	2	LQ[7]	B	LQ[7]	2×[6]	LQ[7]	2×[6]
C	B[4]	2	At least A	3		C		2×[6]		2×[6]
D	A	3	At least A[5]	3[5]	LQ[7]	D	LQ[7]	3×[6]	LQ[7]	3×[6]

[1] In case the definition of the imperfections character is required ISO 23279 is applied.

[2] Acceptance level is expressed in quality grades.

[3]Acceptance level (quality grade) for visual and inspection testing is in compliance with quality levels in accordance with ISO5817.

[4] The minimum number of exposure for circumferential weld testing may correspond to the requirements of class A of ISO 17636.

[5] Ultrasonic testing in accordance with ISO 11666f for Quality Level D (ISO 5817) is not recommended, but upon its application it can be defined with the same requirements as Quality Level C (ISO 5817).

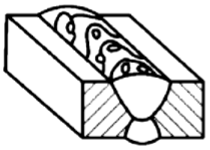
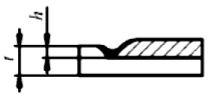
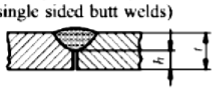
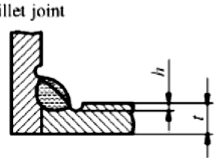
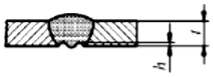
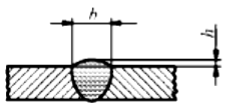
[6] Quality levels 2 and 3 can have index "x" which designates all imperfections above 25 mm are not permitted.

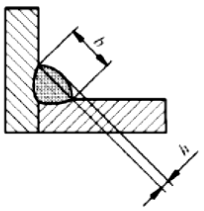
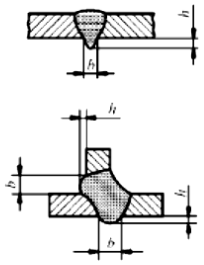
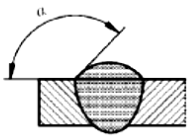
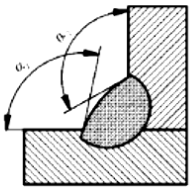
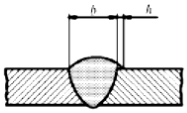
[7] Control level is not established.

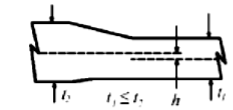
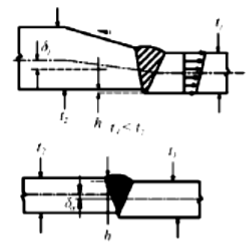
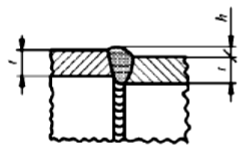
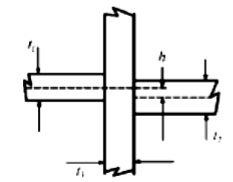
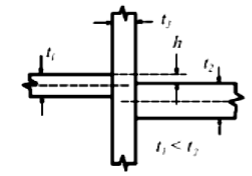
3.3.2 Assessment of the welded joints quality by the visual testing and measurement results.

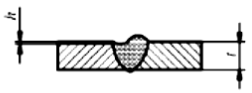
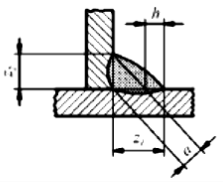
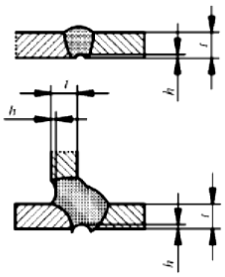
3.3.2.1 If otherwise is not agreed with the Register, assessment of the welded joints quality on the visual testing results shall be carried out in accordance with ISO 5817 for external imperfections (refer to Table 3.3.2.1) for quality levels specified as per 3.3.1.2 or 3.3.1.3.

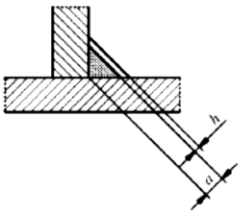
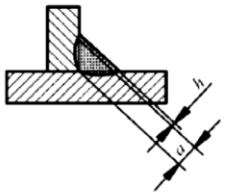
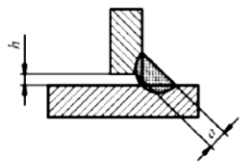
Table 3.3.2.1

No	Imperfection designation Reference to	ISO 6520	Specifications of imperfections and the weld dimensions	Limits for imperfections for quality levels ISO 5817			Remarks
				B	C	D	
1	Crack	100	–	Not permitted			
2	Crater crack	104	–	Not permitted			
3	Surface pore 	2017	d – maximum dimention: butt welds; fillet welds	Not permitted Not permitted	$d \leqslant 0{,}2s$ but max. 2,0 mm $d \leqslant 0{,}2a$ but max. 2,0 mm	$d \leqslant 0{,}3s$ but max. 3,0 mm $d \leqslant 0{,}3a$ but max. 3,0 mm	Clusters and lines on the weld surface are not permitted
4	End crater pipe 	2025	h – crater height (cross sectional dimension of under cut)	Not permitted	$h \leqslant 0{,}10t$ but max. 1,0 mm	$h \leqslant 0{,}20t$ but max. 2,0 mm	For levels C and D may not be permitted under painting conditions
5	Lack of fusion (surfaced)	401	–	Not permitted			
6	Incomplete root penetration (for single sided butt welds) 	4021	h – maximum height l – maximum length of a single imperfection	Not permitted	Not permitted	$h \leqslant 0{,}2t$, but max. 2,0 mm $l \leqslant 25$ mm	For level D may not be permitted under painting conditions
7	Intermittent undercut and Continuous undercut: butt weld [1]  fillet joint 	5012, 5011	h – maximum height h – maximum height	$h \leqslant 0{,}05t$ but max. 0,5 mm $h \leqslant 0{,}05t$ but max. 0,5 mm	$h \leqslant 0{,}10t$ but max. 0,5 mm $h \leqslant 0{,}10t$ but max. 0,5 mm	$h \leqslant 0{,}20t$, but max. 1,0 mm $h \leqslant 0{,}20t$, but max. 1,0 mm	[1] Simultaneous undercut on both edges of the weld side is not permitted
8	Strinkage grooves (undercuts on both sides of the weld) 	5013	h – maximum height l – maximum length of a single imperfection	$h \leqslant 0{,}05t$ but max. 0,5 mm $l \leqslant 25$ mm	$h \leqslant 0{,}1t$ but max. 1 mm $l \leqslant 25$ mm	$h \leqslant 0{,}2t$ but max. 2,0 mm $l \leqslant 25$ mm	
9	Excess weld metal 	502	h – maximum height reinforcement b – breadth of reinforcement	$h \leqslant 1$ mm + $0{,}1b$ but max. 5 mm	$h \leqslant 1$ mm + $0{,}15b$ but max. 7 mm	$h \leqslant 1$ mm + $0{,}25b$ but max.10 mm	

No	Imperfection designation Reference to	ISO 6520	Specifications of imperfections and the weld dimensions	Limits for imperfections for quality levels ISO 5817			Remarks
				B	C	D	
10	Excessive convexity 	503	h – maximum convexity b – breadth of reinforcement	$h \leqslant 1$ mm + $0{,}1b$ but max. 3 mm	$h \leqslant 1$ mm + $0{,}15b$ but max. 4 mm	$h \leqslant 1$ mm + $0{,}25b$ but max. 5 mm	
11	Excessive penetration (weld root slack) 	504	h – maximum penetration height b – breadth of penetration	$h \leqslant 1$ mm + $0{,}2b$ but max. 3 mm	$h \leqslant 1$ mm + $0{,}6b$ but max. 4 mm	$h \leqslant 1$ mm + $1{,}0b$ but max. 5 mm	
12	Incorrect weld toe: butt welds  fillet welds $\alpha_1 \geqslant \alpha$, $\alpha_2 \geqslant \alpha$ 	505	α – angle between base metal surface and flat surface tangent to convexity	$\alpha \geqslant 150°$ $\alpha \geqslant 110°$	$\alpha \geqslant 100°$ $\alpha \geqslant 110°$	$\alpha \geqslant 90°$ $\alpha \geqslant 90°$	For smooth transition for quality levels B and C special handling of the weld may be required
13	Overlap 	506	h – overlap dimension	Not permitted	Not permitted	$h \leqslant 0{,}2b$	

No	Imperfection designation Reference to	ISO 6520	Specifications of imperfections and the weld dimensions	Limits for imperfections for quality levels ISO 5817			Remarks
				B	C	D	
14	Linear misalignment between plates and caps of pipes: projected as symmetrical; 	5071	h – height of linear misalignment defined as misalignment of axes along the thickness plates	$h \leqslant 0{,}1t_1$ but max. 3 mm	$h \leqslant 0{,}15t_1$ but max. 4 mm	$h \leqslant 0{,}25t_1$ but max. 5 mm	
	projected as unsymmetrical 		defined as deviation of external plate line	$h \leqslant 0{,}1t_1$ but max. 3 mm	$h \leqslant 0{,}15t_1$ but max. 4 mm	$h \leqslant 0{,}25t_1$ but max. 5 mm	
15	Linear misalignment between tubes (pipes) 	5072	h — height of linear misalignment defined as the deviation of the welded pipes external diameter $t = \min\{t_1 \text{ и } t_2\}$	$h \leqslant 0{,}5t$ but max. 2 mm	$h \leqslant 0{,}5t$ but max. 3 mm	$h \leqslant 0{,}5t$ but max. 4 mm	
16	Linear misalignment of cruciform joints: projected as symmetrical; 		h – height of linear misalignment: defined as deviation of axes along the thickness plates $t = \min\{t_1, t_2 \text{ и } t_3\}$	$h \leqslant 0{,}15t$	$h \leqslant 0{,}30t$	$h \leqslant 0{,}50t$	
	projected as unsymmetrical 		defined as deviation of common external line of plates $t = \min\{t_1, t_2 \text{ и } t_3\}$	$h \leqslant 0{,}15t$	$h \leqslant 0{,}30t$	$h \leqslant 0{,}50t$	

No	Imperfection designation Reference to	ISO 6520	Specifications of imperfections and the weld dimensions	Limits for imperfections for quality levels ISO 5817			Remarks
				B	C	D	
17	Sagging Incompletely filled groove 	509 511	h – height of sagging or incompleteness of groove l – length of imperfection	$h \leqslant 0{,}05t_1$ but max. 0,5 mm $l \leqslant 25$ mm	$h \leqslant 0{,}1t$ but max. 1 mm $l \leqslant 25$ mm	$h \leqslant 0{,}25t_1$ but max. 2,0 mm $l \leqslant 25$ mm	
18	Burn-through (leakage of welding bath with formation of through hole in the weld)	510		Not permitted	Not permitted	Not permitted	
19	Excessive asymmetry of fillet weld 	512	$h = z_1 - z_2$ – height of asymmetry (different crater dimensions)	$h \leqslant 1{,}5$ mm + 0,15a	$h \leqslant 1{,}5$ mm + 0,15a	$h \leqslant 1{,}5$ mm + 0,15a	
20	Irregular surface: pimpling and scaling; drops between beads	514	h – height of pimpling and scaling h – height of drops between beads	$h \leqslant 1{,}5$ mm $h \leqslant 1{,}5$ mm	$h \leqslant 2$ mm $h \leqslant 2$ mm	$h \leqslant 2$ mm $h \leqslant 2$ mm	Height of drops between beads, height of pimpling and scaling shall be measured among tops of pimpling and scaling
21	Root concavity 	515	h – height of root concavity l – length of imperfection	$h \leqslant 0{,}05t$ but max. 0,5 mm $l \leqslant 25$ mm	$h \leqslant 0{,}1t$ but max. 1 mm $l \leqslant 25$mm	$h \leqslant 0{,}2t$ but max. 2,0 mm $l \leqslant 25$ mm	
22	Root porosity	516		Not permitted	Not permitted	Permitted but only local	May not be permitted for level D under conditions of painting
23	Poor restart.	517		Not permitted	Not permitted	Permitted	May not be permitted for level D under conditions of painting

No	Imperfection designation Reference to	ISO 6520	Specifications of imperfections and the weld dimensions	Limits for imperfections for quality levels ISO 5817			Remarks
				B	C	D	
24	Insufficient throat thickness 	5213	h – height if insufficience (reduction from nominal dimension) of fillet weld thickness a l – length of imperfection	Not permitted	$h \leqslant 0{,}3$ mm + $0{,}1a$ but max. 1 mm $l \leqslant 25$ mm	$h \leqslant 0{,}3$ mm + $0{,}1a$ but max. 1 mm $l \leqslant 25$ mm	
25	Excessive throat thickness 	5214	h – height of excessive throat of fillet weld thickness a	$h \leqslant 1$ mm + $0{,}15a$ but max. 3 mm	$h \leqslant 1$ mm + $0{,}2a$ but max 4 mm	Unlimited	
26	Stray arc: local breakage of the base metal surface close to weld due to arc burning outside grooving	601		Not permitted	Not permitted	Permitted, if the properties of the base metal are not affected	Refer to Table 9.13, Part A, IACS Standard No. 47
27	Spatter 	602		Not permitted	To be removed from the surface subject to coating requirements.		Refer to para. 4.2.4.2, Part A, IACS Standard No. 47
28	Incorrect root gap for fillet welds 	617	h – height of root gap of single sided weld a – thickness of fillet weld	$h \leqslant 0{,}5$ mm + $0{,}1a$ but max 2 mm	$h \leqslant 0{,}5$ mm + $0{,}2a$ but max 3 mm	$h \leqslant 1$ mm + $0{,}3a$ but max 4 mm	On agreement with the Register gaps exceeding the appropriate limit may be compensated for by a corresponding increase in the throat.

3.3.2.2 All imperfections detected on the visual testing and measurement results shall be removed and the location of corrections shall be tested again in compliance with 3.1.5.

3.3.2.3 On the visual testing and measurement results the welded joints shall be considered fit/accepted if inadmissible imperfections are not detected for an acceptable level listed in Table 3.3.2.1.

3.3.3 Assessment of the welded joints quality by the magnetic particle testing results.

3.3.3.1 If otherwise is not agreed with the Register, assessment of the welded joints quality on the magnetic particle testing results shall be carried out in accordance with ISO 23278 (refer to Table 3.3.3.1) for the quality levels specified by the requirements 3.3.1.2 or 3.3.1.3.

Table 3.3.3.1

Indicator bead type	Assessment level (quality grade) in compliance with ISO 23278[1]		
	1	2	3
Linear[2] l – indicator bead length	$l \leq 1.5$ mm	$l \leq 3$ mm	$l \leq 6$ mm
Non-linear[3] d – size of a major axis of the indicator bead	$d \leq 2$ mm	$d \leq 3$ mm	$d \leq 4$ mm

[1]Acceptance levels 2 and 3 may include an index "×" designating that all the linear indicator beads shall be assessed as per level 1.

[2]A linear indicator bead is an indicator bead with its length exceeding the width of more than three times.

[3]Non-linear indicator bead is an indicator bead with its length equal to or less than three widths.

3.3.3.2 To reduce the dimensions or remove the imperfections that caused inadmissible indicator beads (indications), local grinding or cleaning can be used if permitted as per the production specifications for a particular product.

Location of corrections shall be subject to re-inspection and assessment in accordance with the specification used for the initial testing as per 3.1.5.

3.3.3.3 On the magnetic particle testing results the welded joints shall be considered fit/accepted if inadmissible imperfections are not detected for an acceptable level listed in Table 3.3.3.1.

3.3.4 Assessment of the welded joints quality by the dye penetrant testing results.

3.3.4.1 If otherwise is not agreed with the Register, assessment of the welded joints quality on the dye penetrant testing results shall be carried out in accordance with ISO 23277 (refer to Table 3.3.4.1) for the quality levels specified by the requirements 3.3.1.2 or 3.3.1.3.

Table 3.3.4.1

Indicator bead type	Assessment level (quality grade) in compliance with ISO 23277[1]

	1	2	3
Linear[2] l – indicator bead length	$l \leq 2$ mm	$l \leq 4$ mm	$l \leq 8$ mm
Non-linear[3] d – size of a major axis of the indicator bead	$d \leq 4$ mm	$d \leq 6$ mm	$d \leq 8$ mm

[1]Acceptance levels 2 and 3 may include an index "×" designating that all the linear indicator beads shall be assessed as per level 1.

[2]A linear indicator bead is an indicator bead with its length exceeding the width of more than three times.

[3]Non-linear indicator bead is an indicator bead with its length equal to or less than three widths.

3.3.4.2 To reduce the dimensions or remove the imperfections that caused inadmissible indicator beads (indications), local grinding or cleaning can be used if permitted as per the production specifications for a particular product.

Location of corrections shall be subject to re-inspection and assessment in accordance with the specification used for the initial testing as per 3.1.5.

3.3.4.3 On the dye penetrant testing results the welded joints shall be considered fit/accepted if inadmissible imperfections are not detected for an acceptable level listed in Table 3.3.4.1.

3.3.5 Assessment of the welded joints quality by the radiographic testing results.

3.3.5.1 At the radiographic testing assessment of the welded joints quality shall be carried out with interpretation of the images on radiographs for the following types of internal imperfections:

pores;
slag inclusions;
metal tungsten inclusions;
metal copper inclusions;
lack of fusion;
lack of penetration;
cracks.

Surfaced imperfections in welds shall be assessed in compliance with 3.3.2.1.

3.3.5.2 For the dimensions of the welded joints imperfections under radiographic control shall be taken dimensions of their images on radiographs in accordance with the following requirements.

The following are accepted for the dimensions of the pores, slag or tungsten inclusions:

for spherical pores and inclusions their diameter d, as measured by the longest axis;

for elongated pores and inclusions their length l and width h.

Note. Inclusion is extended (linear) if its length is more than three times the maximum width or diameter.

For the dimensions of lack of fusion, incomplete penetration and cracks their length L is accepted.

If the distance between similar imperfections in-line is less than the size of the smallest imperfections, such imperfections shall be one extended imperfections.

Dimensions of such an imperfection shall be defined as the distance

measured by the outermost edges of the group imperfections.

If the distance between arranged parallel uniform extended imperfections is less than 3 times the width of the smallest imperfection, these imperfections shall be considered as an extended imperfection. Dimensions of such an imperfection shall be defined as the distance measured by the outermost edges of the group imperfections.

If more than one pore is located within the circle of a diameter equal to 3 times a pore diameter, such imperfections are considered group porosityor pore accumulation (cluster). For the cluster size the distance measured at the outermost edges of each other specified by the requirements 3.3.1.2 or 3.3.1.3.

imperfections in the cluster shall be taken.

If the distance between two and more in-line uniform imperfections of one but not more than three extensions (diameter or length) of the smallest imperfections, those imperfections are called a line. For the inclusion line size the length measured at the outermost edges of each other imperfections in the line shall be taken.

3.3.5.3 If otherwise is not agreed with the Register, assessment of the welded joints quality on the radiographic testing results shall be carried out in accordance with ISO 10675-1 (refer to Table 3.3.5.3) for the quality levels.

Table 3.3.5.3

Ser. No.	Imperfection name and type	Reference to ISO 6520-1	Specifications of imperfections	Limits for imperfection for quality levels		
				1	2[1]	3[1]
1	2	3	4	5	6	7
1	Cracks	100	-	Not permitted	Not permitted	Not permitted
2a	Gas pores and uniformly distributed porosity Single layer weld	2011 2012	A – the sum of the different pore areas related to the evaluation area Wp x L d – maximum pore diameter	$A \leq 1\%$ $d \leq 0.2s$, but max 3.0 mm L= 100 mm	$A \leq 1.5\%$ $d \leq 0.3s$, but max 4.0 mm L= 100 mm	$A \leq 2.5\%$ $d \leq 0.4s$, but max 5.0 mm L= 100 mm
2b	Gas pores and uniformly distributed porosity Multi layer weld	2011 2012	A – the sum of the different pore areas related to the evaluation area Wp x L d – maximum pore diameter	$A \leq 2\%$ $d \leq 0.2s$, but max 3.0 mm L= 100 mm	$A \leq 3\%$ $d \leq 0.3s$, but max 4.0 mm L= 100 mm	$A \leq 5\%$ $d \leq 0.4s$, but max 5.0 mm L= 100 mm
3	Clustered (localized) porosity	2013	A – the sum of the different pore areas	$A \leq 4\%$ $d \leq 0.2s$, but	$A \leq 8\%$ $d \leq 0.3s$, but	$A \leq 16\%$ $d \leq 0.4s$, but

			related to the evaluation area $Wp \times L$ d – maximum pore diameter	max 2.0 mm L= 100 mm	max 3.0 mm L= 100 mm	max 4.0 mm L= 100 mm
4a	Linear porosity (lines) Single layer weld	2014	A – the sum of the different pore areas related to the evaluation area $Wp \times L$ d – maximum pore diameter	$A \leq 2\%$ $d \leq 0.2s$, but max 2.0 mm L= 100 mm	$A \leq 4\%$ $d \leq 0.3s$, but max 3.0 mm L= 100 mm	$A \leq 8\%$ $d \leq 0.4s$, but max 4.0 mm L= 100 mm
4b	Linear porosity (lines) Multilayer weld	2014	A – the sum of the different pore areas related to the evaluation area $Wp \times L$ d – maximum pore diameter	$A \leq 4\%$ $d \leq 0.2s$, but max 2.0 mm L= 100 mm	$A \leq 8\%$ $d \leq 0.3s$, but max 3.0 mm L= 100 mm	$A \leq 16\%$ $d \leq 0.4s$, but max 4.0 mm L= 100 mm
5	Wormholes (pipes) and elongated cavity	2016 2015	h – width of imperfection projection Σl – maximum total length of weld imperfection projection L	$h < 0.2s$, but max 2.0 mm $\Sigma l \leq s$, but max 25 mm L= 100 mm	$h \leq 0.3s$, but max 3.0 mm $\Sigma l \leq s$, but max 50 mm L= 100 mm	$h < 0.4s$, but max 4.0 mm $\Sigma l \leq s$, but max 75 mm L= 100 mm
6	Shrinkage cavity (except for crater pipe – 2024)	202	h – width of imperfection projection l – length of imperfection projection	Not permitted	Not permitted	$h < 0.4s$, but max 4.0 mm $l \leq 25$ mm
7	Crater pipe	2024	h – width of imperfection projection l – length of imperfection projection	Not permitted	Not permitted	$h < 0.2\ t$, but max 2.0 mm $l \leq 0.2\ t$, but max 2.0 mm
8	Slag inclusions, flux inclusions, oxide inclusions	301 302 303	h – width of imperfection projection Σl – maximum total length of weld imperfection projection L	$h < 0.2s$, but max 2.0 mm $\Sigma l \leq s$, but max 25 mm L= 100 mm	$h < 0.3s$, but max 3.0 mm $\Sigma l \leq s$, but max 50 mm L= 100 mm	$h < 0.4s$, but max 4.0 mm $\Sigma l \leq s$, but max 75 mm L= 100 mm
9	Metallic inclusions (other	304	l – length of imperfection	$h < 0.2s$, but max	$h < 0.3s$, but max	$h < 0.4s$, but max

	than copper)		projection	2.0 mm	3.0 mm	4.0 mm
10	Copper inclusions	3042		Not permitted	Not permitted	Not permitted
11[2]	Lack of fusion	401	Σl – maximum total length of weld imperfection projection *L*	Not permitted	Not permitted	Permitted but only intermittent and not surfaced Σl ≤ 25 mm *L*= 100 mm
12[2]	Lack of penetration	402	Σl – maximum total length of weld imperfection projection *L*	Not permitted	Not permitted	Σl ≤ 25 mm *L*= 100 mm

Designations:
L – any (with imperfection maximum density) 100 mm weld length;
s – nominal thickness of the butt weld;
t – material thickness;
Wp – weld width.

[1] Quality levels 2 and 3 can have index "x" which designates all imperfections above 25 mm are not permitted.

2 If the weld length is under 100 mm, the maximum imperfection length shall not be above 25 per cent of that length.

3.3.5.4 All detected imperfections inadmissible for the specified accepted level on the radiographic testing results shall be removed and the location of corrections shall be tested again in accordance with 3.1.5.

3.3.6 Assessment of the welded joints quality by the ultrasonic testing results.

3.3.6.1 If otherwise is not agreed with the Register, assessment of the ultrasonic testing results shall be carried out in accordance with the accepted levels based on the echo-signal length and amplitude as per ISO 11666 (refer to Table 3.3.6.1) and the following requirements for their application and interpretation of the testing result as regards instructions of 5.1 of ISO 11666.

Table 3.3.6.1

Method for setting the reference level of sensitivity according to	Evaluation level of sensitivity for acceptance level		Acceptance level 2 (AL 2) for thicknesses [2, 3, 4]		Acceptance level 3 (AL 3) for thicknesses [2, 3, 4]	
	2	3	8 mm ≤ *t*<15	15 mm ≤	8 mm ≤ *t*<15	15 mm ≤

ISO 17640[1]			mm	t<100 mm	mm	t<100 mm
1	2	3	4	5	6	7
1 (side-drilled holes)	H_0 - 14 dB	H_0 - 10 dB	For $l \le t$; H_0 - 4 dB For $l > t$; H_0 - 10 dB	For $l \le 0.5t$; H_0 For $0.5t < l \le t$; H_0 - 6 dB For $l > t$; H_0 - 10 dB	For $l \le t$; H_0 For $l > t$; H_0 - 6 dB	For $l \le 0.5t$; H_0 + 6 dB For $0.5t < l \le t$; H_0 - 2 dB For $l > t$; H_0 - 6 dB
2 (flat-bottom holes)	H_0 - 8 dB	H_0 - 4 dB	For $l \le t$; H_0 + 2 dB For $l > t$; H_0 - 10 dB	For $l \le 0{,}5t$; H_0 + 6 dB For $0.5t < l \le t$; H_0 For $l > t$; H_0 - 4 dB	For $l \le t$; H_0 + 6 dB For $l > t$; H_0	For $l \le 0.5t$; H_0 + 10 dB For $0{,}5t < l \le t$; H_0 + 4 dB For $l > t$; H_0
3 (rectangular notch)	H_0 - 14 dB	H_0 - 10 dB	For $l \le t$; H_0 - 4 dB For $l > t$; H_0 - 10 dB	–	For $l \le t$; H_0 For $l > t$; H_0 - 6 dB	–
4 (straddle and tandem techniques)	H_0 - 22 dB	H_0 - 18 dB	–	For $l \le 0.5t$; H_0 - 8 dB For $0.5t < l \le t$; H_0 - 14 dB For $l > t$; H_0 - 14 dB	–	For $l \le 0{,}5t$; H_0 - 14 dB For $0{,}5t < l \le t$; H_0 + -0 dB For $l > t$; H_0 - 14 dB

[1] Refer to 3.2.5.14.

[2] H_0 – reference levels of sensitivity according to the requirements of ISO 17640 (refer to 3.2.5.13).

[3] l – conventional length of imperfection/

[4] t – thickness of base metal (of the thinnest element)

3.3.6.2 All imperfections, echo-signal level of which exceeding the reference level of sensitivity, shall be assessed in accordance with the definition of the characteristics as per ISO 23279, Stage 3, in order to identify the planar (two-dimensional) imperfections.

3.3.6.3 All the specified as per

3.4 ASSESSMENT OF WELDED JOINT QUALITY IN ALUMINIUM ALLOY HULL STRUCTURES

3.4.1 General.

planar (two-dimensional) imperfections are considered inadmissible and subject to be corrected.

3.3.6.4 All detected imperfections inadmissible for the specified accepted level on the ultrasonic testing results shall be removed and the location of corrections shall be tested again in accordance with 3.1.5.

3.4.1.1 The assessment of welded joint quality in aluminium alloy hull structures shall be carried out in compliance with quality levels of the relevant requirements of ISO 10042 or

other international and national standards recognized by the Register.

3.4.1.2 Requirements for the quality levels that meet the requirements of ISO 10042 for hull structures of ships shall be agreed with the Register individually depending on the type of a ship and its size.

In any case, an acceptable level of quality shall be at least "C" in

accordance with ISO 10042 except for the size requirements for weld reinforcement during an external examination and measurements, which can be lowered to level "D" as agreed with the Register.

3.4.1.3 For specific non-destructive testing procedure acceptable levels of imperfection acceptance in accordance with the specified quality levels as per

Table 3.4.1.3

ISO 10042, as well as the requirements for the class and procedure of control are established by the requirements of the relevant international standards and shall be assigned in accordance with Table 3.4.1.3.

Reduced acceptable levels of imperfection acceptance as well as the requirements for the class and procedure of control are the subject of the Register special consideration in each particular case.

3.4.1.4 Assessment of the welded joints quality within each level of assessment of imperfections shall be performed as per an alternative system of "fit-unfit" ("acceptance – non-acceptance") applying assessment

criteria, according to 3.4.2, 3.4.3, 3.4.4.

Quality level in compliance with ISO 10042	Requirements for radiographic testing		Requirements for penetrant methods	
	Methods and class as per ISO 17636	Assessment level (quality grade) in compliance with ISO 10675	Methods and class as per ISO 3452	Assessment level (quality grade) in compliance with ISO 23277
B	B	1	Test class (level) is not specified	2×
C	B[1]	2		2×
D	A	3		3×

[1] The minimum number of exposure for circumferential weld testing may correspond to the requirements of class A of ISO 17636.

3.4.2 Assessment of the welded joints quality by the visual testing and measurement results.

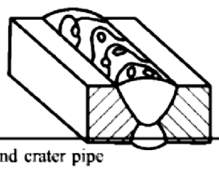
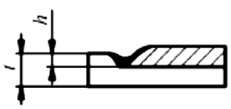
3.4.2.1 If otherwise is not agreed with the Register, assessment of the welded joints quality on the visual testing and measurement results shall be carried out in accordance with ISO 10042 (refer to Table 3.4.2.1) for the quality levels agreed with the Register.

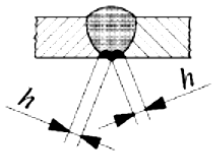
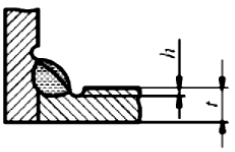
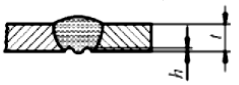
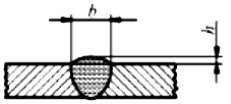
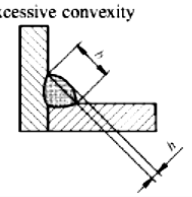
detected for an acceptable level listed in Table 3.4.2.1

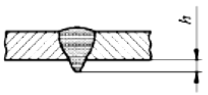
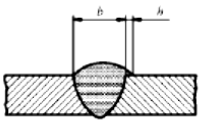
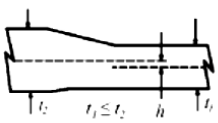
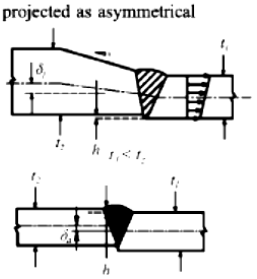
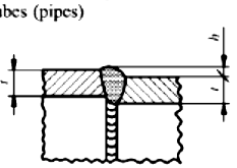
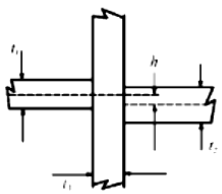
3.4.2.2 All imperfections detected on the visual testing and measurement results shall be removed and the location of corrections shall be tested again in compliance with 3.1.5.

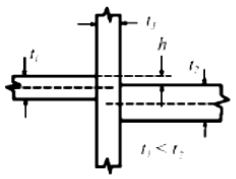
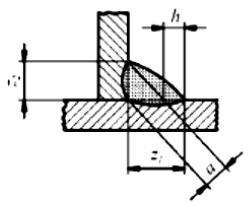
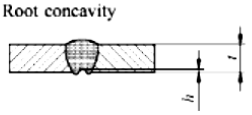
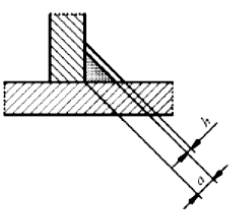
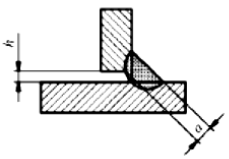
3.4.2.3 On the visual testing and measurement results the welded joints shall be considered fit/accepted if inadmissible imperfections are not

Table 3.4.2.1

No.	Imperfection designation	Reference to ISO 6520	Specifications of imperfections and the weld dimensions	Limits for imperfections for quality levels ISO 10042			Remarks
				B	C	D	
1	Crack	100	–	Not permitted			–
2	Crater crack	104	l – length h – height	Not permitted		$l \leqslant 0{,}4t$ or $l \leqslant 0{,}4a$ $h \leqslant 0{,}4t$ or $h \leqslant 0{,}4a$	–
3	Surface pore 	2017	d – maximum dimension for weld profile concavity: 0,5 mm $\leqslant t \leqslant$ 3 mm $t >$ 3 mm	$d \leqslant 0{,}1t$ or $d \leqslant 0{,}1a$ $d \leqslant 0{,}2t$ or $d \leqslant 0{,}2a$ but max. 1 mm	$d \leqslant 0{,}2t$ or $d \leqslant 0{,}2a$ $d \leqslant 0{,}3t$ or $d \leqslant 0{,}3a$ but max. 1,5 mm	$d \leqslant 0{,}3t$ or $d \leqslant 0{,}3a$ $d \leqslant 0{,}4t$ or $d \leqslant 0{,}4a$ but max. 3 mm	Clusters and lines on the weld surface are not permitted
4	End crater pipe 	2025	h – crater height (cross sectional dimension of undercut)	Not permitted	$h \leqslant 0{,}20t$, but max. 1,5 mm	$h \leqslant 0{,}40t$, but max. 3 mm	For levels C and D may not be permitted under painting conditions

No.	Imperfection designation	Reference to ISO 6520	Specifications of imperfections and the weld dimensions	Limits for imperfections for quality levels ISO 10042			Remarks
				B	C	D	
5	Lack of fusion (surfaced) 	401	h – height l – length of a single imperfection	Not permitted	Not permitted	$h \leqslant 0{,}1t$ or $h \leqslant 0{,}1a$ but max. 3 mm $l \leqslant 25$ mm	
6	Incomplete root penetration (for single sided butt welds) 	4021	h – maximum height l – maximum length of a single imperfection	Not permitted	Not permitted	$h \leqslant 0{,}20t$ but max. 2,0 mm $l \leqslant 25$ mm Single non systematical imperfections may be permitted	For level D may not be permitted under painting conditions
7	Undercut: continuous 	5011	h – maximum height	Not permitted	$h \leqslant 0{,}10t$ but max. 0,5 mm	$h \leqslant 0{,}20t$ but max. 1,0 mm	
	intermittent 	5012	h – maximum height l – length	$h \leqslant 0{,}10t$ but max. 0,5 mm $l \leqslant 25$ mm	$h \leqslant 0{,}10t$ but max. 1 mm $l \leqslant$ mm	$h \leqslant 0{,}20t$ but max. 1,5 mm $l \leqslant 25$ mm	
8	Strinkage grooves (undercuts on both sides of the weld) 	5013	h – maximum height l – maximum length of a single imperfection	$h \leqslant 0{,}05t$ but max. 0,5 mm $l \leqslant 25$ mm	$h \leqslant 0{,}1t$ but max. 1 mm $l \leqslant 25$ mm	$h \leqslant 0{,}2t$ but max. 1,5 mm $l \leqslant 25$ mm	
9	Excess weld metal 	502	h – maximum reinforcement height b – breadth of reinforcement	$h \leqslant 1{,}5$ mm + $0{,}1b$ but max. 6 mm	$h \leqslant 1{,}5$ mm + $0{,}15b$ but max. 8 mm	$h \leqslant 1{,}5$ mm + $0{,}2b$ but max. 10 mm	
10	Excessive convexity 	503	h – maximum convexity b – breadth of fillet weld	$h \leqslant 1{,}5$ mm + $0{,}1b$ but max. 3 mm	$h \leqslant 1{,}5$ mm+$0{,}15b$ but max. 4 mm	$h \leqslant 1{,}5$ mm + $0{,}3b$ but max. 5 mm	

No.	Imperfection designation	Reference to ISO 6520	Specifications of imperfections and the weld dimensions	Limits for imperfections for quality levels ISO 10042			Remarks
				B	C	D	
11	Excessive penetration 	504	h – maximum penetration height b – breadth of penetration	$h \leqslant 3$ mm	$h \leqslant 4$ mm	$h \leqslant 5$ mm	
12	Overlap 	506	h – overlap height l – length of a single imperfection	Not permitted	Not permitted	$h \leqslant 0{,}2t$ $l \leqslant 25$ mm	
13	Linear misalignment between plates and caps of pipes: projected as symmetrical 	5071	h – dimension of linear misalignment: defined as misalignment of axes along the thickness plates	$h \leqslant 0{,}2t$ but max. 2 mm	$h \leqslant 0{,}3t$ but max. 4 mm	$h \leqslant 0{,}4t$ but max. 8 mm	
	projected as asymmetrical 		defined as deviation of external plate line	$h \leqslant 0{,}2t$ but max. 2 mm	$h \leqslant 0{,}3t$ but max. 4 mm	$h \leqslant 0{,}4t$ but max. 8 mm	
14	Linear misalignment between tubes (pipes) 	5072	h – height of linear misalignment defined as the deviation of the welded pipes external diameter $t = \min\{t_1 \text{ and } t_2\}$	$h \leqslant 0{,}2t$ but max. 4 mm	$h \leqslant 0{,}3t$ but. 6 mm	$h \leqslant 0{,}4t$ but max. 10 mm	
15	Linear misalignment of cruciform joints: projected as symmetrical 		h – height of linear misalignment defined as deviation of axes along the thickness plates $t = \min\{t_1, t_2 \text{ and } t_3\}$	$h \leqslant 0{,}2t$	$h \leqslant 0{,}30t$	$h \leqslant 0{,}50t$	

No.	Imperfection designation	Reference to ISO 6520	Specifications of imperfections and the weld dimensions	Limits for imperfections for quality levels ISO 10042			Remarks
				B	C	D	
	projected as asymmetrical 		defined as deviation of common external line of plates $t = \min\{t_1, t_2 \text{ and } t_3\}$	$h \leqslant 0{,}15t$	$h \leqslant 0{,}30t$	$h \leqslant 0{,}50t$	
16	Sagging Incompletely filled groove 	509 511	h – height of sagging or incompleteness of groove l – length of imperfection	$h \leqslant 0{,}05t$ but max. 0,5 mm $l \leqslant 25$ mm	$h \leqslant 0{,}1t$ but max. 1 mm $l \leqslant 25$ mm	$h \leqslant 0{,}2t$ but max. 2,0 mm $l \leqslant 25$ mm	
17	Excessive asymmetry of fillet weld 	512	$h = z_1 - z_2$ – height of asymmetry (different crater dimensions)	$h \leqslant 1{,}5$ mm + $0{,}2a$	$h \leqslant 2$ mm + $0{,}25a$	$h \leqslant 3$ mm + $0{,}3a$	
18	Root concavity 	515	h – height of root concavity l – length of imperfection	$h \leqslant 0{,}05t$ but max. 0,5 mm $l \leqslant 25$ mm	$h \leqslant 0{,}1t$ but max.1 mm $l \leqslant 25$ mm	$h \leqslant 0{,}2t$ but max.2,0 mm $l \leqslant 25$ mm	
19	Insufficient throat thickness 	5213	h – height if insufficience (reduction from nominal dimension) of fillet weld thickness a l – length of imperfection	$h \leqslant 0{,}1a$ but max. 1 mm $l \leqslant 25$ mm	$h \leqslant 0{,}2a$ but max. 1,5 mm $l \leqslant 25$ mm	$h \leqslant 0{,}3a$ but max. 2 mm $l \leqslant 25$ mm	
20	Incorrect root gap for fillet weld 	617	h – height of root gap of single sided weld a – thickness of fillet weld	$h \leqslant 0{,}5$ mm + $0{,}1a$ but max. 3 mm	$h \leqslant 0{,}5$ mm + $0{,}15a$ but max. 4 mm	$h \leqslant 1$ mm + $0{,}2a$ but max. 5 mm	On agreement with the Register gaps exceeding the appropriate limit may be compensated for by a corresponding increase in the throat

3.4.3 Assessment of the welded joints quality by the dye penetrant testing results.

3.4.3.1 If otherwise is not agreed with the Register, assessment of the welded joints quality on the dye penetrant testing results shall be carried out in accordance with the requirements of ISO 23277 (refer to Table 3.4.3.1) for the quality levels agreed with the Register.

Table 3.4.3.1

Indicator bead type	Assessment level (quality grade) in compliance with ISO 23277[1]		
	1	2	3
Linear[2] l – indicator bead length	$l \leq 2$ mm	$l \leq 4$ mm	$l \leq 8$ mm
Non-linear[3] d – size of a major axis of the indicator bead	$d \leq 4$ mm	$d \leq 6$ mm	$d \leq 8$ mm

[1]Acceptance levels 2 and 3 may include an index "×" designating that all the linear indicator beads shall be assessed as per level 1.

[2]A linear indicator bead is an indicator bead with its length exceeding the width of more than three times.

[3]Non-linear indicator bead is an indicator bead with its length equal to or less than three widths.

3.4.3.2 To reduce the dimensions or remove the imperfections that caused inadmissible indicator beads (indications), local grinding or cleaning can be used if permitted as per the production specifications for a particular product.

Location of corrections shall be subject to re-inspection and assessment in accordance with the specification used for the initial testing as per 3.1.5.

3.4.3.3 On the dye penetrant testing results the welded joints shall be considered fit/accepted if inadmissible imperfections are not detected for an acceptable level listed in Table 3.4.3.1.

3.4.4 Assessment of the welded joints quality by the radiographic testing results.

3.4.4.1 At the radiographic testing assessment of the welded joints quality shall be carried out with interpretation of the images on radiographs for the following types of internal imperfections:

solid (oxide) inclusions;

metal tungsten inclusions;

lack of fusion;

lack of penetration;

cracks.

Surfaced imperfections in welds shall be assessed in compliance with 3.4.2.1.

3.4.4.2 For the dimensions of the welded joints imperfections under radiographic control shall be taken dimensions of their images on radiographs in accordance with the following requirements.

The following are accepted for the dimensions of the pores, slag or tungsten inclusions:

for spherical pores and inclusions their diameter *d*;

for elongated inclusions their length *l* and width *h*.

For the dimensions of lack of fusion, incomplete penetration and cracks their length *L* is accepted.

If the distance between similar imperfections in-line is less than the size of the smallest imperfections, such imperfections shall be one extended imperfections.

Dimensions of such an imperfection shall be defined as the distance measured by the outermost edges of the group imperfections.

If the distance between arranged parallel uniform extended imperfections is less than 3 times the width of the smallest imperfection, these imperfections shall be considered as an extended imperfection. Dimensions of such an imperfection shall be defined as the distance measured by the outermost edges of the group imperfections.

If more than one pore is located within the circle of a diameter equal to 3 times a pore diameter, such imperfections are considered group porosity or pore accumulation (cluster). For the cluster size the distance measured at the outermost edges of each other imperfections in the cluster shall be taken.

If the distance between two and more in-line uniform imperfections of one but not more than three extensions (diameter or length) of the smallest imperfections, those imperfections are called a line. For the inclusion line size the length measured at the outermost edges of each other imperfections in the line shall be taken.

3.4.4.3 If otherwise is not agreed with the Register, assessment of the welded joints quality on the radiographic testing results shall be carried out in accordance with ISO 10675-2 (refer to Table 3.4.4.3) for the quality levels agreed with the Register.

Table 3.4.4.3

No.	Imperfection designation	Reference to ISO 6520-1	Specifications of imperfections	Limits for imperfection for quality levels		
				1	2[1]	3[1]
1	Crack	100	-	Not permitted	Not permitted	Not permitted
2*a*	Gas pore	2011	*d* – maximum pore diameter	$d \leqslant 0{,}2s$ but max. 4mm	$d \leqslant 0{,}3s$ but max. 5 mm	$d \leqslant 0{,}4s$ but max. 6 mm

2*b*	Uniformly distributed porosity Material thickness 0,5 mm ⩽ s ⩽3 mm	2012	A – the sum of the different pore areas related to the evaluation area $Wp \times L$	$A \leqslant 1$ % L = 100 mm	$A \leqslant 2$% L = 100 mm	$A \leqslant 6$% L = 100 mm
2*c*	Uniformly distributed porosity Material thickness 3 mm < s ⩽12 mm	2012	A – the sum of the different pore areas related to the evaluation area $Wp \times L$	$A \leqslant 2$% L = 100 mm	$A \leqslant 4$ % L = 100 mm	$A \leqslant 10$ % L = 100 mm
2*d*	Uniformly distributed porosity Material thickness 12 mm < s ⩽30 mm	2012	A – the sum of the different pore areas related to the evaluation area $Wp \times L$	$A \leqslant 3$ % L = 100 mm	$A \leqslant 6$ % L = 100 mm	$A \leqslant 15$ % L = 100 mm
2*e*	Uniformly distributed porosity Material thickness s > 30mm	2012	A – the sum of the different pore areas related to the evaluation area $Wp \times L$	$A \leqslant 4$ % L = 100 mm	$A \leqslant 8$ % L = 100 mm	$A \leqslant 20$ % L = 100 mm
3	Clustered (localized) porosity	2013	dA – maximum diameter of the clustered porosity	$dA \leqslant 15$ mm or dA, max ⩽ $Wp/2$	$dA \leqslant 20$ mm or dA, max ⩽ Wp	$dA \leqslant 25$ mm or dA, max ⩽ Wp
4	Linear porosity	2014	l – linear porosity length	Not permitted	Not permitted	$l \leqslant 25$ mm
5	Elongated cavity and pipes (wormholes)	2015 2016	l – imperfection length	$l \leqslant 0{,}2s$ but max. 3 мм	$l \leqslant 0{,}3s$ but max. 4 mm	$l \leqslant 0{,}4s$ but max. 6 mm
6	Oxide inclusions	303	l – length of an inclusion s – nominal thickness of the butt weld	$l \leqslant 0{,}2s$ but max. 3 mm	$ll \leqslant 0{,}5s$ but max. 5 mm	$l \leqslant s$ but max. 10 mm
7	Tungstan inclusions	3041	l – imperfection length	$l \leqslant 0{,}2s$ but max. 3 mm	$l \leqslant 0{,}3s$ but max. 4 mm	$l \leqslant 0{,}4s$ but max. 6 mm
8[2]	Lack of fusion	401	l – imperfection length	Not permitted	Not permitted	Permitted but only intermittent and not surfaced $l \leqslant 25$ mm, L = 100 mm
9[2]	Lack of penetration	402	l – imperfection length	Not permitted	Permitted as applied to the double-sided welded joint and not surfaced $l \leqslant 25$ mm, L = 100 mm	l < 25 mm, L = 100 mm

Symbols:
L – any (with imperfection maximum density) 100 mm weld length;
S – nominal thickness of the butt weld;
t – material thickness;
Wp – weld width.

[1] Quality levels 2 and 3 can have index "x" which designates all imperfections above 25 mm are not permitted.

2 If the weld length is under 100 mm, the maximum imperfection length shall not be above 25 per cent of that length.

3.4.4.4 All detected imperfections inadmissible for the specified accepted level on the radiographic testing results shall be removed and the location of corrections shall be tested again in accordance with 3.1.5.

4. WELDING CONSUMABLES

4.1 GENERAL

4.1.1 Application.

4.1.1.1 The welding consumables intended for welding the structures specified in 1.1.1 shall be tested and approved by the Register.

Based on the results of manufacturer survey and testing of welding consumables, the Register issues a Certificate of Approval for Welding Consumables, which is drawn up by the manufacturer's name and is subject to annual endorsement.

4.1.1.2 The requirements of this Section apply to the initial approval and annual endorsement of the Certificate of Approval for Welding Consumables regarding the welding consumables used for welding the normal, higher and high strength hull structural steels, corrosion-resistant (stainless) steels and aluminium alloys.

This Section specifies the requirements for approval of the following categories of welding consumables:

covered electrodes for manual arc welding, and also for gravity and contact welding;

"wire-flux" combinations for submerged arc welding;

"wire-gas" combinations for gas-shielded metal arc welding (including tungsten inert gas welding — TIG, as well as plasma arc welding); flux-cored wire with or without shielding gas for metal arc welding;

flux-cored wire with or without shielding gas for metal-arc welding.

welding consumables for electrogas and electroslag welding.

4.1.2 Grading and designation.

4.1.2.1 General explanations.

Welding consumables are classified depending on their purpose, and also on the mechanical and chemical properties of the filler metal.

Different grades or types of consumables may be used for specific applications or materials on a case-by-case basis.

The welding consumables covered by the requirements of this Section shall be classified using the basic and additional symbols given in 4.1.2.2 to 4.1.2.6.

4.1.2.2 Welding consumables for welding normal and higher strength hull structural steels.

The welding consumables intended for welding the normal and higher strength hull structural steels, which meet the requirements of 3.2, Part XIII "Materials", are divided into grades depending on the minimum yield stress of deposited metal and the impact test temperatures of weld metal and deposited metal with the assignment of the basic symbols according to Table 4.1.2.2.

Table 4.1.2.2

Strength level of deposited metal or weld metal R_{eH}, MPa, min	Impact test temperature of deposited metal and weld metal specimens, ºC				
	+20	0	-20	-40	-60
305	1	2	3	4	–
375	1Y	2Y	3Y	4Y	5Y
400	–	2Y40	3Y40	4Y40	5Y40

4.1.2.3 Welding consumables for high strength steels.

The welding consumables intended for welding the high strength steels, which meet the requirements of 3.13, Part XIII "Materials", are divided into grades depending on the minimum yield stress of deposited metal and the impact test temperatures of weld metal and deposited metal with the assignment of the basic symbols according to Table 4.1.2.3.

Table 4.1.2.3

Strength level of deposited metal or weld metal ReH, MPa, min	Impact test temperature of deposited metal and weld metal specimens, ºC				
	+20	0	-20	-40	-60
420			3Y42	4Y42	5Y42
460			3Y46	4Y46	5Y46

500			3Y50	4Y50	5Y50
550			3Y55	4Y55	5Y55
620			3Y62	4Y62	5Y62
690			3Y69	4Y69	5Y69

4.1.2.4 Welding consumables for corrosion-resistant (stainless) steels.

The welding consumables intended for welding the corrosion-resistant (stainless) steels, which meet the requirements of 3.16, Part XIII "Materials", are divided into grades with the assignment of symbols M-l, MF-2, F-3, AM-4, A-5, A-6, A-7ss, AF-8dup, A-9sp and A-10sp according to the provisions in 4.8.1.2 considering the structure and composition of the steels to be welded.

Additionally to the designation of the welding consumable grade, the symbol of a typical chemical composition (brand) of deposited metal shall be indicated similarly to 3.16.1.1, Part XIII "Materials" for the base metal (refer also to 4.8.1.3).

4.1.2.5 Welding consumables for welding aluminium alloys.

The welding consumables intended for welding aluminium alloys, which meet the requirements of Section 5, Part XIII "Materials", are divided into grades A, B, C and D (for international alloys) and 1, 2, 3 and 4 (for national alloys) in accordance with the provisions in 4.9.1.3 depending on the composition and strength level of the base metal used for approval tests.

Initial letter W or R is placed before the grade symbol to designate the product type: wire or rod, respectively.

4.1.2.6 Additional symbols.

For the welding consumables intended for welding normal and higher strength steels, as well as high strength steels, the following additional symbols are used:

H15, H10 and H5 for controlled diffusible hydrogen content in the deposited metal as per 4.2.3;

T – for approval of welding consumables for two-run welding technique, which provides welding in single run on each weld side without an additional back welding and gouging of the weld root;

M – for approval of welding consumables for multi-run welding technique;

TM – for approval of welding consumables for two-run and multi-run welding technique;

S – for approval of welding consumables for semiautomatic welding technique;

SM – for approval of welding consumables for semiautomatic and automatic multi-run welding technique;

V – for approval of welding consumables for vertical welding with the forced weld formation using the electrogas and electroslag welding technique.

PW – for approval of welding consumables supplied with the confirmed mechanical properties of weld metal after heat treatment for stress relief.

4.1.3 Approval procedure.

4.1.3.1 Request for approval.

To approve welding consumables, a manufacturer shall submit to the Register a request for approval together with enclosed documents and specific

information indicated in 4.3.1.3, 4.4.1.3, 4.5.1.5 and 4.6.1.4

4.1.3.2 Quality of manufacturing.

The manufacturer's production facilities, method of production and quality control of welding consumables shall be such as to ensure reasonable uniformity in manufacture.

The manufacturer shall ascertain this uniformity by means of analysis and systematic testing on each production batch.

In general, the welding consumables shall maintain the manufacturer-specified and secured characteristics (stated in the requirements for products acceptance) for a period of time of at least six months after the date of delivery, when properly stored and kept in the original packaging.

The consumables shall be supplied so packaged as to ensure compliance with the above requirement; the packaging shall be sufficiently strong to resist the usual transportation and handling operations.

The manufacturer shall mark (stamp or seal) each container or bag, as applicable, with the markings which are necessary to trace back each production.

4.1.3.3 Surveys and tests.

The welding consumables are approved subject to satisfactory results of the following:

survey of the production potential and the quality assurance system of the manufacturer of welding consumables by the Surveyor to the Register;

tests of welding consumables to the extent of the initial approval as per 4.3 to 4.9 witnessed by the Surveyor to the Register directly at the manufacturer's or in the independent testing centre recognized by the Register.

The approval tests required shall be performed on samples of consumables representative of the production. Sampling procedures shall be agreed with the Surveyor to the Register.

In general, the approval tests consist of the following control checks and tests:

sampling inspection of the quality of product manufacture together with checking the welding and technological properties usually carried out during survey of production;

determination of the mechanical properties and chemical composition of deposited metal if the latter is specified by the technical documentation for manufacture and supply of products (coated electrodes, flux-cored wire);

determination of the mechanical properties of the butt welded joint metal;

determination of the content of diffisible hydrogen in deposited metal for the welding consumables with the relevant additional symbols (refer to 4.2.3.1);

determination, where necessary, of the weld metal and welded joint susceptibility to hot cracking;

special types of tests relevant to the welding consumables for welding corrosion-resistant (stainless) steels according to 4.8.

Unless otherwise specified, test specimens and procedure shall meet the requirements of this Section or Register-recognized standards.

In order to approve the welding consumables and welding processes,

the requirements to which are not specified in the Rules, these shall be tested to the extent agreed with the Register in each particular case.

4.1.4 Certificate of Approval for Welding Consumables.

4.1.4.1 Upon satisfactory completion of the survey and tests required in this Section to the extent of the initial approval, the Register issues to a manufacturer the Certificate of Approval for Welding Consumables of a set form.

4.1.5 Annual inspections and tests.

4.1.5.1 The Certificate of Approval for Welding Consumables is issued for a period of up to five years and is subject to annual re-approval surveys and tests carried out under the Register technical supervision.

The re-approval surveys and tests shall be carried out at a yearly interval. The tests shall be completed by the end of each calendar year at the latest.

The scope of annual re-approval tests of the welding consumables is specified for particular types of the welding consumables and welding procedures as per 4.3.8.1, 4.4.4.1, 4.5.5.1, 4.6.5, 4.7.3, 4.8.5 and 4.9.3.

4.1.5.2 In case re-approval tests show unsatisfactory results, the grade of welding consumables shall be lowered according to the actual values of the properties obtained.

The approval may be resumed not before three months' period after the manufacturer has taken measures for production quality stabilization and performance of the tests for welding consumables upgrading in the established order.

4.1.5.3 Welding consumables approved by the Register on the basis of the test results conducted at the user's during the welding procedure approval shall be subjected to re-approval tests in the normal way either at the manufacturer's or, on its authorization, at the user's works.

4.1.5.4 Where conditions of re-approval are not met, the validity of the Certificate of Approval for Welding Consumables is ceased, and the welding consumables indicated therein may no longer be used for fabrication of the structures subject to survey by the Register.

Upon expiry the Certificate of Approval for Welding Consumables may be extended by the Register on the basis of the tests generally equivalent to the re-approval tests. Where the Certificate ceases to be valid ahead of time on the manufacturer’s initiative, its extension requires testing to the extent agreed with the Register in each particular case.

In case the manufacturer has and maintains the quality system recognized by the Register, the Surveyor to the Register may not be present during the tests, provided they are conducted by the manufacturer in compliance with the quality control system in force at the manufacturer's and the test results are checked.

Note: The welding consumables manufacturer's quality system approval (certification) documents issued by the classification societies – IACS members, as well as by other competent bodies authorized in accordance with the national legislation or international agreements may be

recognized by the Register after their review in each particular case.

4.1.6 Manufacturer's responsibilities.

4.1.6.1 With the Register approval, the manufacturer assumes responsibility for ensuring that during fabrication the composition and properties of the products will conform to those of the tested welding consumables.

The manufacturer shall state in their catalogues and on packaging (label, tag) the information on the Register approval by indicating "Approved by the Register, ..." and specifying the grade of the welding consumable according to the Certificate of Approval for Welding Consumables. Besides, the information on storage conditions and use of welding consumables shall be indicated in the catalogue and on packaging.

The manufacturer shall keep up-to-date records of the manufacture of the approved consumables, including details of the history of the single productions and results of associated tests. The Register shall have free access to these records at all times.

The manufacturer is responsible for reporting to the Register any major modifications introduced in the production procedure for their further agreement with the Register.

The manufacturer takes on responsibility for full compliance with the all the requirements stated by the Register in connection with granting and renewing the Certificate of Approval for Welding Consumables.

4.1.7 Rights of the Register.

4.1.7.1 During validity of the Certificate of Approval for Welding Consumables the Register may require from the manufacturer to con6rm the stable quality of raw material and finished product composition and properties, as well as adherence to the production process.

Where the production process, quality control and acceptance procedures change as well as where suppliers of raw materials and appropriate specifications, which may impair the quality of the welding consumables produced by the manufacturer, are substituted, the Register may require additional tests to be conducted by the manufacturer.

4.1.7.1 Where proofs exist of a welding consumable unsatisfactory quality, which have been obtained during its acceptance for fabrication of the structures subject to survey by the Register, the Certificate of Approval for Welding Consumables loses its validity and shall be withdrawn.

The Register approval may be resumed only provided the manufacturer submits adequate proofs showing that factors causing the production poor quality have been eliminated and new re-approval tests have been carried out.

4.1.8 Special cases of approval of welding consumables.

4.1.8.1 Referred to special cases of approval of welding consumable are:

upgrading/uprating of welding consumables at manufacturer's request;

approval of welding consumables for compliance with international or national standards;

approval of welding consumables for compliance with the properties guaranteed by the manufacturer, which exceed or supplement the requirements of the Register Rules or appropriate standards;

approval of welding consumables fabricated under license or manufacturer's subsidiary companies;

approval of welding consumables based on the tests carried out in the course of approval by the Register of the welding procedures of the company using the welding consumables;

approval of welding consumables based on the results of the tests carried out by other classification societies or technical supervision authorities;

single permits for use of welding consumables having an approval of other classification societies or technical supervision authorities;

survey of the individual batches of welding consumables.

4.1.8.2 Tests on upgrading of welding consumables are carried out at the manufacturer's request and are generally combined with annual re-approval tests of the welding consumables.

The scope of the tests for upgrading of welding consumables shall comply with the requirements 4.2 to 4.7 for the relevant types of welding consumables.

4.1.8.3 Welding consumables are generally approved by the Register for compliance with international or national standards in the following cases:

at the manufacturer's request;

in cases where requirements for welding consumables are not specially stated in the Register Rules.

In such cases, the scope and procedure of re-approval tests of the welding consumables shall meet the requirements of the appropriate standards.

4.1.8.4 Where welding consumables are approved by the Register for compliance with properties guaranteed by the manufacturer, which supplement or exceed the requirements of the Register Rules and/or appropriate standards, an adequate entry shall be made in the Certificate of Approval for Welding Consumables.

The properties shall be confirmed by the test results.

4.1.8.5 When consumables of the same brand are manufactured in different workshops belonging to the same manufacturer, the complete series of tests is generally performed in one workshop only. In the other workshops (subsidiaries), upon agreement with the Register, a reduced test program equivalent to annual re-approval tests is permitted.

The manufacturer shall submit the data to the Register, which confirm that materials used in terms of their composition, fabrication process and welding characteristics are identical to those used in the main works.

However, shall there be any doubt, complete test series may be required by the Register.

The above requirements are also applicable to all manufacturers producing welding consumables under license.

If a unique powder flux is combined with different wires coming from several factories belonging to the same firm for a combination "wire -

flux", the flux may be approved by the Register on the basis of testing the wire delivered by one of the suppliers, if all the suppliers produce and deliver the wires according to the same specification.

4.1.8.6 For approval of welding consumables on the basis of the tests of the welding procedures (refer to Section 6) the user of the welding consumables shall be authorized by the manufacturer to perform such works (combination of tests).

In this case the welding procedure approval test programme shall be extended and shall include the tests for determination of the deposited metal properties.

4.1.8.7 Where welding consumables have approvals from other classification societies, the scope of the tests to obtain the Register approval may be reduced to that required for re-approval tests of the welding consumables.

In such case, a copy of the detailed report on the tests performed shall be appended to the request for the Register approval.

The scope and results of the tests shall comply with the requirements of the present Part.

4.1.8.8 In special cases, if the requirements of 4.1.8.7 are met, the Register may issue a single permit for use of welding consumables, which have been approved by other classification societies but do not have the Certificate of Approval for Welding Consumables issued by the Register.

Such permit is limited:

by the scope of the consumables used;

by use;

by time of use.

The Register reserves the right to require check tests of the welding consumables at the user's within the scope of the tests for determination of the deposited metal properties, the results of which are presented in the form of the test report certified by the Register.

4.1.8.9 The single batches of welding consumables may be surveyed by the Register on the manufacturer or customer’s request as applied to the manufacturers holding the Certificate of Approval for Welding Consumables.

The survey may be carried out to confirm the conformity of a specific batch of products to the requirements related to:

the Register Rules for the relevant grade of welding consumables;

standards for manufacture and acceptance of the given type of products;

additional requirements of the customer specified in the order for the products to be delivered.

4.2 GENERAL REQUIREMENTS FOR WELDING OF TEST ASSEMBLIES AND TESTS

4.2.1 Preparation and welding of test assemblies.

4.2.1.1 Base metal.

The base metal used for the test assemblies shall be of the steel grade appropriate to the welding consumables grade as specified in the present Section.

For the preparation of all weld metal test assemblies any grade of structural steel may be used.

When the chemical composition of welded metal is substantially different from the base metal, an overlay of side walls and backing strip may be carried out, as deemed necessary.

For the preparation of butt and tee assemblies, steel grades shall be chosen depending on the grade of welding consumables in compliance with the requirements of the present Section. If the welding consumable is intended for welding the steel of different grades, the butt assemblies shall be made of the highest grade steel.

The edge preparation shall be performed either by mechanical machining or by gas cutting with subsequent dressing with abrasive tools.

4.2.1.2 Welding conditions and type of current.

Welding conditions used for manufacture of test assemblies (amperage, voltage, travel speed, type of current and electrodes) shall be within the range recommended by the manufacturer for normal good welding practice.

Where it is stated that welding consumables are suitable for both alternating and direct current, alternating current shall be used for welding the test assemblies for mechanical tests.

When samples for checking the operating characteristics of welding consumables required, both types of current shall be generally used.

When samples for hot cracking tests are required, direct current shall be used.

Type of current is identified with the following symbols and their combinations:

AC – alternating current;

DC+ – direct current for positive electrode;

DC- – direct current for negative electrode;

DC± – direct current for positive and negative electrodes.

Post-weld heat treatment of the test assemblies is not allowed, where the consumables are approved for the as-welded condition only.

4.2.2 Mechanical tests.

4.2.2.1 Tensile tests:

.1 longitudinal cylindrical test specimens for tensile test.

For deposited metal test, the longitudinal cylindrical proportional test specimens shall be used according to Fig. 2.2.2.3, ***a,*** Part XIII "Materials" with dimensions: $d = 10$ mm, $L_0 = 50$ mm, $L_c = 60$ mm, $R \geq 5$ mm.

The longitudinal axis of the test specimen shall coincide with the centre of the weld and:

the mid-thickness of the weld in the deposited metal test assemblies made following the multi-run procedure;

the mid-thickness of the 2nd run metal in the two-run butt welded assemblies.

Upon agreement with the Register, in certain cases the use of the fivefold longitudinal cylindrical test specimens of other diameters (more or less than 10 mm) is allowed according to 2.2.2.3, Part XIII "Materials".

The specimens may be heated to a temperature not exceeding 250 °C for 16 h for hydrogen removal prior to tinting.

The yield stress, tensile strength and elongation shall be determined for each specimen, entered in a test report and shall meet the requirements established for specific grade of the welding consumable.

The value of reduction in area shall also be determined and reported for information;

.2 transverse flat tensile test specimens.

For testing a butt welded joint, the transverse flat tensile test specimens with dimensions according to Fig. 4.2.2.1 and cut out perpendicularly to the longitudinal axis of the weld shall be used. The upper and lower surfaces of the weld shall be filed, ground or machined flush with the surface of the plate.

Tensile strength and fracture area be determined for each specimen, entered in a test report and shall meet the requirements established for specific grade of the welding consumable.

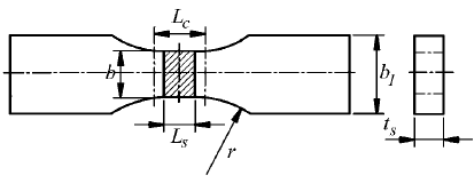


Fig. 4.2.2.1 A transverse tensile test specimen:
l_s – greatest weld width (weld top)

4.2.2.2 Bend tests:

.1 transverse test specimens for weld root and face bend test.

For testing a butt welded joint, the transverse bend test specimens shall be made according to Fig. 2.2.5.1, Part XIII "Materials" and cut out perpendicularly to the longitudinal axis of the weld. The upper and lower surfaces of the weld shall be filed, ground or machined flush with the surface of the plate.

The specimen comers in tension may be rounded to a radius not exceeding 2 mm.

If the test procedure allows for the bending of test specimen round the mandrel, then the test specimen length may exceed $11a_0$.

While tensile testing the transverse specimens, their weld face and root, the specimen dimensions shall be as follows:

$a_0 = t$, where t – metal plate thickness of the butt weld assembly;

$b_0 = 30$ mm.

If the plate thickness (a_0) exceeds 25 mm, it may be reduced to this size by machining on the compression side of the test specimen.

The bend test specimens are tested in pairs: one specimen at a time for tensioning the weld root and face for the multi-run procedure or for tensioning on the side of the 1st and 2nd runs for the two-run procedure;

.2 transverse side bend test specimens.

The transverse side bend test specimens with dimensions:

$a_0 = 10$ mm,

$b_0 = t$, where t – metal plate thickness of the butt weld assembly,

shall be usually used in addition to or in lieu of weld root and face tensioning for approval of "wire-gas" combinations, and also for approval of electrogas and electroslag welding.

In the latter case at the plate thickness $t \geq 40$ mm it is allowed to divide the specimen in two parts of the width $b_0 \geq 20$ mm.

.3 longitudinal bend test specimens.

The longitudinal bend test specimens shall be usually used in lieu of transverse specimens for approval of the welding consumables of grades A-9sp and A-10sp intended for welding heterogeneous joints according to 4.8.4.1;

.4 requirements for test procedure.

Bend test results are considered satisfactory, when after bending through an angle of 120°, no cracks appear on the specimen surface being in tension. However, superficial cracks found on the specimen surface or open weld defects not exceeding 3 mm long shall be disregarded.

The mandrel diameter is determined by the welding consumables grade and, for the materials intended for welding normal and higher strength hull structural steels is equal to three times the test specimen thickness.

4.2.2.3 Impact test.

The impact energy of the deposited metal and butt weld metal shall be determined on V-notch specimens meeting the requirements of 2.2.3, Part XIII "Materials".

The sketch for cutting out the specimens from the test assemblies of the deposited metal and butt welded joint for impact testing shall allow positioning their longitudinal axis perpendicularly to the longitudinal axis of the weld and the fulfilment of the following requirements:

for deposited metal and butt welded test assemblies with multi-run technique, the specimens shall be taken at mid-thickness of the weld;

for butt welded test assemblies with two-run technique, the specimens shall be taken at a distance not exceeding 2 mm below the surface on the 2nd run side;

for electrogas and electroslag welded test assemblies, the specimens shall be taken from a butt welded test assembly at a distance not exceeding 2 mm below the surface.

The notch shall be cut in the face of the specimen perpendicular to the surface of the plate and to be positioned in the centre of the weld, and for electrogas and electroslag welding, an additional set of specimens with the notch at 2 mm from the fusion line in the weld metal shall be taken.

A set of three specimens shall be tested. The test temperature and the average impact energy shall meet the requirements specified for specific grade of welding consumables.

The average impact energy for one of the specimens tested may be lower than required provided it is not lower than 70 per cent of this value.

4.2.3 Tests for checking diffusible hydrogen content in deposited metal.

4.2.3.1 The tests for checking diffusible hydrogen content in the deposited metal shall be carried out relative to the covered electrodes and flux-cored wire of the following grades:

2, 3 and 4, if applicable (welding consumables may be classified according to 4.2.3.4) in accordance with the application of the manufacturer;

2Y, 2Y40, 3Y, 3Y40, 4Y, 4Y40, as well as 5Y and 5Y40;

3Y (42/69), 4Y (42/69) and 5Y (42/69).

The requirements to conducting the tests and classification of the welding consumables depending on the hydrogen content, according to 4.2.3.4, are also applicable for approval of the "wire-flux" combinations intended for welding:

high strength steels (refer to 4.7.4);

higher strength steels relative to manufacture of MODU and FOP structures (refer to 2.5.4.3, Part XIII "Materials" of the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units (MODU) and Fixed Offshore Platforms (FOP).

Relative to the combination of "solid wire – gas" it is not necessary to conduct the tests and classification of welding consumables with respect to the diffusible hydrogen content according to 4.2.3.4.

4.2.3.2 The tests for checking diffusible hydrogen content in the deposited metal may be conducted with application of the following methods:

vacuum-mercury method complying with the requirements of ISO 3690;

vacuum method complying with the requirements of GOST 23338 (method 2);

chromatographical method complying with the requirements of GOST 23338 (method I) or the Register-agreed procedure, provided that testing results comply with ISO 3690;

glycerine method complying with the requirements of the Register-recognized national standards or according to the Register-agreed procedure satisfying the requirements to conducting the tests mentioned in 4.2.3.3.

4.2.3.3 The diffusible hydrogen content shall be determined by the glycerine method in compliance with the following requirements to the tests procedure.

Subject to testing are four specimens with the dimensions:

thickness – 12 mm, width – 25 mm;

length – about 125 mm.

Hull structural steel of normal or higher strength of any grade may be used as the base metal.

Prior to welding, after grinding and degreasing, the specimens shall be weighed to an accuracy of up to 0.1 g.

On the 25 mm width surface of each specimen, a single bead of welding of about 100 mm long shall be deposited by a 4.0 mm electrode burning a length of about 150 mm of the electrode. The welding shall be carried out with an arc as short as possible and with welding current of about 150 A.

Before welding, if recommended by the manufacturer, the electrodes shall be subjected to calcination or drying.

Within 30 s after completion of the weld, the slag shall be removed from each specimen and the specimen shall be quenched in water at approximately 20 °C.

After 30 s in water the specimen shall be cleaned, dried and deposited in an apparatus for the collection of diffusible hydrogen by the displacement of glycerine.

When testing the flux-cored wire, welding conditions shall comply with

the recommendations of the welding consumables manufacturer and be selected in such a way as to provide a mass of the deposited metal equal to that at welding by the covered electrodes.

During testing, the glycerine shall be maintained at 45 °C.

All the four specimens shall be welded and placed into the separate apparatuses for the collection of diffusible hydrogen for period, which shall exclude any alteration of the hydrogen content affected by humidity alteration of the electrode coating after calcination or execution of welding conditions. As a rule, this time period shall not exceed 30 min.

The specimens shall be kept soaking in glycerine at 45 °C for 48 h, and after being removed from the apparatus, the specimens shall be cleaned by means of water, dried by alcohol and weighed to the nearest 0.1g in order to determine the mass of deposited metal. The amount of gas developed shall be measured to nearest 0.05 cm^3 and corrected for temperature 0 °C and pressure of 760 mm Hg.

4.2.3.4 The individual and averaged diffusible hydrogen content of four specimens shall be recorded and reported.

The averaged value of the diffusible hydrogen content in the deposited metal shall not exceed the values specified for the symbol of electrode concerned given in Table 4.2.3.4.

Table 4.2.3.4

Hydrogen content symbol	Diffusible hydrogen content in deposited metal (≤ cm^3 per 100 g of deposited metal) for test method:	
	Mercury method (ISO 3690)	Glycerine method
H15	15	10
H10	10	5
H5	5	Not applied[1]

[1]To grade the welding consumables for symbol H5, only the mercury or similar methods may be used (vacuum or chromatographical methods, refer also to 4.7.4.1).

4.2.4 Hot cracking tests of welded joint.

4.2.4.1 Hot cracking tests of weld metal and welded joint shall be carried out by welding a tee-joint test assembly as shown in Fig. 4.2.4.1.

The number of test assemblies to be tested:

three assemblies for manual welding with covered electrodes;

one assembly for semiautomatic gas-shielded welding with a solid and flux-cored wire: (for use with or without a shielding gas);

one assembly for manual and mechanized tungsten inert gas welding.

Where possible, the test assemblies shall be welded using the filler materials of different diameters:

electrodes of 4 mm in diameter and of the maximum diameter to be approved;

welding wire of 1.2 mm in diameter for the "solid wire – gas" combinations

and of the maximum diameter to be approved (generally 1.6 mm);

flux-cored wire for gas-shielded welding and flux-cored wire for use without shielding gas of 1.2 mm (or 1.4 diameter and of the maximum diameter to be approved (1.6 to 2.4 mm).

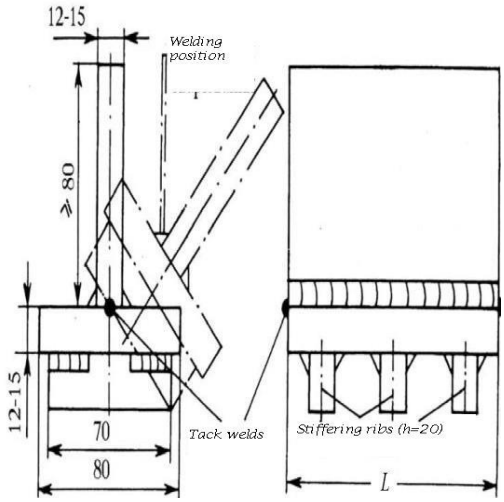


Fig. 4.2.4.1 A tee-joint test assembly for cracking tests of welded joints (dimensions are given in mm):
L = 120 mm for manual welding with covered electrodes; L = 250 mm for semiautomatic welding with a consumable electrode; L = 200 mm for manual inert gas welding with a consumable electrode

4.2.4.2 The lower plate shall be stiffened by welding three transverse ribs to protect it against deformation. The gaps in a joint shall be eliminated before welding the test assembly.

To match the test assembly, tack welds shall be made on the butt ends of the plates. The lower plate shall be stiffened by welding three transverse ribs of about 20 mm in height (h=20) to protect it against deformation.

4.2.4.3 The tee-joint test assembly shall be welded in the downhand (gravity) position PA. The fillets shall be single-run welds joined at the maximum current recommended for the particular type and size of electrodes by the manufacturer.

The second fillet shall be welded immediately after the first one and shall end at that side of the test assembly where the first one was started. Both fillets shall be executed at a constant speed without weaving.

4.2.4.4 When welding a test assembly with covered electrodes (welding process 111), the length of each fillet (about 120 mm) shall correspond to that of the consumed part of the electrode according to Table 4.2.4.4-1.

When welding a tee-joint test assembly using the semiautomatic gas-shielded welding ("wire – gas" combination), the diameters of welding wire and the throat thickness shall be according to Table 4.2.4.4-2.

For welding with flux-cored wire, the relevant parameters for welding the test assembly shall be according to Table 4.2.4.4-3.

For inert gas welding of the test assembly with a tungsten electrode, the fillet dimensions shall approximately correspond to those when welding with covered electrodes of 4 to 5 mm in diameter.

Table 4.2.4.4-1

Diameter of electrode, mm	Consumed length of electrode, mm	
	1st weld	2nd (back) weld
4	200	150
5	150	100
6	100	75

Table 4.2.4.4-2

Diameter of welding wire, mm	1st weld		2nd (back) weld	
	Effective throat thickness of fillet *a*, mm	Weld length *L*, mm	Effective throat thickness of fillet *a*, mm	Weld length *L*, mm
1.2	9	250	7	250
1.6	9	250	7	250

Table 4.2.4.4-3

Diameter of welding wire, mm	1st weld		2nd (back) weld	
	Effective throat thickness of fillet *a*, mm	Weld length *L*, mm	Effective throat thickness of fillet *a*, mm	Weld length *L*, mm
1.2 or 1.4	9	250	7	250
2.4[1]	10	250	9	250

[1] Or the maximum diameter to be approved.

4.2.4.5 After welding the test assembly and its complete cooling to the room temperature, slag and spatter shall be removed from the surface of the weld and affected zone, and the fillets shall be visually examined for surface cracks.

In case the cracks are revealed, the test results are considered unsatisfactory and the further examination of the test assembly is not conducted.

Upon satisfactory results of the examination for surface cracks, the test assembly examination shall be continued by fracture testing as per 4.2.4.6 or, upon agreement with the Register, by magnetic particle testing.

4.2.4.6 The fracture test of the tee-joint test assembly shall be conducted in compliance with the following requirements.

The first fillet shall be removed in a mechanical manner, and the second (back) one shall be tested for fracture with the failure to be positioned approximately in the middle of the fillet cross-section.

Note. During fracture testing, the test assembly of 250 mm in length shall be preliminary divided into three equal parts, and the test assembly of 200 mm in length, into two sections. The test assemblies of 120 mm in length shall be tested for fracture as a whole.

4.2.4.7 The fracture surface of the back weld shall be visually examined for intolerable defects. The examination shall be conducted with the naked eye and by means of 5× or 10× magnifying glass.

The welded joints, which have no cracks or intolerable defects on the fracture surface of back welds revealed in magnetic particle testing, are considered resistant to hot cracking.

4.2.5 Requirements for re-test procedures.

4.2.5.1 Tensile and bend tests.

Where the results of a tensile or bend test do not comply with the specified requirements, duplicate test specimens shall be prepared and tested. In case of the sufficient metal reserve, the specimens for re-test shall be taken from the test assembly used in the initial testing. Where insufficient original welded assembly is available, a new test assembly shall be prepared using welding consumables of the same batch.

If the new assembly is made with the same welding procedure (in particular, the same number of layers and runs), only the duplicate re-test specimens need to be tested. Otherwise all test specimens shall be prepared for re-testing, including the duplicate test specimens failed in the initial testing.

In case the results of tests carried out on the duplicate test specimens are satisfactory, the welding consumable submitted to tests may be accepted.

If at least one specimen (from the additional ones) yields unsatisfactory results, the welding consumable submitted to tests shall be rejected.

4.2.5.2 Impact test.

The cases of unsatisfactory test results include:

when the average value of three impact tests fails to meet the specified requirements;

or more than one result out of three is below the required average value,

or the result on any one of the specimens is more than by 30 per cent below the required average value.

In any of the above cases, re-tests may be conducted on the additional three specimens machined from the same test assembly if the sufficient metal reserve is available.

At that the test results are considered satisfactory if the new average value of impact energy (three initial tests plus additional tests) exceeds the required average value and not more than two results out of six are below the required average value, and not more than one specimen has yielded the result, which is by 30 per cent below the required one.

When the test results for three initial and three additional specimens are unsatisfactory, the further tests shall be agreed with the Register. In this case a new test assembly shall be welded using the welding consumables of the same batch, and the test shall be conducted to the extent that shall include all the types of the tests provided for testing the first test assembly, as well as those with satisfactory results.

4.2.5.3 Hot cracking tests.

Where cracks are detected in the welded joint test assemblies being tested, the test results are considered unsatisfactory, and the welding consumables cannot be approved.

Where isolated end crater cracks caused by the welder's poor skills are revealed, re-tests shall be performed with the same number of test assemblies after the relevant additional training of a welder in operating the welding consumables being tested.

4.3 COVERED ELECTRODES FOR MANUAL ARC WELDING OF NORMAL AND HIGHER STRENGTH HULL STRUCTURAL STEELS

4.3.1 General.

4.3.1.1 The following requirements apply to covered electrodes intended for the manual arc welding of normal and higher strength hull structural steels, steel forgings and castings of the corresponding strength grades, and of comparable steels intended for manufacturing ship's structures and pressure vessels.

The number of test assemblies and specimens required is given in Table 4.3.1.1.

4.3.1.2 Covered electrodes are divided, for the various strength levels of the deposited metal (R_{eH}, min), into the following grades:

1, 2, 3 and 4 for normal strength steels;

2Y, 3Y, 4Y and 5Y for higher strength steels with the specified yield stress of up to 355 MPa, inclusive;

2Y40, 3Y40, 4Y40 and 5Y40 for higher strength steels with the specified minimum yield stress of up to 390 MPa inclusive.

Depending on the diffusible hydrogen content in the deposited metal, symbols H15, H10 or H5 are added to the grade mark as per 4.2.3.4.

4.3.1.3 A manufacturer shall submit for review the following information and technical documentation attached to the request for approval: trade name of electrodes;

range of standard sizes (diameter, length) of the welding consumables to be approved; type of electrode covering;

grade, for which the application is made, including additional symbols;

chemical composition (analytical tolerances) of the deposited metal;

weld metal recovery according to the relevant international and national standards;

welding technique and type of current;

proposed range of application and welding positions;

marking and packing;

information on manufacturing capacity, facilities and quality control procedure;

instructions/recommendations for use;

previous approvals granted to the proposed "wire- flux" combination by other classification societies or supervisory bodies with copies of the required document attached.

The technical documentation to be approved by the Register:

manufacturer's technical specifications or specifications for welding consumables, including the current catalogue editions;

instructions on the products manufacture, acceptance and quality control.

Table 4.3.1.1

Test assembly						Number and type of specimens[2]
Type	Welding position[1]	Diameter of electrode, mm	Number	Thickness, mm	Dimensions	

1	2	3	4	5	6	7
Deposited metal	PA	Ø 4 mm	1	20	Refer to Fig. 4.3.2.1	1TL+3KV
		max Ø	1			
Butt joint	PA	First run: Ø 4 mm Intermediate runs: Ø 5 mm Last two layers: Ø 4 mm	1	15 ÷ 20	Refer to Fig. 4.3.3.1	1TT+1RB+ 1FB+3KV
	PF	First run: Ø 3.0 mm or Ø 3.5 mm Remaining runs: Ø 4 mm	1			1TT+1RB+ 1FB+3KV
	PC	First run: Ø 4 mm Remaining runs: Ø 4 mm	1			1TT+1RB+ 1FB+3KV
	PE	First run: Ø 3.0 mm or Ø 3.5 mm Remaining runs: Ø 4 mm	1			1TT+1RB+ 1FB+3KV
Fillet joint	PB	First side: min Ø	1	15 ÷ 20	Refer to Fig. 4.3.6.2	M+FF+HV
		Second side: max Ø				

[1] Welding positions are designated according to ISO 6947.

[2] The following abbreviations are used for the type of specimens:

TL — longitudinal cylindrical tensile test specimen;

TT — transverse flat tensile test specimen;

RB — transverse root bend test specimen;

FB — transverse face bend test specimen;

FF — fillet fracture test specimen;

M — transverse macrosection;

HV — hardness measurement specimen.

4.3.2 Tests of deposited metal.

4.3.2.1 Preparation of test assemblies.

Two deposited metal test assemblies shall be welded in the flat position as shown in Fig. 4.3.2.1. one with 4 mm diameter electrodes and the other with the largest size manufactured. If the electrodes are available in one diameter only, one test assembly is sufficient.

Any grade of hull structural steel may be used for the preparation of the test assembly.

The weld metal shall be deposited in a single or multi-run layers according to normal practice to use electrodes (bead width), and the direction of deposition of each layer shall generally alternate from each end of the plate, each run of weld metal being not less than 2 mm and not more than 4 mm thick.

Between each run the assembly shall be left in still air until it has cooled to less than 250 °C, but not below 100 °C, the temperature being taken in the centre of the weld on the surface of the bead. After being welded, the test assemblies shall not be subjected to any heat treatment.

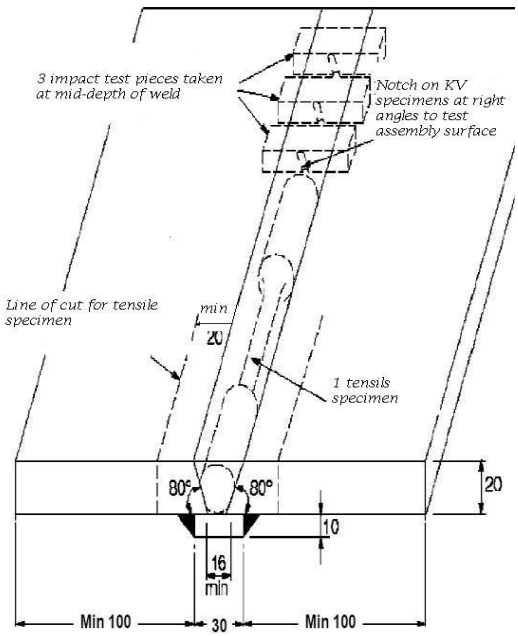


Fig. 4.3.2.1 Deposited metal test assembly for testing of electrodes for manual
arc welding.
The designation of specimens required for testing shall be according to Table 4.3.1.1 and dimensioned in mm.

Fig. 4.3.2.4

4.3.2.2 Chemical analysis of deposited metal.

Test specimens shall be taken from each test assembly for chemical analysis of the deposited metal including the content of all alloying elements and impurities regulated by documentation for the product manufacture and acceptance control.

4.3.2.3 Test procedure.

From each test assembly according to Fig. 4.3.2.1, one longitudinal tensile test specimen and three impact test specimens shall be taken.

The specimen cutting-out, preparation and tests shall be performed in accordance with 4.2.2.1.1
and 4.2.2.3, respectively.

4.3.2.4 Requirements for test results.

The results of all tests shall comply with the requirements of Table 4.3.2.4 for the relevant welding consumable grades.

Grade	Yield stress R_{eH}, MPa	Tensile strength R_m, MPa	Elongation, A_5 (L_0=5d), min	Butt weld tests.	
				Test temperature, °C	Impact energy value KV, J, min
1	305	400 ÷ 560	22	20	47
2				0	47
3				- 20	47
4				- 40	47
2Y	375	490 ÷ 660	22	0	47
3Y				-20	47
4Y				-40	47
5Y				-60	47
2Y40	400	510 ÷ 690	22	0	47
3Y40				-20	47
4Y40				-40	47

5Y40				-60	47

4.3.3 Tests of butt welded joint

4.3.3.1 Preparation and manufacture of test assemblies.

To check the properties of a butt welded joint in each welding position (downhand, vertical-upward, vertical-downward, overhead and horizontal-vertical) for which the electrodes are approved, one test assembly shall be welded in each position.

In this case the electrodes for welding in downhand and vertical-upward positions may be considered to meet the relevant requirements for welding in horizontal-vertical position.

If the electrodes are approved for welding in downhand position only, two test assemblies shall be prepared in that position.

Depending on the grade of electrodes for preparing the welded joint test assemblies, the hull structural steel of one among the categories shall be used as listed in Table 4.3.3.1.

Table 4.3.3.1

Electrode grade	Test assembly steel grade[1]
1	A
2	A, B, D
3, 4	A, B, D, E
2Y	A32, A36, D32, D36
3Y	A32, A36, D32, D36, E32, E36
4Y, 5Y	A32, A36, D32, D36, E32, E36, F32, F36
2Y40	A40, D40
3Y40	A40, D40, E40
4Y40, 5Y40	A40, D40, E40, F40

[1] The actual tensile strength R_m of grades A32 to F32 shall be greater than 490 MPa.

Butt-welding joint test assemblies for electrode testing shall meet Fig. 4.3.3.1.

The copy of a certificate for the base metal for preparing the welded joint test assemblies shall supplement the test report.

4.3.3.2 Requirements for welding test assemblies.

The test assemblies for individual welding positions shall be welded as indicated below:

.1 downhand position — PA. One test specimen welded using 4 mm electrodes for the first run, 5 or 6 mm electrodes for intermediate runs (excluding the last two) in compliance with the normal practice of using electrodes.

Electrodes of the maximum diameter to be approved for the last two runs.

.2 Downhand position — PA (when the second down- hand test is required). One test specimen welded using 4 mm electrodes for the first run, 5 mm electrodes for the second run, and electrodes of the maximum diameter to be approved for the remaining runs;

.3 horizontal-vertical position — PC. One test specimen welded using 4 mm or 5 mm electrodes for the first run, 5 mm electrodes for the remaining runs;

.4 vertical-upward and overhead positions - PF and PE, respectively. One test specimen welded using 3.0 (3.25) mm electrodes for the first run, 4 mm or possibly 5 mm electrodes, if recommended by the manufacturer for welding in the positions concerned for the remaining runs;

.5 Vertical-downward position — PG. When the electrodes shall be used for vertical-downward welding, this procedure shall be used for preparation and welding of the test assembly using the electrodes of the diameter recommended by the manufacturer.

For all assemblies, the back sealing run shall be made with 4 mm diameter electrodes, in the welding position appropriate to each test specimen, after back gouging to sound metal.

For electrodes suitable for downhand welding only, the test assemblies may be turned over to carry out the backing seal.

The test assembly shall be welded in compliance with the normal practice of using electrodes. Between each run the assembly shall be left in still air until it has cooled to less than 250 °C, but not below 100 °C, the temperature being taken in the centre of the weld on the surface of the bead. After being welded, the test assemblies shall not be subjected to any heat treatment.

4.3.3.3 Radiographic testing.

Prior to the preparation of specimens for mechanical testing, the radiographic testing of butt weld test assemblies is recommended for detecting any internal defects.

4.3.3.4 Test procedure.

According to Fig. 4.3.3.1, from each butt weld test assembly shall be taken:

one transverse flat tensile test specimen;

three transverse V-notched impact test specimens;

one transverse root and one transverse face static bend test specimens.

4.3.3.5 Requirements for test results.

The test results shall comply with the requirements of Table 4.3.3.5 for the relevant welding consumable grades.

The requirements for test procedure and their results evaluation shall meet the requirements in 4.2.

Table 4.3.3.5

Grade	Tensile strength (transverse samples) R_m, MPa, min	Butt weld tests.		
		Temperature of testing, °C	Impact energy *KV*, J, min.	
			Downhand, horizontal-vertical, and overhead position welding	Vertical position (upward and downward)
1	400	20	47	34
2		0	47	34
3		- 20	47	34
4		- 40	47	34
2Y	490	0	47	34
3Y		-20	47	34

4Y		-40	47	34
5Y		-60	47	34
2Y40	510	0	47	39
3Y40		-20	47	39
4Y40		-40	47	39
5Y40		-60	47	39

4.3.4 Tests for checking diffusible hydrogen content in deposited metal.

4.3.4.1 Tests for checking diffusible hydrogen content in deposited metal shall be carried out in accordance with the separate requirement of the Register according to 4.2.4.

4.3.5 Tests for checking diffusible hydrogen content in deposited metal.

4.3.5.1 The tests for checking diffusible hydrogen content in the deposited metal shall be carried out in compliance with the provisions in 4.2.3 relative to the covered electrodes intended for welding the higher strength steels of categories: 2Y, 2Y40, 3Y, 3Y40, 4Y, 4Y40, as well 5Y and 5Y40.

Grade 2, 3 and 4 electrodes intended for welding normal strength steels may be classified for diffusible hydrogen content in the deposited metal as an option in accordance with the manufacturer's request.

The tests for checking diffusible hydrogen content in the deposited metal are generally conducted at the initial approval of welding consumables, and also if required by the Register during annual tests or on the manufacturer's request during upgrading tests.

4.3.6 Tests of electrodes for manual arc fillet welding.

4.3.6.1 Where the electrodes, according to the manufacturer's request, are submitted for approval for fillet welding only, and the scope of their testing to the full extent as per 4.3.3.1 cannot be applied, they shall be subjected to the following tests for the initial approval:

tee-joint testing according to 4.3.6.2 in all the welding positions, for which the electrodes shall be used;

checking of the deposited metal properties according to 4.3.2;

checking of the diffusible hydrogen content in the deposited metal according to 4.3.5 and 4.2.3.

When the electrodes are submitted for approval for both fillet and butt welding, the extent of additional tests (in addition to the general requirements for the test extent) for the initial approval may, at the discretion of the Register, be limited to welding one tee-joint test assembly in the horizontal-vertical position (PB).

4.3.6.2. Tee-joint test assemblies shall be welded as per Fig. 4.3.6.2.

Tee-joint assembly for testing electrodes for fillet welding position, for which the electrodes are intended (horizontal- vertical, vertical-upward, vertical-downward and overhead).

The test assemblies shall be welded with electrodes of the diameter recommended by the manufacturer for the welding position specified.

The test assembly length shall be sufficient to allow at least the deposition of the entire length of the electrode being tested. The first weld

on the test assembly shall be made with the electrode of the maximum diameter manufactured, and the second one, with the electrode of the minimum diameter manufactured.

The fillet size is usually determined by the electrode diameter and welding current being recommended by the manufacturer for specific diameter and welding position.

The material for test assembly preparation shall comply with 4.3.3.1.

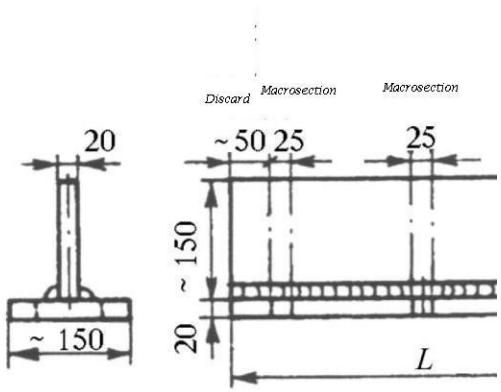


Fig. 4.3.6.2 Tee-joint testing for tests of electrodes for
fillet joint welding

4.3.6.3 Testing of tee-joint assembly:

.1 three macrosections of about 25 mm thick shall he selected and prepared from three sections along each tee-joint test assembly as shown in Fig. 4.3.6.2.

The macrosections shall be examined for root penetration, satisfactory weld profile and freedom from cracks, as well as from porosity and slags;

.2 the hardness of the weld metal, HAZ and base metal shall be measured on the macro sections as shown 4.3.6.3.

The readings of the weld metal hardness on HV10 scale shall be the following:

≥ 120 HV for electrodes for welding the normal strength steel;

≥ 150 HV for electrodes for welding the higher strength steel with the yield stress $R_{eH} \leq$ 355 MPa;

≥ 170 HV for electrodes for welding the higher strength steel with the yield stress 355 MPa < $R_{eH} \leq$390 MPa.

The hardness of the base metal and HAZ shall also be measured and reported;

.3 two remaining parts of the tee-joint assembly shall be subjected to fracture testing.

One part is tested, after the removal of the first weld by mechanical gouging or with a chisel, by folding the plates together and tensioning the remaining weld root (refer to 6.3.4.4).

Another part is tested after the removal of the second weld by mechanical gouging or with a chisel.

The fractured surfaces shall be examined for root penetration and freedom from cracks and significant porosity.

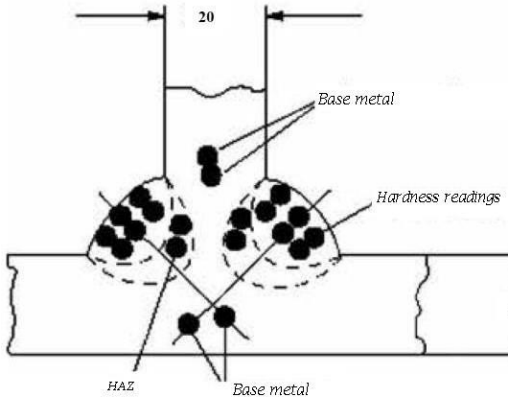


Fig. 4.3.6.3 Arrangements for macrosection hardness measurements on tee connection specimens

4.3.7 Tests of electrodes for gravity and contact welding.

4.3.7.1 The electrodes approved only for gravity and contact welding shall be subjected to the initial tests similar to those for manual electrodes:

deposited metal tests;

tee-joint tests (refer to 4.3.6);

butt weld tests, where appropriate.

In so doing, additionally to the manual welding of test assemblies, the tests using the gravity and contact welding, according to the manufacturer's recommendations shall be carried out to the following extent:

tee-joint assembly tests (refer to 4.3.6);

butt weld tests, where appropriate.

Where the electrodes for fillet welding are used for the gravity and contact welding, the tee-joint test assemblies shall be welded using the procedure recommended by the manufacturer and the longest size of electrode manufactured. In this case a report shall include the manufacturer's recommendations on the range of a welding current for each electrode size.

Where the approval is required for normal and higher strength steels, the higher strength steel shall be used for welding tee-joint and butt weld test assemblies.

4.3.8 Annual and upgrading tests.

4.3.8.1 Annual tests and re-approval surveys of the welding consumables manufacturers.

All the organizations recognized by the Register as electrode manufacturers shall be annually surveyed and their products shall be tested.

The annual tests shall, as a minimum, include the following:

.1 covered electrodes for standard manual arc welding.

The extent of annual testing of the electrodes intended for manual arc welding shall include the preparation of two deposited metal test assemblies according to 4.3.2.

The mechanical properties of the deposited metal (one longitudinal tensile test specimen and three impact test specimens from each test assembly) shall comply with the requirements of Table 4.3.2.4.

The above mentioned is also applicable to the electrodes for fillet welding only.

If required by the Register, the tests may include the welding of a butt weld test assembly in a downhand or vertical position instead of the deposited metal test assembly for 4 mm electrodes. In this case the test extent may be limited to preparing three impact test specimens.

The extent of annual testing of the electrodes with the controlled

diffusible hydrogen content and designated H10 and H5 may, on the Register's demand, include the test of welding consumables for the diffusible hydrogen content in the deposited metal according to 4.2.3;

.2 covered electrodes for gravity and contact welding.

Where the electrodes are approved only for gravity and contact welding, the extent of annual testing shall include the welding of one deposited metal test assembly using the procedure recommended by the manufacturer.

When these electrodes are also approved for standard manual arc welding, the annual tests shall be performed according to 4.3.8.1.1.

4.3.8.2 Tests on electrode upgrading:

.1 tests on electrode upgrading are conducted only on the manufacturer's request and shall be preferably combined with the annual tests. Those tests usually need the preparation of butt weld test assemblies in addition to the standard annual tests;

.2 where the upgrading deals only with the change of a temperature when testing the impact test specimens without changing a strength group, only the additional tests of the impact test specimens made of the butt weld assemblies for each welding position specified in the Certificate of Approval for Welding Consumables shall be conducted at the changed temperature. These butt weld assemblies shall be tested in addition to two deposited metal test assemblies required for the usual annual tests (during which the impact tests of specimens are also conducted at the changed temperature);

.3 where the upgrading deals with the extension of the range of approval for welding the steels of a higher strength group, in addition to the standard extent of annual tests, the butt weld test assemblies shall be tested to the lull extent according to 4.3.3. In this case the steel for welding the butt weld test assemblies shall meet the requirements in 4.3.3.1 for upgraded welding consumables;

.4 tests for upgrading the electrodes approved for fillet welding only are carried out as follows:

in case the requirements only for the impact test temperature change, the deposited metal shall be tested at the temperature corresponding to the new grade (i.e. without extending the annual test scope);

in case the strength group of electrodes is revised, the tests shall be conducted to the full extent as required for the initial approval according to 4.3.6.

4.4 "WIRE-FLUX" COMBINATIONS FOR SUBMERGED ARC WELDING

4.4.1 General.

4.4.1.1 The requirements given below apply to the "wire-flux" combinations for submerged arc welding of hull structural steels of normal and higher strength, steel forgings and castings of the relevant grades, and also comparable steels for the construction of ship's structures and pressure vessels.

The approval of welding consumables granted in accordance

with these requirements is valid for standard single wire welding.

Other welding procedures like such as tandem and multi-wire welding, one-side welding on flux or ceramic backing shall be submitted to separate approval tests. These tests shall be generally carried out in accordance with the requirements given below and detailed in a separate program to be agreed with the Register on a case-by-case basis, depending on the welding procedure proposed.

4.4.1.2 "Wire-flux" combinations depending on the strength level of the deposited or weld metal ($R_{eH,}$ min) are divided into the following grades:

1, 2, 3 and 4 for normal strength steels;

1Y, 2Y, 3Y, 4Y and 5Y for higher strength steels with the specified minimum yield stress of up to 355 MPa, inclusive;

2Y40, 3Y40, 4Y40 and 5Y40 for higher strength steels with the specified minimum yield stress of up to 390 MPa inclusive.

Depending on the welding procedure, the following symbols are added to the grade designation:

T — for welding consumables approved for a two- run technique;

M — for welding consumables approved for multirun technique;

TM — for welding consumables approved for both techniques.

4.4.1.3 A manufacturer shall generally submit for review the information and technical documentation attached to the request for approval containing the following data:

commercial name of the flux, for which the approval is requested; type of flux (fused or ceramic), typical analysis (or reference to the relevant normative document), type and size of granules (for fused fluxes);

commercial name of the associated wire, limits of chemical composition (or reference to the relevant normative document) and diameters to be approved; producer, supplier, conditions under which it is supplied (surface protection, type, size and weight of the standard coils);

welding technique and grading, under which the approval is requested; type of current and maximum current values, for which the approval is requested;

typical chemical composition of the deposited metal, with particular reference to the contents of Mn, Si and other alloying elements, which shall be specified in all cases; conditions to which the chemical composition refers;

conditions to which the chemical composition refers;

indications, where applicable, regarding the range of the welding parameters (current, voltage and welding speed);

information regarding the efficiency of "wire-flux" combination submitted for approval;

recommended edge preparation for various thicknesses; recommendations and limitations on wire stickout, if any;

packaging and labeling (marking);

information on manufacturer's workshops, manufacturing facilities, manufacturing and heat treatment cycles, methods and procedures of manufacturer's quality controls;

instructions and recommendations before using the flux (backing or hardening), as applicable;

previous approvals granted to the proposed "wire- flux" combination by other classification societies or supervisory bodies with copies of the required document attached.

The technical documentation to be approved by the Register:

manufacturer's technical specifications or specifications for welding consumables, including the current catalogue editions;

instructions on the products manufacture, acceptance and quality control.

4.4.1.4 In the general case the number of test assemblies and specimens needed for the initial approval of welding consumables is given in Table 4.4.1.4. In this case, several additional specimens (test assemblies) can be welded at the request of the Inspector of the Register in order to control the welding-technological properties and to develop welding modes.

4.4.2 Multirun welding technique (M).

4.4.2.1 General requirements.

Approval of the multipass welding technique requires testing deposited metal and butt weld specimens. Any grade of hull structural steel may be used for the preparation of the deposited metal test assembly.

For preparing the welded joint test assemblies, the hull structural steel of one among the categories shall be used as listed in Table 4.4.2.1 (ship-construction steels) depending on the "wire-flux" combination submitted for approval.

Table 4.4.1.4

Welding technique	Test assembly				Number and type of specimens[1]
	Type	Number	Thickness, mm	Dimensions	
M	Deposited metal	1	20	Refer to Fig. 4.4.2.2.1	2TL+3KV
	Butt weld joint	1	20 ÷25	Fig. 4.4.2.3.1	2TT+2RB+2FB+3KV
T	Butt weld joint	1	12 ÷15	Refer to Fig. 4.4.3.2.1 and Table 4.4.3.2.1	2TT+2TB+3KV
	Butt weld joint	1	20 ÷25		1TL+2TT+2TB+3KV
	Butt weld joint	1	30 ÷35		1TL+2TT+2TB+3KV
TM	[2]	[2]	[2]	[2]	[2]

[1] The following abbreviations are used for the type of specimens:
TL — longitudinal cylindrical tensile test specimen;
TT — transverse flat tensile test specimen;
RB — transverse root bend test specimen;
FB — transverse face bend test specimen;
TB — transverse side bend test specimen for a two-run technique;
KV — transverse Charpy V-notch impact test specimen.

[2]Test assemblies and tests of all types of specimens are required for both welding techniques; only one longitudinal tensile test (1TL) is required on the deposited metal test.

Table 4.4.2.1

"Wire-flux" combination grade	Test assembly steel grade[1]

1	A
2	A, B, D
3, 4	A, B, D, E
1Y	A32, A36
2Y	A32, A36, D32, D36
3Y	A32, A36, D32, D36, E32, E36
4Y, 5Y	A32, A36, D32, D36, E32, E36, F32, F36
2Y40	A40, D40
3Y40	A40, D40, E40
4Y40, 5Y40	A40, D40, E40, F40

[1] The actual tensile strength R_m of grades A32 to F32 shall be greater than 490 MPa.

4.4.2.2 Deposited metal test.

4.4.2.2.1 Preparation of test assemblies.

One deposited metal test assembly shall be welded in the downhand position with the use of a wire 4 mm thick, as shown in Fig. 4.4.2.2.1.

Welding conditions (amperage, voltage and travel speed) shall be within the range recommended by the manufacturer for normal good multi-run welding practice.

The weld metal is deposited in multi-run layers according to the manufacturer's recommendations and the normal practice, and the direction of deposition of each layer shall, in general, alternate from each end of the plate.

After the completion of the each run, the flux and welding slag shall be removed.

Between each run the assembly shall be left in still air until it has cooled to less than 250 °C, but not below 100 °C, the temperature being taken in the centre of the weld on the surface of the bead. The thickness of each layer shall be neither less than the diameter of the wire nor less than 4 mm.

After being welded, the test assemblies shall not be subjected to any heat treatment.

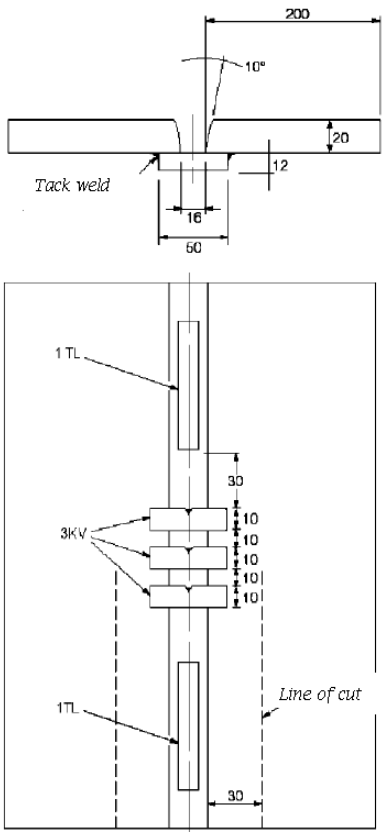


Fig. 4.4.2.2.1 Deposited metal test assemblies when testing "wire–flux" combinations (designations of test assemblies shall comply with Table 4.4.1.4, all dimensioned in mm unless specified otherwise)

4.4.2.2.2 Chemical analysis of deposited metal.

Test specimens shall be taken from each test assembly for chemical analysis of the deposited metal including the content of all alloying elements and impurities regulated by documentation for the product manufacture and acceptance control (as a rule, for ceramic fluxes).

4.4.2.2.3 Test procedure.

Two longitudinal tensile test specimens and three impact test specimens shall be taken from the test assembly as shown in Fig. 4.4.2.2.1.

The specimens shall be cut out, prepared and tested according to the instructions in 4.2.2.1.1 and 4.2.2.3, respectively.

4.4.2.2.4 Requirements for test results.

The test results shall comply with the requirements of Table 4.4.2.2.4 for the relevant welding consumable grades.

4.4.2.3 Butt weld test.

4.4.2.3.1 Preparation of test assembly.

One butt weld test assembly shall be welded in a downhand position, in general with a wire having a diameter of 4 mm as shown in Fig. 4.4.2.3.1. The assembly length shall be sufficient for cutting out the specimens numbered and dimensioned as specified.

The welding shall be performed by the multi-run technique and the welding conditions shall be the same as those adopted for the deposited metal test assembly.

The back sealing run shall be made in a downhand position after back gouging to sound metal.

After being welded, the test assemblies shall not be subjected to any heat treatment.

4.4.2.3.2 Radiographic testing.

Prior to the preparation of specimens for mechanical testing, the radiographic testing of butt weld test detecting any internal defects.

4.4.2.3.3 Testing. The test specimens as shown in Fig. 4.4.2.3.1 and in accordance with Table 4.4.1.4, shall be taken from each butt weld test assembly:

two transverse flat tensile test specimens;

three transverse V-notched impact test specimens;

Table 4.4.1.4

Grade	Yield stress R_e MPa	Tensile strength R_m MPa	Elongation A_5 ($L_0=5d$),% min	Butt weld tests.	
				Test temperature, ℃	Impact energy *KV*, J, min
1	305	400-560	22	20	34
2				0	34
3				-20	34
4				-40	34
1Y				20	34

2Y	375	490-660	22	0	34
3Y				-20	34
4Y				-40	34
5Y				-60	34
2Y40	400	510-690	22	0	39
3Y40				-20	39
4Y40				-40	39
5Y40				-60	39

two transverse root and two transverse face bend test specimens.

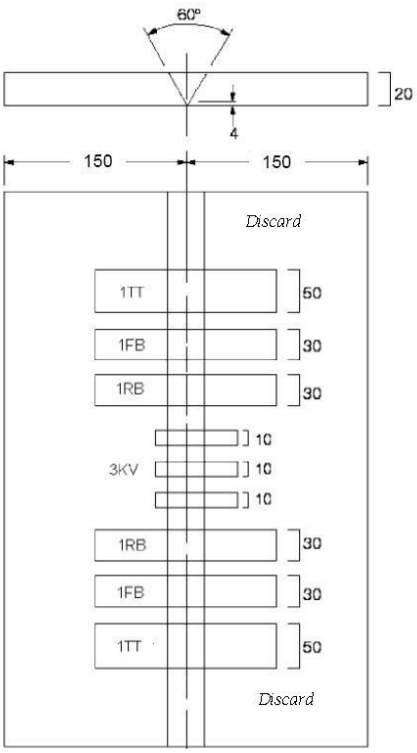


Fig. 4.4.2.3.1 Butt weld testing for the multipass welding technique when testing "wire–flux" combinations (designations of test assemblies shall comply with Table 4.4.1.4, all dimensioned in mm unless specified otherwise)

4.4.2.3.3 Requirements for test results.

The test results shall comply with the requirements of Table 4.4.2.3.4 for the relevant welding consumable grades.

Table 4.4.2.3.4

Grade	Tensile strength (transverse specimens) R_m, MPa	Butt weld tests.	
		Temperature of testing, °C	Impact energy value *KV*, J, min
1	2	3	4
1	400	20	34
2		0	34
3		- 20	34

4		- 40	34
1	2	3	4
2Y	490	20	34
3Y		0	34
4Y		-40	34
5Y		-60	34
2Y40	510	0	39
3Y40		-20	39
4Y40		-40	39
5Y40		-60	39

The requirements for test procedure and their results evaluation shall meet the requirements in 4.2.

4.4.3 Two-run technique (T).

4.4.3.1 Number of test assemblies and general requirements.

Where the "wire-flux" combination approval for use with two-run technique only is requested, two butt weld test assemblies of the base metal thickness within the ranges below depending on the "wire-flux" combination grade shall be prepared:

for grades 1 and 1Y: 12 — 15 mm and 20 — 25 mm;

for grades 2, 2Y, 3, 3Y, 4, 4Y,5Y: 20 — 25 mm and 30 — 35 mm;

for grades 2Y40, 3Y40, 4Y40, 5Y40: 20 — 25 mm and 30 — 35 mm.

In this case deposited metal testing is not required, and the test extent is limited to testing two butt weld test assemblies according to 4.4.3.2.

A limitation of approval to the lower and medium thickness range (up to the maximum welded plate thickness) may be agreed with the Register, and then the test assemblies shall be welded from the plates of a thickness of 12 — 15 mm and 20 — 25 mm, irrespective of the quality grade, for which the combination approval is required.

Where approval is required for welding normal and higher strength steels, two test assemblies of higher strength steel shall be welded. In this case the Register may demand additional testing of two butt weld test assemblies of normal strength steel.

4.4.3.2 Butt weld test.

4.4.3.2.1 Preparation and manufacture of test assemblies.

The preparation of butt weld test assemblies to approve the two-run welding technique, including the maximum welding wire diameter, steel grades for preparing the test assemblies and details of edge preparation, shall be carried out according to Table 4.4.3.2.1.

The test assemblies shall be dimensioned as shown in Fig. 4.4.3.2.1 and allow cutting out the specimens numbered and dimensioned as specified.

Some minor deviations in the edge preparation are allowed, if recommended by the manufacturer.

A joint gap shall not exceed 1 mm.

Each butt joint shall be welded in two runs, one from each side. Welding conditions (amperage, voltage and travel speed) shall be within the range

recommended by the manufacturer for normal good two-run welding practice.

After the completion of the first run, the flux and welding slag shall be removed and the test assembly left in still air until it has cooled to 100 °C. the temperature being taken in the centre of the weld on the surface of the bead. After being welded, the test assemblies shall not be subjected to any heat treatment.

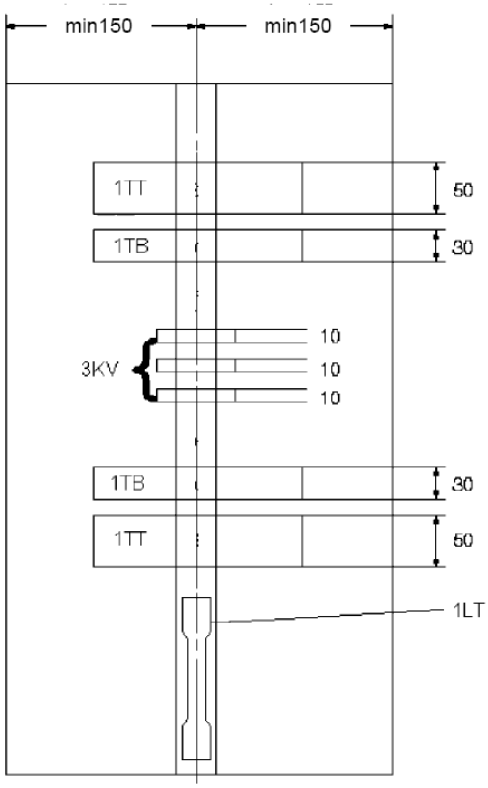


Fig. 4.4.3.2.1 Butt weld testing for the two-pass welding technique when testing "wire–flux" combinations (designations of test assemblies shall comply with Table 4.4.1.4, all dimensioned in mm unless specified otherwise)

4.4.3.2.2 Radiographic testing.

Prior to the preparation of specimens for mechanical testing, the radiographic testing of butt weld test assemblies is recommended for detecting any internal defects.

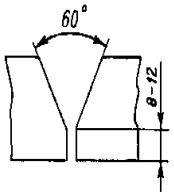
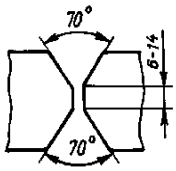
4.4.3.2.3 Test procedure.

According to Fig. 4.4.3.2.1 and Table 4.4.1.4, the test specimens, of which type and number correspond to the assembly thickness, shall be taken from each butt weld test assembly.

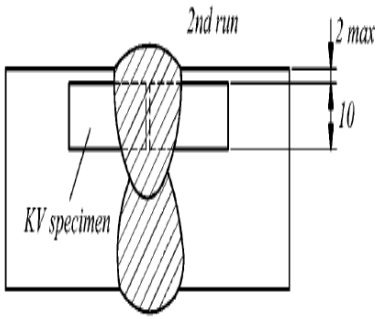
The notch orientation and position on the impact test specimens shall be as shown in Fig. 4.4.3.2.3.

Table 4.4.3.2.1

Thickness, mm	Edge preparation (recommended), mm	Maximum wire diameter, mm	Grade of welding consumables	Steel grade on	
				normal strength test assemblies	increased strength[1]
1	2	3	4	5	6

12–15		5	1 1Y	A –	– A32, A36
20–25		6	1 1Y	A –	– A32, A36
			2 2Y 2Y40	A, B or D – –	– A32, A36, D32, D36 A40, D40
			3, 4 3Y 3Y40 4Y, 5Y 4Y40, 5Y40	A, B, D, E – – – –	– from A32 to E36 A40, D40, E40 from A32 to F36 A40, D40, E40, F40
30–35		7	2 2Y 2Y40	A, B or D – –	– A32, A36, D32, D36 A40, D40
			3, 4 3Y 3Y40 4Y, 5Y 4Y40, 5Y40	A, B, D, E – – – –	– from A32 to E36 A40, D40, E40 from A32 to F36 A40, D40, E40, F40

[1] The actual tensile strength R_m of grades A32 to F32 shall be greater than 490 MPa.



All dimensions are in mm, unless otherwise specified

The test results shall comply with the requirements of Table 4.4.2.2.4 for longitudinal cylindrical tensile specimens and in Table 4.4.2.3.4 for the other types of specimens in accordance with the grade of the welding consumables to be approved.

The requirements for test procedure

Fig. 4.4.3.2.3 Arrangements for cutting of impact bending specimens to test butt welds made according to the two-pass welding technique (designations of test assemblies shall comply with Table 4.4.1.4, all dimensioned in mm unless specified otherwise)

4.4.3.2.4 Requirements for test results.

and their results evaluation shall meet the requirements in 4.2.

4.4.3.2.5 Chemical analysis of deposited metal.

Test specimens shall be taken from each test assembly for chemical analysis of the deposited metal including the content of all alloying elements and impurities regulated by documentation for the product manufacture and acceptance control (as a rule, for ceramic fluxes) manufacture and acceptance control (as a rule, for ceramic fluxes).

4.4.4 Annual and upgrading tests.

4.4.4.1 Annual tests and re-approval surveys of the welding consumables manufacturers.

All the organizations recognized by the Register as welding consumable manufacturers to be used in "wire-flux" combinations shall be annually surveyed and their products shall be tested.

The annual tests shall, as a minimum, include the following:

.1 "wire-flux" combinations for multi-run welding technique.

The extent of the annual tests for the "wire-flux" combinations for the multi-run welding technique shall include the preparation and tests of one deposited metal test assembly according to 4.4.2.2.

One longitudinal tensile test specimen and three impact test specimens shall be tested. The test results shall comply with the requirements of Table 4.4.2.2.4;

.2 "wire-flux" combinations for two-run welding technique.

The extent of the annual tests for the "wire-flux" combinations for the two-run welding technique shall include the preparation and tests of one butt weld test assembly of at least 20 mm thick according to 4.4.3.2.

One transverse tensile test specimen, two transverse bend test specimens and three impact test specimens shall be tested. In this case, where the combination shall be approved for the two-run welding technique only, one longitudinal cylindrical tensile test specimen shall be tested as well.

The test results shall meet the requirements in Table 4.4.3.2.4;

.3 "wire-flux" combinations for multi-run and two- run welding techniques.

The extent of the annual tests for the "wire-flux" combinations for the multi-run and two-run welding techniques shall include the preparation and tests of a deposited metal test assembly and a butt weld test assembly of at least 20 mm thick as per 4.4.4.1.1 and 4.4.4.1.2 and respectively. In this case the preparation and test of a longitudinal cylindrical tensile test specimen from the butt weld test assembly are not required.

If the combination is approved for welding normal and higher strength steels, a butt weld test assembly of higher strength steel shall be prepared and tested as per 4.4.4.1.2.

4.4.4.2 Upgrading tests.

4.4.4.2.1 Where the upgrading deals only with the change of a temperature when testing the impact test specimens without changing a strength group, only the additional tests of three impact test specimens made of the butt weld assembly prepared as per 4.4.2.3 for a multi-run welding technique or as per 4.4.3.2 for the base metal of the approved maximum thickness as applied to the two-run welding technique, shall be conducted at that changed temperature.

These butt weld test assemblies shall be tested in addition to the extent of the annual tests as per 4.4.4.1 (for which impact test specimens are also tested at the changed temperature).

4.4.4.2.2 Where the upgrading deals with the extension of the range of approval to cover the welding of higher strength level steels, the butt weld test assemblies shall be tested to the full extent as per or 4.4.3.2 in addition to the usual extent of annual testing. In this case the steel for preparing the butt weld assemblies shall meet the requirements in 4.4.2.1 or 4.4.3.2.1 (for multi-run and two-run techniques, respectively) for the new higher grade of welding consumables.

4.5 WIRE AND "WIRE-GAS" COMBINATIONS FOR SHIELDED METAL ARC WELDING

4.5.1 General.

4.5.1.1 The requirements given below apply to "wire-gas" combinations, and also to flux-cored wire (for welding with and without shielding gases), which are intended for semiautomatic and automatic welding of normal and higher strength hull structural steels, steel forgings and castings of the relevant grades, and also comparable steels for the construction of ship's structures and pressure vessels.

As applied to an approval procedure, the welding consumables in question are divided into the following groups:

for use in semiautomatic multi-run welding;

for use in single-electrode automatic multi-run welding;

for use in single-electrode automatic two-run welding.

Note. The terms "manual", "semiautomatic" and "automatic" welding in this Part of the Rules are used to designate the following degrees of the welding process mechanization:

manual welding means a process wherein all operations are carried out manually by a welder;

semiautomatic welding means a process wherein the filler metal feed is mechanized while other operations are carried out manually by a welder. According to ISO 857-1, this process is defined as "partially mechanized welding";

automatic welding means a process wherein all main operations, except the product movement, are mechanized. According to ISO 857-1, this process is defined as "fully mechanized welding".

The approval of welding consumables granted in accordance with these requirements is valid for the standard single-wire welding.

Other welding procedures such as tandem and multi-wire welding, one-side welding on flux or ceramic backing shall be submitted to separate approval tests.

These tests are shall be generally carried out in accordance with the requirements given below and detailed in a separate program to be agreed with the Register on a case-by-case basis, depending on the welding procedure proposed.

4.5.1.2 The "wire-gas" combinations depending on the strength level of the deposited or weld metal (R_{eH}, min) are divided into the following grades:

1, 2, 3 and 4 for normal strength steels;

1Y, 2Y, 3Y, 4Y and 5Y for higher strength steels with the specified

minimum yield stress of up to 355 MPa, inclusive;

2Y40, 3Y40, 4Y40 and 5Y40 for higher strength steels with the specified minimum yield stress of up to 390 MPa inclusive.

Depending on the welding procedure, the following symbols are added to the grade designation:

S — for welding consumables approved for semiautomatic multi-run technique;

T — for welding consumables approved for automatic two-run technique;

M — for welding consumables approved for automatic multi-run technique;

TM — for welding consumables approved for both techniques.

For welding consumables approved for semiautomatic and automatic multi-run techniques, the additional symbols shall be added in the combination as appropriate (SM).

Additional symbols H15, H10 or H5 as per 4.5.1.4 are used to designate the grade depending on the diffusible hydrogen content in the deposited metal as applied to a flux-cored wire.

4.5.1.3 Shielding gas composition:

.1 composition of the shielding gas used in approval testing shall be given in the test report and Certificate of Approval for Welding Consumables. Unless otherwise agreed with the Register, the use of the shielding gas of another composition for the same wire requires additional approval testing;

.2 approval of welding wire in combination with any specific gas composition may be applied to, and extended over, the combinations of this wire with the shielding gases of the similar group of a typical mixture to be determined as per Table 4.5.1.3.2.

Table 4.5.1.3.2

Group of shielding gas mixture		Composition of gas mixtures in volume, %			
		CO_2	O_2	H_2	Ar
M1	1	> 0 ÷ 5	–		Base[1, 2]
	2	> 0 ÷ 5	–	–	Base[1, 2]
	3	–		–	Base[1, 2]
	4	> 0 ÷ 5		–	Base[1, 2]
M2	1	> 5 ÷ 25	–	–	Base[1, 2]
	2	–		–	Base[1, 2]
	3	> 5 ÷ 25		–	Base[1, 2]
M3	1	> 25 ÷ 50	–	–	Base[1, 2]
	2	–		–	Base[1, 2]
	3	> 5 ÷ 50		–	Base[1, 2]
C	1	100	–	–	–
	2	Warp		–	–

[1] Argon can be replaced with helium in the volume of up to 95% of the content of argon.

[2] Approval shall only apply to gas mixtures with the same or a higher content of helium.

4.5.1.4 Normalization of the diffusion hydrogen content:

.1 The tests for checking the diffusible hydrogen content in the

deposited metal shall be carried out relevant to the flux-cored wire intended for welding the higher strength steels of the following categories of welding consumables:

Grade 2, 3 and 4 where applicable (welding consumables may be classified according to 4.2.3.4) in accordance with the manufacturer's request.

1Y, 2Y, 2Y40, 3Y, 3Y40, 4Y, 4Y40, and also 5Y and 5Y40.

The tests are carried out as per 4.2.3 under the welding conditions recommended by the manufacturer at a welding speed providing mass of the metal deposited on a specimen similar in value to that for testing the electrodes (15 to 20 g per 100 mm of the weld);

.2 on the basis of the test results obtained and requirements in 4.2.3.4, the symbols H15, H10 or H5 featuring the diffusible hydrogen content in the deposited metal shall be added to the designation of the combination grade according to 4.5.1.2.

4.5.1.5 Information and documentation to be submitted for review.

A manufacturer shall generally submit for review the information and technical documentation attached to the request for approval containing the following data:

commercial name, type of welding wire, limits of chemical composition in the case of bare wires and information on additives in the case of flux-cored wires (or reference to a relevant normative document), and range of wire diameters to be approved; producer, supplier, conditions of supply (surface condition, type, diameters and weight of standard coils);

welding technique and grading, under which the approval is requested;

type of current, welding positions and range of current, for which the approval is requested;

properties, composition and requirements relevant to the shielding gas or gas mixture;

commercial brand and a manufacturer, in the case of gas mixtures of special types;

typical chemical composition of the deposited metal, with particular reference to the contents of Mn, Si and other alloying elements, which shall be specified in all cases;

conditions to which the chemical composition refers;

main operating characteristics and welding techniques (such as spray arc, short arc or dip transfer), associated recommendations and limitations;

packaging and labeling (marking);

information on manufacturing capacity, facilities and quality control procedure;

recommendations for storing and preservation of flux-cored and coated wires;

information on the approval granted by other classification societies or technical supervisory bodies with copies of the required document attached.

The technical documentation to be approved by the Register:

manufacturer's technical specifications or specifications for welding consumables, including the current catalogue editions;

instructions on the products manufacture, acceptance and quality control.

4.5.2 Welding wire and "wire-gas" combinations for semiautomatic multi-run welding.

4.5.2.1 General requirements.

The approval test relevant to semiautomatic multirun welding shall be conducted according to 4.3 using the flux-cored wire or "wire-flux" combinations for welding the test assemblies. The number of test assemblies and specimens required is given in Table 4.5.2.1.

4.5.2.2 Deposited metal test.

4.5.2.2.1 Preparation and manufacture of test assemblies.

Two test assemblies of the deposited metal shall be welded in a downhand position as shown in Fig. 4.3.2.1. One shall use a wire of 1.2 mm or the smallest size, and the other shall use a wire of the largest size intended for welding hull structures. If only one diameter is available, one test assembly is sufficient. Any grade of hull structural steel may be used for the preparation of the test assembly.

The weld metal is deposited in multi-run layers according to the manufacturer's recommendations and the normal practice, and the direction of deposition of each layer shall, in general, alternate from each end of the plate.

Each weld bead shall be within 2 mm to 6 mm thick.

Between each run the assembly shall be left in still air until it has cooled to less than 250 °C, but not below 100 °C, the temperature being taken in the centre of the weld on the surface of the bead. After being welded, the test assemblies shall not be subjected to any heat treatment.

Table 4.5.2.1

Test assembly						Number and type of specimens[2]
Type	Welding position[1]	Diameter of electrode, mm	Number	Thickness, mm	Dimensions	
Deposited metal	PA	1.2 or min Ø	1	20	Refer to Fig. 4.3.2.1	1TL+3KV
		max Ø	1[4]			
Butt joint	PA	First run: 1.2 or min Ø Remaining runs: max Ø	1[5]	15 ÷ 20	Refer to Fig. 4.3.3.1	1TT+1RB+1FB+3KV
	PF	First run: 1.2 or min Ø Remaining runs: max Ø for of specific position	1			1TT+1RB+1FB+3KV
	PC		1			1TT+1RB+1FB+3KV
	PE		1			1TT+1RB+1FB+3KV
Fillet joint	[6]	First side: min Ø	1	15 ÷ 20	Refer to Fig. 4.3.6.2	M+FF+HV
		Second side: max Ø				

[1] Welding positions are designated according to ISO 6947 (refer to Fig. 6.2.2.4-1).

[2] When the approval is requested only for one or limited number of welding positions, the butt weld test assemblies shall be welded in such positions only.

[3] The following abbreviations are used for the type of specimens:
TL — longitudinal cylindrical tensile test specimen;
TT — transverse flat tensile test specimen;
RB — transverse root bend test specimen;
FB — transverse face bend test specimen;
FF — fillet fracture test specimen;
M — transverse macrosection;
HV — hardness measurement specimen.

[4] When the approval is requested only for one diameter, only one deposited metal test assembly shall be prepared.

[5] When the approval is requested for a downhand welding position only, two test assemblies shall be prepared in this position: one using the largest diameter wire, and another using the wire of an increasing diameter from the first to the last run.

[6] Fillet weld test assemblies shall be welded in the position required for approval.

4.5.2.2.2 Chemical analysis of! deposited metal.

Test specimens shall be taken from a test assembly for chemical analysis of deposited metal, including the content of all alloying elements and impurities regulated by documentation for the product manufacturer and acceptance control (as a rule, for flux-cored wire).

4.5.2.2.3 Mechanical tests.

As shown in Table 4.5.2.1 and Fig. 4.3.2.1, from each butt weld test assembly the following specimens shall be taken:

The specimens shall be cut out, prepared and tested according to the instructions in 4.2.2.1.1 and 4.2.2.3, respectively.

The results of all tests shall comply with the requirements of Table 4.3.2.4 for the relevant welding consumable grades.

4.5.2.3 Butt weld test.

4.5.2.3.1 Preparation and manufacture of test assemblies.

To check the properties of a butt welded joint in each welding position (downhand, horizontal, vertical upwards and downwards and overhead) for which the "wire-gas" combination shall be approved, one test assembly shall be welded in each position as shown in Fig. 4.3.3.1.

The hull structural steel of one of the grades shall be used for preparing the assemblies as shown in Table 4.3.3.1.

The test assemblies for individual welding positions shall be welded as indicated below:

downhand position — PA. One test specimen welded using a wire of 1.2 mm or the minimum diameter to be approved for the first run and a wire of the maximum diameter to be approved for the remaining runs;

when the approval is requested for a downhand welding position only, two test assemblies shall be prepared in this position: one using the largest diameter wire, and another using the wire of an increasing diameter from the first to the last run.

When the wire of one diameter is available, one test assembly shall be prepared;

welding positions other than the downhand one (PE, PG, PC and PE). One test specimen welded using a wire of 1.2 mm or the minimum diameter to be approved for the first run and a wire of the maximum diameter recommended by a manufacturer for a

specific welding position for the remaining runs.

After being welded, the test assemblies shall not be subjected to any heat treatment.

4.5.2.3.2 Radiographic testing.

Prior to the preparation of specimens for mechanical testing, the radiographic testing of butt weld test assemblies is recommended for detecting any internal defects.

4.5.2.3.3 Mechanical tests.

According to Table 4.5.2.1 and Fig. 4.3.3.1, from each butt weld test assembly shall be taken:

one transverse flat tensile test specimen;

three transverse V-notched impact test specimens;

one transverse root and one transverse face static bend test specimens.

The test results shall comply with the requirements of Table 4.3.3.5 for the relevant welding consumable grades. The requirements for test procedure and their results evaluation shall meet the requirements in 4.2.

4.5.2.4 Tee-joint weld test.

The tee-joint weld test is required for the "wire-gas" combinations intended for fillet welding only and is conducted similarly to the requirements in 4.3.6 for the covered electrodes.

Test assemblies shall be manufactured in the welding positions to be approved according to 4.3.6.2. The test extent and results shall comply with the requirements in 4.3.6.3.

4.5.2.5 Tests for checking diffusible hydrogen content in deposited metal.

The tests for checking the diffusible hydrogen content in the deposited metal shall be carried out in compliance with the provisions in 4.2.3 and 4.5.1.4 relevant to the flux-cored wire intended for welding the higher strength steels of categories: 1Y, 2Y, 2Y40, 3Y, 3Y40, 4Y, 4Y40, and also 5Y and 5Y40.

Grade 2, 3 and 4 flux-cored wire intended for welding normal strength steels may be graded for the diffusible hydrogen content in the deposited metal as an option in accordance with the manufacturer's request

The tests for checking the diffusible hydrogen content in the deposited metal are generally conducted at the initial approval of welding consumables, and also, if required by the Register, during annual tests or on the manufacturer's request during upgrading tests.

4.5.3 Welding wire and "wire-gas" combinations for automatic multi-run welding.

4.5.3.1 General requirements:

.1 the wire and "wire-gas" combinations tested according to 4.5.2 and approved by the Register for semiautomatic multi-run welding are also approved for automatic multi-run welding without additional testing.

This provision is valid if the automatic and semiautomatic welding conditions (current, heat input, etc.) are similar, i.e. different in the way of welding torch movement only;

.2 the tests on the approval of an automatic multi-run welding technique shall be conducted according to 4.4.2 using a flux-cored wire or "wire-gas" combinations for welding test assemblies.

The number of specimens required for testing and taken from each tests assembly shall be according to Table 4.4.1.4.

4.5.3.2 Deposited metal test.

4.5.2.2.1 Preparation and manufacture of test assemblies.

One test assembly of! the deposited metal shall be welded in a downhand position as shown in Fig. 4.4.2.2.1.

The wire diameter, test assembly welding conditions (amperage, voltage, welding speed) shall comply with the manufacturer's recommendations.

The test assembly shall be prepared and manufactured according to 4.4.2.2.1, except the requirements for the minimum thickness of each layer which shall be 3 mm.

4.5.3.2.2 Chemical analysis of deposited metal.

Test specimens shall be taken from a test assembly for chemical analysis of deposited metal, including the content of all alloying elements and impurities regulated by documentation for the product manufacturer and acceptance control (as a rule, for flux-cored wire).

4.5.3.2.3 Mechanical tests.

Two longitudinal tensile test specimens and three impact test specimens shall be taken from the test assembly as shown in Fig. 4.4.2.2.1.

The specimens shall be cut out, prepared and tested according to the instructions in 4.2.2.1.1 and 4.2.2.3, respectively.

The results of all tests shall comply with the requirements of Table 4.4.2.4 for the relevant welding consumable grades.

4.5.3.3 Butt weld tests.

4.5.3.3.1 Preparation and manufacture of test assemblies.

To check the properties of a butt welded joint in each welding position, one test assembly shall be welded for which the "wire-gas" combination shall be approved as shown in Fig. 4.4.2.3.1.

The welding positions to be approved are usually limited to the downhand position only, and in this case only one test assembly is required for testing.

The wire diameter, test assembly welding conditions (amperage, voltage, welding speed) shall comply with the manufacturer's recommendations.

The test assembly shall be prepared and manufactured according to 4.4.2.3.I.

4.5.3.3.2 Radiographic testing.

Prior to the preparation of specimens for mechanical testing, the radiographic testing of butt weld test assemblies is recommended for detecting any internal defects.

4.5.3.3.3 Mechanical tests.

According to Table 4.4.1.4 and Fig. 4.4.2.3.1, from each butt weld test assembly shall be taken:

two transverse flat tensile test specimens;

three transverse V-notched impact test specimens;

two transverse root and two transverse face bend test specimens.

The test results shall comply with the requirements of Table 4.4.2.3.4 for the relevant welding consumable grades. The requirements for test procedure and their results evaluation shall meet the requirements in 4.2.

4.5.3.4 Tests for checking diffusible hydrogen content in deposited metal.

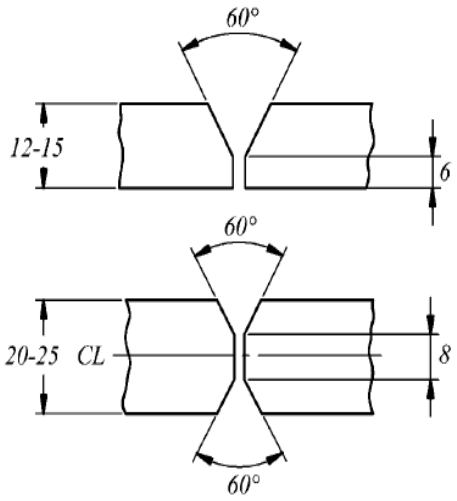
The tests for checking the diffusible hydrogen content in the deposited metal shall be carried out in compliance with the provisions in 4.2.3 and 4.5.1.4 relevant to the flux-cored wire intended for welding the higher strength steels of categories: 1Y, 2Y, 2Y40, 3Y, 3Y40, 4Y, 4Y40, and also 5Y and

The tests for checking diffusible hydrogen content in the deposited metal are generally conducted at the initial approval of welding consumables, and also, if required by the Register, during annual tests.

4.5.4 Welding wire and "wire-gas" combinations for automatic two-run welding.

4.5.4.1 General requirements.

The approval tests of the automatic two-run welding shall be conducted in compliance with 4.3 using a flux- cored wire or "wire-flux" combinations for



5Y40.

Grade 2, 3 and 4 flux-cored wire intended for welding normal strength steels may be graded for the diffusible hydrogen content in the deposited metal as an option in accordance with the manufacturer's request

welding test assemblies.

The number of test assemblies and specimens required is given in Table 4.4.1.4.

4.5.4.2 Butt weld tests.

4.5.4.2.1 Preparation and manufacture of test assemblies.

The test assemblies shall be prepared and manufactured considering the following requirements:

.1 to approve the "wire-gas" combinations for the automatic two-run welding, two butt weld test assemblies prepared and manufactured according to 4.4.3.1 and 4.4.3.2 shall be welded within the base metal thickness range of 12 to 15 mm, and 20 to 25 mm. Where approval is requested for welding plates over 25 mm thick, then two test assemblies shall be prepared, one of the metal of about 20 mm thick, and another of the metal of the maximum thickness to be approved;

Fig. 4.5.4.2.1 The recommended edge preparation for butt weld testing in case of approval of "wire–shielding gas" combinations intended for automatic two-pass welding technique (dimensioned in mm unless stated otherwise)

.2 edge preparation on the butt weld test assemblies is shown in Fig. 4.5.4.2.1.

Some minor deviations in edge preparation are allowed if recommended by the manufacturer.

For the test assemblies of a metal over 25 mm thick, the edge preparation

details shall additionally be submitted for information. The deviations or differences in edge preparation shall be justified by the manufacturer's recommendations as applied to the given welding technique and metal thickness;

.3 diameters of the welding wire used for welding the test assemblies shall comply with the manufacturer's recommendations and be additionally submitted to the Register for information.

4.5.4.2.2 Radiographic testing.

Prior to the preparation of specimens for mechanical testing, the radiographic testing of butt weld test assemblies is recommended for detecting any internal defects.

4.5.4.2.3 Mechanical tests.

According to Table 4.4.1.4 and Fig. 4.4.3.2.1, the test specimens, of which type and number correspond to the assembly thickness, shall be taken from each butt weld test assembly.

The notch orientation and position on the specimens for impact testing shall be as shown in Fig. 4.4.3.2.3.

The test results shall comply with the requirements of Table 4.4.2.2.4 for longitudinal cylindrical tensile specimens and in Table 4.4.2.3.4 for the other types of specimens in accordance with the grade of the welding consumables to be approved.

The requirements for test procedure and their results evaluation shall meet the requirements in 4.2.

4.5.4.3 Chemical analysis of deposited metal.

Test specimens shall be taken from a test assembly for chemical analysis of the deposited metal on the side of the second run, and the results shall be recorded in a test report, if the chemical composition is regulated by the manufacturer's documentation (as a rule for flux- cored wire).

4.5.4.4 Tests for checking diffusible hydrogen content in deposited metal.

The tests for checking diffusible hydrogen content in the deposited metal shall be carried out according to 4.5.3.4.

4.5.5 Annual and upgrading tests.

4.5.5.1 Annual tests and re-approval surveys of the welding consumables manufacturers.

All the organizations recognized by the Register as welding consumable manufacturers to be used in "wire-flux" combinations shall be annually surveyed and then- products shall be tested.

The annual tests shall, as a minimum, include the following:

.1 wires and combinations for semiautomatic multirun or simultaneously for semiautomatic and automatic multi-run welding.

The extent of the annual tests for the wire and "wire- flux" combinations for the semiautomatic multi-run or simultaneously for semiautomatic and automatic multirun welding shall include the preparation and tests of one deposited metal test assembly according to 4.5.2.2.

The wire diameter shall correspond to the range of diameters specified in the Certificate for Approval of Welding Consumables for the semiautomatic welding. One longitudinal cylindrical tensile test specimen and three impact test specimens shall be tested.

The test results shall comply with the requirements of Table 4.3.2.4.

The chemical analysis of the deposited metal shall be performed following the requirements for the initial approval if it is regulated by the manufacturer's documentation for the acceptance control of products (as a rule for flux-cored wire);

.2 wires and combinations for automatic multi-run welding.

The extent of the annual tests for the wire and "wire- flux" combinations for the automatic multi-run welding technique shall include the preparation and tests of one deposited metal test assembly according to 4.5.3.2.

The wire diameter shall correspond to the range of diameters specified in the Certificate for Approval of Welding Consumables for the automatic welding. One longitudinal cylindrical tensile test specimen and three impact test specimens shall be tested.

The test results shall comply with the requirements of Table 4.4.2.2.4.

The chemical analysis of the deposited metal shall be performed following the requirements for the initial approval if it is regulated by the manufacturer's documentation for the acceptance control of products (as a rule for flux-cored wire);

.3 wires and combinations for automatic two-run welding.

The extent of the annual tests for the wire and "wire- flux" combinations for the automatic two-run welding technique shall include the preparation and tests of one butt weld test assembly of 20 to 25 mm thick according to 4.5.4.2.

Where approval is requested for the automatic two-run welding, one transverse tensile test specimen, two bend test specimens, three impact test specimens, and also one longitudinal tensile test specimen shall be tested. The wire diameter used in welding shall be recorded in the test report;

.4 for H10 and H5 flux-cored welding wires with the controlled diffusible hydrogen content, the check of welding consumables for the diffusible hydrogen content in the deposited metal according to 4.2.3 may be included in the annual test program on the Register's demand.

4.5.5.2 Upgrading tests.

During upgrading tests of the welding consumables the following shall be taken into account:

.1 where the upgrading deals only with the change of temperature when testing impact test specimens for the multi-run welding technique, the test extent is similar to the requirements in 4.3.8.2.2, and for the two-run welding technique, an additional (to the requirements in 4.5.5.1.3) butt weld test assembly 12 — 15 mm thick shall be prepared for testing three impact test specimens;

.2 where the upgrading deals with the extension of the range of approval to cover the welding of higher strength level steels, then for the multi-run welding technique, the butt weld test assemblies shall be tested to the lull extent as per or 4.5.3.3 in addition to the usual extent of annual testing.

The total extent of tests (annual and additional for upgrading) for the two-run technique shall meet the requirements for the initial approval as per 4.5.4.

4.6 WELDING CONSUMABLES FOR WELDING HIGH STRENGTH STEEL

4.6.1 General.

4.6.1.1 The requirements of this Chapter supplement those in 4.3, 4.4 and 4.5 and specify the conditions for approval and testing of the welding consumables intended for welding high strength steels delivered in heat treated

condition (quenched and tempered) or after the TMCP, and meeting the requirements in 3.13, Part XIII "Materials".

When the special requirements are lacking, the similar requirements for approval of the welding consumables for welding normal and higher strength hull structural steels shall apply.

4.6.1.2 The requirements of this Section are used for approval of the following types of welding consumables:

covered electrodes for manual arc welding (similar to 4.3);

"wire-flux" combinations for multi-run submerged arc welding (similar to 4.4.2);

"wire-gas" combinations for gas-shielded metal-arc welding (including tungsten inert gas welding — TIG);

flux-cored wire with or without shielding gas for metal-arc welding.

4.6.1.3 The welding consumables for welding the high strength steels, complying with the requirements in 3.13, Part XIII "Materials", are divided into grades depending on the minimum yield stress of the base and deposited metals, as well as the temperature in impact testing the weld and deposited metal according to Table 4.1.2.3.

The designation of the welding consumable grade includes two groups of basic symbols:

3, 4 and 5 for designating the temperature during testing the impact test specimens for the deposited and weld metals;

Y42, Y46, Y50, Y55, Y62 and Y69 for designating the requirements for the minimum yield stress of the deposited metal.

For the welding consumables intended for welding high strength steels, the following additional symbols according to 4.1.2.6 are used:

H10 and H5 — for content of diffusible hydrogen in the deposited metal according to 4.2.3.4;

S — for approval of welding consumables for semiautomatic welding;

M — for approval of welding consumables for multi-run welding technique;

SM — for approval of welding consumables for semiautomatic and automatic multi-run welding technique.

4.6.1.4 The welding consumable grade shall be used and selected considering the grade the high strength steel to be welded and requirements in 2.2.5.

4.6.2 Deposited metal test

4.6.2.1 Depending on the type of welding consumables and the degree of the welding procedure mechanization, the test assemblies of the deposited metal shall be welded in a downhand position following the relevant provisions in 4.3.2.1, 4.4.2.2.1 or 4.5.3.2.1.

The high strength steel compatible in properties (refer to 4.6.1.4) with the weld metal shall be used as the base metal for preparing the test assemblies.

As an alternative, the bevels of the test assembly of any grade metal shall be buttered with the welding consumables to be approved or with those similar in composition and properties.

4.6.2.2 Following the requirements in 4.3.2.2, 4.4.2.2.2, 4.5.2.2.2 or 4.5.3.2.2, the test assemblies shall be

sampled for chemical analysis of the deposited metal including the content of all alloying elements and impurities if these regulated by documentation for the product manufacture and acceptance control.

The analysis results shall be within the limits set by the standards or manufacturer's documentation.

4.6.2.3 Depending on the type of welding consumables and the degree of the welding procedure mechanization, test specimens shall be taken from the deposited metal test assemblies and prepared for the tests, which the type and number shall comply with the relevant requirements in 4.3.2.3, 4.4.2.2.3, 4.5.2.2.3 or 4.5.3.2.3.

4.6.2.4 The mechanical properties shall meet the requirements in Table 4.6.2.4.

The requirements for test procedure and results evaluation shall comply with the provisions in 4.2.

Table 4.6.2.4

Grade		Yield stress R_{eH}, MPa	Tensile strength R_m, MPa [1, 2]	Elongation, A_5 min (L_0=5d), min	Butt weld tests.	
					Temperature of testing, °C	Impact energy value KV, J, min
3	Y42	420	530 ÷ 580	20	-20	47
4					-40	
5					-60	
3	Y46	460	570 ÷ 720	20	-20	47
4					-40	
5					-60	
3	Y50	500	610 ÷ 770	18	-20	50
4					-40	
5					-60	
3	Y55	550	670 ÷ 770	18	-20	55
4					-40	
5					-60	
3	Y62	620	720 ÷ 890	18	-20	62
4					-40	
5					-60	
3	Y69	690	770 ÷ 9400	17	-20	69
4					-40	
5					-60	

[1] The values of tensile strength of the deposited metal can be 10% below the values in the table if compliant with Table 4.6.3.3 for the tensile strength value during tests of transverse flat specimens from butt weld testing assemblies.

[2] For welding of very thick products (50 mm or more) when the strengthening effect of the base metal under the note "1" does not work and the temporary resistance of the deposited metal determines the temporary resistance of the welded connection, welding consumables of the following strength category shall be used (with higher values of the "Y" index in the category designation).

4.6.3 Tests of butt welded joint

4.6.3.1 Depending on the type of welding consumables and the degree of the welding procedure mechanization, the butt weld test assemblies according to the relevant provisions in 4.3.3.1, 4.3.3.2, 4.4.2.3.1,or 4.5.3.3.1 shall be prepared and welded.

The high strength steel with the proper values of the minimum yield stress and tensile strength and compatible in impact toughness indices with the welding consumables to be approved shall be used as the base metal for preparing the test assemblies (refer to 2.2.5).

4.6.3.2 Depending on the type of welding consumables and the degree of the welding procedure mechanization, test specimens shall be taken from the butt weld test assemblies and prepared for the tests, which the type and number shall comply with the relevant requirements in 4.3.3.3, 4.4.2.3.3, 4.5.2.3.3 or 4.5.3.3.3.

Prior to the preparation of test specimens, the radiographic testing of the butt weld test assemblies is recommended for checking the presence of any internal defects.

4.6.3.3 The mechanical properties shall meet the requirements in Table 4.6.3.3.

The requirements for test procedure and results evaluation shall comply with the provisions in 4.2.

Table 4.6.3.3

Grade		Tensile strength R_m, MPa, min	Static bending test		Butt weld tests.	
			Bend angle, deg[2]	D/t rato[1]	Temperature of testing, °C	Impact energy value *KV*, J, min
3	Y42	530	120	4	-20	47
4					-40	
5					-60	
3	Y46	570		4	-20	47
4					-40	
5					-60	
3	Y50	610		4	-20	50
4					-40	
5					-60	
3	Y55	670		5	-20	55
4					-40	
5					-60	
3	Y62	720		5	-20	62
4					-40	
5					-60	
3	Y69	770		5	-20	
4					-40	69
5					-60	

[1] D - the diameter of the mandrel; t - the thickness of the specimen

[2] The bending angle reached prior to the emergence of the first crack. Minor weld defects that have opened to a length of less than 3 mm shall be allowed on the specimen surface.

4.6.3.4 Where the bend angle required in Table 4.6.3.3 is not achieved until the first crack, the specimen may be considered as satisfactory tested (meets the specified requirements) if the elongation measured on the gauge length L_0 of the bend test specimen meets the requirements in Table 4.7.2.4 for the minimum elongation value for longitudinal cylindrical tensile specimens.

Calculated length shall be determined as $L_0 = L_S + t$,

where: L_S – joint width, t – specimen thickness (refer to Fig. 4.6.3.4).

4.6.4 Tests for checking diffusible hydrogen content in the deposited metal.

4.6.4.1 The all-grades welding consumables for welding high strength steels, except "solid wire-gas" combinations, shall be subjected to tests for checking diffusible hydrogen content in the deposited metal using the following methods:

vacuum-mercury method complying with the requirements of ISO 3690;

vacuum method complying with the requirements in ISO 3690 (method 2);

chromatographical method complying with the requirements in ISO 3690 (method 1) or the Register-agreed procedure. In the latter case the cooling rate and the time for specimens preparation, and also the diffusible hydrogen amount to be determined shall be comparable with those specified in the reference method according to ISO 3690.

4.6.4.2 The diffusible hydrogen content in the deposited metal checked according to 4.2.3 shall not exceed the limits in Table 4.6.4.2.

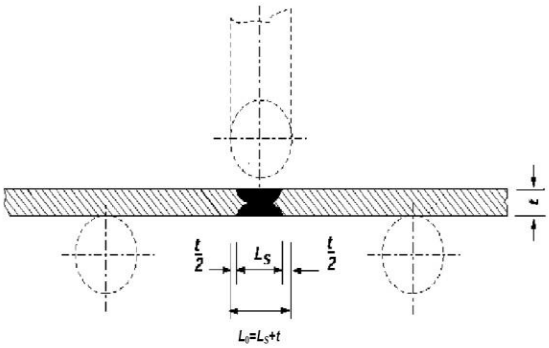


Fig. 4.6.3.4 Sketch for determination of the gauge length L_0 to determine elongation value during bend tests

4.6.5 Annual tests.

All the organizations recognized by the Register as welding consumables manufacturers shall be annually surveyed and their products be tested.

Depending on the type of welding consumables and the degree of the welding procedure mechanization, the annual test extent includes welding the deposited metal test assemblies and carrying out the tests according to the relevant provisions in 4.4.4.1.1, 4.5.5.1.1 or 4.5.5.1.2 with due regard to additional requirements in 4.7.2.

In single cases the annual tests may be extended on the Register demand.

4.7 WELDING CONSUMABLES FOR WELDING ALUMINIUM ALLOYS

4.7.1 General.

4.7.1.1 The requirements of this Chapter specify the conditions for approval of the welding consumables intended for welding hull and other structures of aluminium alloys meeting the requirements in 5.1, Part XIII "Materials".

When the special requirements are lacking, the similar requirements for approval of the welding consumables for welding normal and higher strength hull structural steels shall apply.

4.7.1.2 Welding consumables used for the manufacture of aluminium alloy structures are divided into two groups:

W - wire and a "wire–shielding gas" combination for welding with a melting electrode in an inert gas (MIG, 131 according to ISO 4063) and for welding with a non-melting electrode in an inert gas (TIG, 141) or for plasma arc welding (15);

R - rods for welding with a non-melting electrode in an inert gas (TIG, 141) or for plasma arc welding (15).

4.7.1.3 Classification and designation.

Welding consumables shall be divided into categories based on the composition and the strength of the base metal used for approval testing in accordance with the Table 4.7.1.3-1 and 4.7.1. 3-2 for international and national alloys, respectively.

Table 4.7.1.3-1

Grade of welding consumables		The base metal for testing and immediate approval of international alloys		Dissemination of approval for other alloys	
Wire	Rods	Digital code	Letter symbol	international	national
WA	RA	5754	AlMg3	–	530
WB	RB	5086	AlMg4	5754	530
WC	RC	5083	AlMg4.5Mn0.7	5754, 5086	530, 1550
		5383	AlMg4.5Mn0.9	5754, 5086, 5083, 5456	530, 1550
		5456	AlMg5	5754, 5086, 5083, 5383	530, 1550
		5059	–	5754, 5086, 5083, 5383, 5456	530, 1550, 561
WD	RD	6005A	AlSiMg (A)	6061, 6082	AlSilMgMn)
		6061	AlMg1SiCu	6005A, 6082	
		6082	AlSilMgMn	6005A, 6061	

Note. Approval of welding consumables performed on a more solid Al-Mg alloy shall also apply to Al-Mg alloys of a lower strength category as well as to their combinations (heterogeneous combinations) with Al-Si alloys.

Designation of the grades of welding consumables shall include:

designation of the group of welding consumables (W or R);

designation of the group of the base metal used for approval testing (A, B, C, D for international alloys or 1, 2, 3, 4, 5 for national alloys);

digital designation of the category of the base metal used for approval testing, which shall be indicated in parentheses. Examples: RC (5446), W3 (1561) etc.

Table 4.7.1.3-2

Grade of welding consumables		Base metal for testing and direct approval of national alloys		Dissemination of approval for other alloys	
Wire	Rods	Digital code	Letter symbol	international	national
W1	Rl	1530	AlMg3.5 Si0.6	754	
W2	R2	1550	AlMg5.0 Mn0.6	754, 5086, 083	530
W3	R3	1561	AlMg6.0 Mnl	754, 5086, 083, 5383, 5456	530, 1550
W4	R4	1575	AlMg6.0 Mn0.5Sc	754, 5086, 5083 383, 5456, 5059	530, 1550, 561
W5	R5	–	AlSilMgMn	005A,6061 082	

Note. Approval of welding consumables performed on a more solid Al-Mg alloy shall also apply to Al-Mg alloys of a lower strength category as well as to their combinations (heterogeneous combinations) with Al-Si alloys.

4.7.1.4 Approval for welding wire or rods shall be delivered in combination with a specific group of a typical shielding gas compound according to Table 4.7.1.4 or shall be determined within the compound and the purity of the "special" gas marked with the "S" group index. Composition of the shielding gas shall be given in the test report and Certificate of Approval for Welding Consumables.

Approval of welding wire in combination with any specific gas composition may be applied to, and extended over, the combinations of this wire with the shielding gases of the similar group of a typical mixture to be determined as per Table 4.7.1.4.

For special gases that are marked with the S index, approval shall only apply to a particular compound and purity of the shielding gas or gas mixtures that were used in the tests.

Table 4.7.1.4

Gas group	Shielding gas composition (volume percent)[1]	
	Argon	Helium
1-1	100	–
1-2	–	100
1-3	Other	Over 0 up to 33
1-4	Other	Over 33 up to 66
1-5	Other	Over 66 up to 95
S	Special gases whose designation must comply with EN 439	

[1] Gases of another chemical composition (gas mixtures) can be considered as "special gases" and approved by the Register based on the results of special tests for each composition.

4.7.1.5 The approval procedure and the requirements for manufacturers shall comply with 4.1.3.

The requirements for test procedure and results evaluation shall comply with the provisions in 4.2.

4.7.2 Tests of deposited metal.

One test assembly of! the deposited metal shall be prepared and welded in a downhand position as shown in Fig. 4.7.2.

Dimensions of specimens that depend on the type of welding consumables and the process mechanisation degree shall provide for a sufficient amount of welded metal to perform chemical analyses. The base metal shall be compatible with the chemical composition of the weld metal.

The results of chemical analysis for major alloying elements and impurities shall not exceed the limits set by the manufacturer.

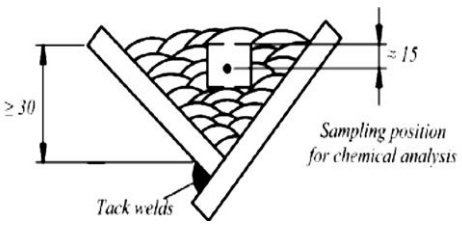


Fig. 4.7.2 Test assembly for deposited metal testing

4.7.3 Butt weld tests.

4.7.3.1. Butt-welded test assemblies shall be welded as per Fig. 4.7.3.1-1 and 4.7.3. 1-2 similar to the requirements of 4.3.3.1 and 4.3.3.2, 4.5.2.3.1, 4.5.3.3.1 or 4.5.4.2.1 depending on the type of welding consumables and the welding process mechanization degree, respectively.

The manufacture of specimens shall require the application of the base metal that meets the approved category of welding consumables according to Table 4.7.1.3-1 or 4.7.1.3-2.

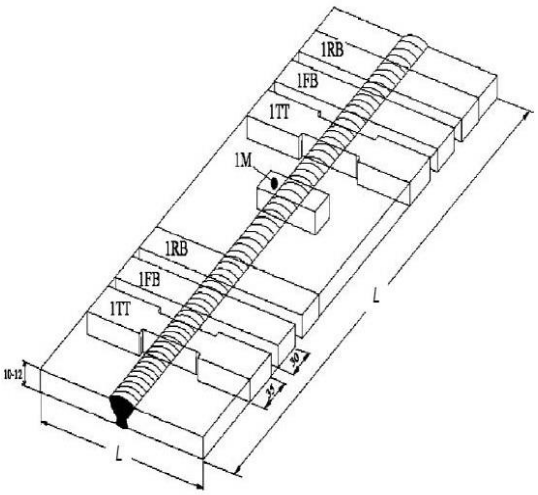


Fig. 4.7.3.1-1 Butt weld tests for welding in various positions

Fig. 4.7.3.1-1 (continued): Processing of edges shall be one-sided V-shaped or two-sided X-shaped with the opening angle of 70 degrees;

for one-sided V-shaped edge processing, return sealing passes shall be allowed; in case of two-sided X-shaped edge processing, welding shall be performed on both sides in the same position; designation of specimens shall meet the requirements in 4.7.3.5 ($L \geq 350$, dimensioned in mm unless stated otherwise).

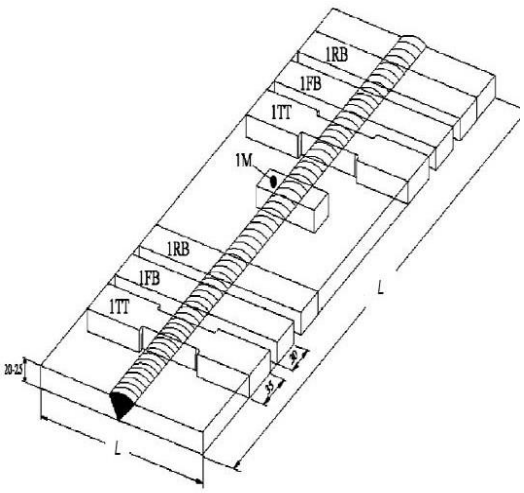


Fig. 4.7.3.1- 2 Additional butt weld testing for welding in the lower position:

processing of edges shall be one-sided V-shaped with the opening angle of 70 degrees;

return sealing passes shall be allowed; designation of specimens shall meet the requirements in 4.7.3.5 ($L \geq 350$, dimensioned in mm unless stated otherwise).

4.7.3.2 To check the properties of a butt welded joint in each welding position (downhand, horizontal, vertical upwards and downwards and overhead) for which welding consumables shall be approved, one joint test assembly with the thickness of 10 to 12 mm shall be welded in each position as shown in Fig. 4.7.3.1-1.

In this case the welding consumables for welding in downhand
and vertical-upward positions may be considered to meet the relevant requirements for welding in horizontal-vertical position.

4.7.3.3 Additionally, a specimen with a thickness of 20 to 25 mm according to Fig. 4.7.3.1-2 shall be prepared and welded in the lower position only.

4.7.3.4 After the completion of welding, specimens shall naturally cool to the room temperature.

For welding consumables with the indexing of specimens of the grade D, butt weld specimens shall be allowed to age for, at least, 72 hours after the completion of welding before starting the test.

4.7.3.5 From each butt weld specimen according to Fig. 4.7.3.1-1 and Fig. 4.7.3.1-2, the following specimens shall be selected and subjected to testing:

2TT - two transverse flat tensile test specimens;

2RB — two transverse root bend test specimens;

2FB — 2 transverse face bend test specimens;

1M — one transverse macrosection;

4.7.3.6 The mechanical properties of butt welds shall meet the requirements in Table 4.7.3.6.

The requirements for test procedure and their results evaluation, including repeated and annual testing, shall meet the requirements in 4.2.

The provisions of destruction in tensile specimens shall be given in the test report.

Macrosections shall be subjected to inspection for the presence of defects such as the lack of penetration, cavities, inclusions, pores, or cracks. It is recommended to implement the static bend test using the method of bending of the specimen around the mandrel according to the arrangement in Fig. 4.7.3.6.

Table 4.7.3.6. **Requirements for the properties of the weld**

Grade of welding consumables	Base metal grade for testing	Tensile strength, R_m, MPa min	Static bending test	
			Diameter of the mandrel	Bending angle[2], deg., min
1	2	3	4	5
RA/WA	5754	190	3*t*	180
RB/WB	5086	240	6*t*	
RC/WC	5083	275	6*t*	
	5083 or 5456	290	6*t*	
	5059	330	6*t*	
RD/WD	6061, 6005(A) or 6082	170	6*t*	
National alloys				
R1/W1	1530	185[1]	6*t*	180
R2/W2	1550	275[1]	6*t*	
R3/W3	1561	305	6*t*	
R4/W4	1575	360	6*t*	
R5/W5	(AlSilMgMn)	170	6*t*	

[1] For welds with a thickness of up to 12.5 mm inclusive.

[2] In evaluating the test results, it is necessary to be guided by the following:

the surface of the specimen shall be free of cracks with the length of more than 3 mm in any direction;

cracks at the edges of the specimen may be disregarded if their occurrence is not due to the absence of welding.

Note: *t* – specimen thickness

Symbols:
W – wire;
R – rods

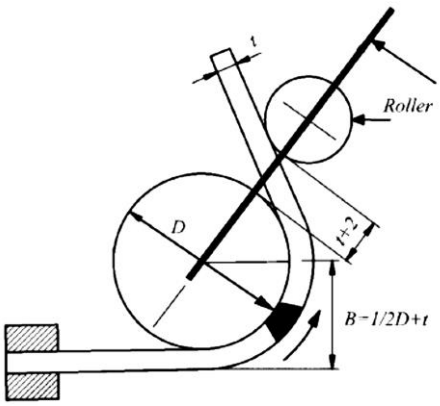


Fig. 4.7.3.6 Arrangements for static bending tests according to the technique of specimen bending around a fixed mandrel

4.8 WELDING CONSUMABLES FOR WELDING OF CORROSION-RESISTANT (STAINLESS) STEEL AND FOR SURFACING

4.8.1 General.

4.8.1.1 The present requirements apply to welding consumables intended for welding of corrosion-resistant (stainless) steels meeting the requirements of 3.16, Part XIII "Materials", also for metal deposition to ship machinery items.

The present Chapter contains provisions related to approval and testing of welding consumables.

When preparing the test assemblies and conducting individual types of tests, one shall be guided by respective provisions of 4.2.

4.8.1.2 The welding consumables for welding of corrosion-resistant steels are divided into grades depending on the structure and composition of steels to be welded in accordance with directions of Table 4.8.1.2. It is assumed that the weld metal has the alloying system similar to that of the base metal and provides mechanical properties and corrosion resistance identical to those of the base metal.

In cases, when the welding consumables are employed for deposition or for welding dissimilar joins, the classification presented in Table 4.8.1.2 is retained, but serving as the basis for it is the chemical composition and structure of the deposit or weld metal (and not of assembled or deposited parts).

4.8.1.3 Designation of the grade of welding consumables intended for welding of corrosion-resistant steels and for deposition shall include, additionally, identification (in brackets) of typical (brand) chemical composition of deposited metal, as specified in 3.16.1.1, Part XIII "Materials" for steels.

Examples: A-6 (x5CrNiMo 19 11 3),

A-6 is a grade of welding consumable according to classification given in Table 4.8.1.2;

x5 is carbon fraction of total mass, in per cent;

Table 4.8.1.2

Grades of welding consumables	Base metal for testing			Scope of use (steel grade)	
	Designation	Kind		AISI/UNS	national
		AISI/UNS	national		
1	2	3	4	5	6
M-1	x20 Cr13 x30Cr13	410 420	20X13 30X13	410 420	20X13 30X13
	x7 CrNiNb 16 4	–	07X16H4Б	–	07X16H4Б
MF-2	x15 CrNi 17 2	431	14X17H2	431	I4XI7H2
	xl0 CrNi 13 1 x8 CrNi 13 4	414, 410S	08X14НДЛ 05X12H2T 06X13H4ДМ	414, 410S	08X14НДЛ 05X12H2T 06X13H4ДМ
	xl0 CrNi 15 4	429	08X15H4ДМЛ	429	08X15H4ДМЛ
F-3	x8 Cr Ti 17	430 T	08X17T	430T	08X17T
AM-4	x8 CrNiTi 17 6	–	08X17H6T	–	08X17H6T
A-5	x2 CrNi 19 11 x10 CrNiTi 18 10 x10 CrNiNb 18 10	304L, 304 LN 321 347	– 08X18H10T I2X18H10T 08X18H10Б	304, 304L, 304LN, 321[1], 347[1], 308, 308L	08X18H10T I2X18H10T 08X18H10Б

A-6	x2 CrNiMo 17 13 2	316L, 316LN	03XI7H14M3	304, 304L, 304LN, 316, 3I6L, 316LN[1], 316Ti, 316Cb, 317, 317L, 3I7LN[1], 321, 347	08XI9H10T 12X18H10T 08X18H10Б 03XI7H14M3 10X17H13M3T 08XI7H13M2T 03X15H16M3Б
	x2 CrNiMo 18 13 3	3I7L, 317LN	–		
	xl0 CrNiMoTi 17 13 3	–	10X17H13M3T		
	x6 CrNiMoTi 17 12 2 x6 CrNiMoNb 18 16 3	316Ti –	08X17H13M2T 03X16H15M3Б		
A-7	x2 CrNiMoCu 20 18 6	S31254	–	S31254	–
	x2 CrNiMoCu 20 25 4 2	N08904	–	S31254, N08904	
AF-8	x2 CrNiMo 22 5 3	S31803	03X22H5AM3	S31803	03X22H5AM3
	x3 CrNiMo 25 6 3 x4 CrNiMo 25 5 3	S31260 S32550	– –	S31260 S32550	–
	x2 CrNiMo 25 7 4 x3 CrNiMo 25 7 3	S32750 S32760	– 03X25H7AM4	S32750 S32760	– 03X25H7AM4
	xl0 CrNiTi 22 6 xl0 CrNiMo 21 6 3	– –	08X22H6T 08X21H6M2T	– –	08X22H6T 08X21H6M2T
A-9sp (special)	x2 CrNi 24 12 xl0 CrNi 24 12 xl0 CrNiCb 24 12	309L 309S 309Cb	– – –	309L, 309S, 309SCb. and also for: welding of heterogeneous welds; welding of intermediate passes when welding clad steels; deposition of an intermediate layer	
A-10sp (special)	Weld metal: x8 CrNiVN 16 25 6 xl CrNi 26 22	– –	– –	For welding: heterogeneous welds; welding of intermediate passes for clad steel connections; steel of grades M-1, M-2, M-3 and AM-4 (that fill the passes)	

[1] The scope of use shall be valid subject to compliance with requirements for mechanical properties in Tables 4.8.4.1-1 and 4.8.4.1-2

Cr, Ni, Mo are symbols of respective alloying elements (chrome, nickel, molybdenum);

19, 11, 3 are fractions of total mass of the above alloying elements (Cr, Ni and Mo, respectively).

4.8.1.4 The requirements of the present Chapter apply to the following welding consumables and welding processes:

coated electrodes for manual arc welding;

combinations "wire-flux" for automatic and semiautomatic welding;

combinations "strip-flux" for automatic deposition;

combinations "wire-gas" for semi-automatic and automatic active and inert-gas metal-arc active or inert gas welding;

combinations "wire-gas" for automatic tungsten inert-gas arc welding;

combinations "rod-gas" for manual tungsten inert-gas welding;

combinations "wire-gas" for automatic inert-gas plasma-arc welding;

flux cored wire for automatic and semi-automatic metal arc welding with or without gas shield.

4.8.1.5 The requirements for welding consumables' approval procedure and also for survey of manufacturers and procedure of issuing the Certificates of Approval of Welding Consumables shall comply with the directions of 4.1.

4.8.2 Scope and types of tests for welding consumables.

4.8.2.1 Welding consumables for welding of corrosion-resistance steels.

As a rule, the welding consumables intended for welded joints on corrosion-resistant steels shall be subjected to the following tests:

to determine the properties of the deposited metal;

to determine the properties of butt welds;

weld metal resistance to ICC;

hot cracking test.

For corresponding categories of welding consumables, additional corrosion testing shall be conducted upon a separate request of the Register or within the scope of approval specified by the manufacturer.

Examples: 1) determining the resistance against pitting corrosion under the influence of chlorides (sea water);

2) test for corrosion cracking under stress in environments containing hydrogen sulphide at room and elevated temperatures etc.

Actual scope of testing for welding consumables of different grades intended for corrosion-proof steel welding jobs shall be determined in accordance with the requirements of Table 4.8.2.1.

4.8.2.2 Welding consumables for welding of cladding corrosion-resistant layers.

Welding consumables intended for the deposition of cladding corrosion-resistant layers in ship engineering articles shall usually be subject to the following tests:

tests for determining weld metal properties:

tests for determining the technological strength of cladding layers during static bending tests;

for weld metal resistance to ICC;

for determination of tendency to hot cracking

Table 4.8.2.1 **The volume and the types of testing of welding consumables for corrosion-resistant steels**

Type of testing assembly and characteristics to be determined	Grades of welding consumables									
	M-1	MF-2	F-3	AM-4	A-5	A-6	A-7	AF-8	A-9sp	A-10sp
Deposited metal test assembly:										
R_m	+	+	+	+	+	+	+	+	+	+
$R_{p0.2}$	+	+	+	+	+	+	+	+	+	+
$R_{p1.0}$	–	–	–	–	–	+	–	–	–	–
A_5	+	+	+	+	+	+	+	+	+	+
KV^{+20}	+	+	+	+	+	+	+	+	+	+
KV below zero	–	–	–	–	–	+	–	–	–	–

chemical composition of deposited metal	+	+	+	+	+	+	+	+	+	+
Test assembly of butt weld:										
R^{cond}_{m} with the fixation of the specimen destruction site	+	+	+	+	+	+	+	+	+	+
angle of V-bend in static bending test	+	+	+	+	+	+	+	+	+	+
weld metal resistance to ICC	+[3]	–	+	+	+	+	+	+	+[3]	+[3]
resistance of cladding metal to pitting corrosion	–	–	–	–	–	–	+	+	–	–
resistance of deposited metal to stress corrosion in presence of	–	–	–	–	–	–	+	+	–	–
a-phase content in weld metal	–	–	–	–	–	+	–	+	+	–
Technological test assembly for determination of tendency to hot cracking[1]	+	+	+	+	+	+	+	+	+	+
Multilayer deposition[2]:										
a-phase content	–	–	–	–	–	+	–	+	+	–
chemical check analysis	+	+	+	+	+	+	+	+	+	+
resistance of deposited metal to ICC	+[3]	–	+	+	+	+	+	+	+[3]	+[3]

End of Table 4.8.2.1.

[1] By agreement with the Register the tee-joint test assembly may be replaced by layer-by-layer control of other types of test assemblies.

[2] The multi-layer deposition is performed in accordance with a separate Register requirement, for example, when it is necessary to carry out a check analysis of a-phase content using the volumetric magnetic method.

[3] for determination of deposited metal properties; for determination of technological strength of the cladding layer in static bending tests;

Examples: M-l (x7CrNiNb 16 4), A-9sp (x2CrNiNb 24 12), A-10sp (xlCrNi 26 22)

Additional corrosion tests of the cladding layer are conducted in accordance with a separate requirement of the Register in compliance with the directions of 4.8.2.1.

Actual scope of testing for welding consumables of different grades intended for deposition jobs shall be determined in accordance with the requirements of Table 4.8.2.2.

Table 4.8.2.2 **The volume and the types of testing of welding consumables for deposition of ship engineering articles**

Type of testing assembly and characteristics to be determined	Grades of welding consumables					
	A-5	A-6	A-7	AF-8	A-9sp	A-10sp
Deposited metal test assembly[1]:						

R_m	+	+	+	+	+	+
$R_{p0.2}$	+	+	+	+	+	+
$R_{p1.0}$	+	+	–	–	–	–
A_5	+	+	+	+	+	+
KV^{+20}	+	+	+	+	+	+
chemical composition of deposited metal	+	+	+	+	+	+
Simulation test assembly of cladding deposit:						
static bending test	+	+	+	+	+[2]	+[2]
a-phase content	+	+	–	+	+	–
chemical check analysis	+	+	+	+	–	–
resistance of deposited metal to ICC	+	+	+	+	+[3]	+[3]
resistance of cladding metal to pitting corrosion	–	–	+	+	–	–
resistance of deposited metal to stress corrosion in presence of	–	–	+	+	–	–
hydrogen sulphide layer-by-layer checking for appearance of hot cracks	+	+	+	+	+	+

[1] For combinations "strip-flux" the specimens intended for determination of the above characteristics shall be taken from multi-layer deposited metal.

[2]Tests shall be carried out using combinations with other consumables forming the clad layer.

[3]The test for resistance to ICC is mandatory, when, the range of approval requested by the manufacturer includes both the transition and main layers of the deposited metal consisting of corrosion-resistant material of type A-9sp (X2CrNiNb 24 12), A-10sp (XlCrNi 26 22).

4.8.3 Requirements for test assembly materials.

4.8.3.1 General.

Types of testing assemblies and requirements for their production corresponding to 4.2 shall remain valid for welding consumables intended for welding corrosion-resistant steels and for depositing.

The following specific application features of high-alloy welding consumables shall be considered:

the likelihood of worsening the resistance to intercrystalline corrosion in the heat affected zone of the base metal, especially when welding on large linear energies;

a higher predisposition of high-alloyed weld metal to forming hot cracks as compared with low-alloy welding consumables;

a higher degree of "shrinkage" of the weld metal and, consequently, higher angular and linear deformation during welding as compared to low-alloy welding consumables;

an increased plasticity of melted metal, which requires a limitation of the welded pool and the use of lower diameters of welding wire when welding in identical conditions as compared with low-alloy welding consumables;

increased resistivity and lower heat-transfer coefficient of high-alloy welding consumables that require specific current load restrictions.

4.8.3.2 Tests of deposited metal.

For testing weld metal, the following shall be prepared and welded in the lower position:

one test assembly, as shown in Fig. 4.2.4.1, intended tor manual and semi-automatic welding

one test assembly, as shown in Fig. 4.2.6.2.1, intended tor automatic welding.

As the base metal for preparation of die test assemblies a steel shall be used, which corresponds to die grade of welding. consumable indicated in Table 4.8.I.2.

As an alternative for preparation of die test assemblies, hull structural steel of normal or higher strength of any grade may be used, with' preliminary feeing of weld edges with welding consumables to be certified or of similar grade.

Deposition as directed in Fig. 4.8.3.2 shall be done in three layers: the first one with consumables for padding of transition layers of Grade A-9sp or A-10sp, and then two cladding layers, using the welding method and consumables to be certified.

In this case; subject to permission of the Register, the deposition by submerged arc (combination "wire-flux") may be replaced with deposition of the cladding layer using combination "wire-gas" or coated electrodes of similar grade and of similar chemical composition.

After deposition of metal layers to the edges of the weld it is recommended to dress the buttered edges with abrasive tools or to perform machining of the edges and the backing strip to restore the geometrical parameters of the prepared edges shape.

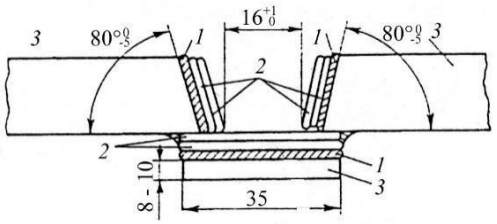


Fig. 4.8.3.2 Deposition edge preparation arrangements for deposited metal specimens:

1 - intermediate layer/sublayer (welding consumables of grade A-9sp or A-10sp); 2 - main cladding layer (welding consumables to be certified); 3 - base metal (normal or higher-strength steel)

Table 4.8.3.2

Process welding	Method welding **(ISO 4063)**	Diameter of welding wire (rod), mm (rod), mm	
		for facing of edges	for filling of the groove
Manual	111	2.5 − 3.0	3.0 − 4.0
Automatic	12	2.0	2.5 − 3.2
Automatic and semi-automatic	131 135	1.0 − 1.2 1.0 − 1.2	1.4 − 1.6 1.4 − 1.6
Manual	141	2.0 − 2.4	2.5 − 3.2
Automatic	141	1.0 − 1.6	1.2 − 1.6
Automatic and semi-automatic	114 136 137	0.9 − 1.4 0.9 − 1.2 0.9 − 1.2	1.2 − 1.6 1.2 − 1.6 1.2 − 1.6
Manual	15	2.0 − 2.4	2.0 − 3.0
Automatic	15	1.0 − 1.2	1.2 − 1.6

For welding of the assembly with deposited metal it is recommended , depending on the welding process and type employed to select the welding wire (or filler rods) with diameter corresponding to values indicated in Table 4.8.3.2.

The welding conditions shall comply with directions of the welding

consumables manufacturer and with the technical documentation for welding of structures approved by the Register.

Heat treatment after welding of deposited metal assemblies is not used normally. Exception is made for welding consumables employed for metal deposition on ship machinery articles. In this case the assemblies are subjected after welding to imitated single-time tempering of welded joint at 630 to 650 °C during 40 min with subsequent cooling in the air.

The temperature inside the furnace, before loading of the specimens shall not exceed 350 °C.

4.8.3.3 Butt weld tests

To determine the weld properties, it is necessary to carry out welding of assemblies, the quantity and dimensions of which are indicated in 4.2 for respective welding materials and processes. By agreement of the Register the quantity of test assemblies may be reduced within the following limits:

for welding consumables intended for downhand welding only one test assembly is sufficient;

for combinations "wire-gas" (131, 135, 141 and 15 by ISO 4063) two assemblies are required. In this case the properties of butt welds shall be determined with respect to downhand and vertical (vertical-upward) welding positions.

For welding of joint assemblies it is recommended to use welding wire with diameters, as specified in Table 4.8.3.2:

for root passes follow the directions given for facing of edges of deposited metal test assemblies;

for filling of the grooves follow the respective directions for deposited metal test assemblies.

The butt-welded test assemblies shall be prepared using the steel of the same grade, which is specified for the welding consumables. When selecting the base metal for a butt-welded test assembly, one shall take into account the necessity to ensure the level of the weld properties specified in Table 4.8.4.1-2 for the grade of welding consumables to be certified.

For welding consumables of Grades A-9sp and A-lOsp intended for dissimilar joints and deposition of intermediate layers, the butt-welded test assemblies may be prepared in two ways:

one side of the test assembly is produced from corrosion-resistant steel of Grade A-5 or A-6, the other side from higher or high strength steel with ultimate breaking strength at least equal to that of deposited metal;

both sides of the test assembly are produced from higher or high strength steel with the level of strength corresponding to the welding consumable to be certified.

4.8.3.4 Hot cracking test.

The welding consumables intended for corrosion- resistant steels shall be subjected to hot cracking test estimated on test results of tee-joint test assemblies.

In case of manual or semi-automatic welding for each welding consumable to be approved, three test assemblies shall be welded, their dimensions as shown in Fig. 4.2.4.3, in case of automatic welding — one test assembly of $L \geq 500$ mm shown in Fig. 4.2.5.

The base metal for manufacture of test assemblies, as well as diameters of

welding wire/rods, shall be selected as specified in 4.8.3.3.

For welding consumables intended exclusively for deposition operations, manufacture of tee-joint test assemblies may be omitted. In this case the resistance to hot cracking is estimated with the use of layer-by-layer control method for the deposited metal and also in the process of side-bend testing of specimens with cladding deposit.

4.8.3.5 Static bending test for lusion-clad layers.

4.8.3.5.1 Bend testing of fusion-clad layers is performed for estimation of clad layer plastic properties, bond surface, as well as heat affected zone.

This type of testing may be done in the following ways:

bending with tensioning of the clad layer (the load is applied normally to the bond surface) and with strain orientation normally to the direction of welding in the process of deposition;

bending with tensioning of the clad layer (the load is applied parallel to the bond surface) and with strain orientation along the direction of welding in the process of deposition;

side-bend testing of specimens (the load is applied parallel to the bond surface). In this case the bending load may either coincide with the direction of welding, or be perpendicular to it.

Testing of fusion-clad layer shall be performed by side-bend method with the load applied normally to the direction of welding.

In static bending other types of tests employed, as required by the Register in cases of ambiguity of the main test results.

Note. The side-bend testing with load application parallel to the direction of welding is performed, as a rule, in approval of welding deposition procedures, as this is the most objective method for estimation of internal defects (poor fusion, cracks, etc.) caused directly by technological factors.

4.8.3.5.2 To conduct static bending test of fusion-clad layers, an assembly-imitator of the cladding deposit shall be manufactured, as required by 4.8.3.5.2.

The cladding layer shall be deposited on hull structural steel of any grade of higher or high strength ensuring proper testing with a mandrel of required diameter (refer to Fig. 4.8.4.2).

The deposition shall be performed with observation of the requirements and recommendations given below.

The first layer (sublayer) shall be deposited using welding consumables of group A-9sp. The thickness of the first layer shall be 3 to 4 mm. The corrosion-resistant deposit shall be made with welding consumables to be approved in 2 or 3 layers, with overlapping of the beads. The plan of deposition beads application shall keep deformation of the main plate to a minimum.

The total thickness of the cladding layer after machining shall not exceed 10 mm.

The arrangements for static bending specimens cutting from the imitation test assembly are shown in Fig. 4.8.3.5.2.

If the range of approval for welding consumables permits heat treatment of fusion-clad items, the imitation assembly, before cutting the specimens out of it, shall be subjected to single-time tempering at 630 to 650 °C during 40 min with subsequent cooling in the air.

To avoid distortion of the plate, the temperature in the furnace at loading of the test assembly into it shall not exceed 350 °C.

Depending on the range of approval requested by the manufacturer the following ways of heat treatment are possible:

after the deposition of an intermediate layer;

after deposition of intermediate layer and of all cladding layers;

two-stage heat treatment: after deposition of sublayer, then after deposition of all cladding corrosion-resistant layers.

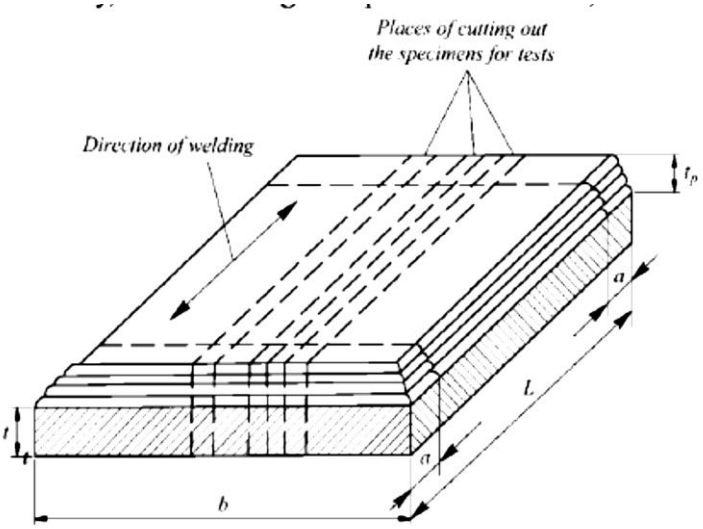


Fig. 4.8.3.5.2 Simulation test assembly of cladding deposit:
t - the thickness of the base metal; t_n - the cladding layer thickness after machining; b - the width of the test assembly; L - the length of the test assembly; a - remains;

Note. Dimension requirements:
a) for manual and semi-automatic welding methods:
$t = 14–16$; $6 \le t_н \le 10$, $b \ge 60$ mm; $L \ge 200$; $a \approx 25$;
b) for depositing with automatic submerged arc welding with a wire electrode:
$t = 16–20$; $6 \le t_н \le 10$, $b \ge 100$ mm; $L \ge 480$; $a \approx 50$;
c) for depositing with automatic welding with a belt electrode:
$t = 16–20$; $6 \le t_н \le 10$, $b \ge 120$ mm; $L \ge 480$; $a \approx 50$;

4.8.3.6 Test assemblies for preparation of specimens tested for resistance to intercrystalline corrosion.

In testing of welding consumables resistance to ICC may be estimated using specimens of weld metal or deposited metal.

In such circumstances the testing of consumables employed exclusively for deposition jobs (for example, for compositions "strip-flux") may be limited to deposited metal only. In all other cases, unless otherwise agreed upon with the Register, used as the main method of testing for resistance to ICC shall be the method, which involves testing of the weld metal in accordance with directions of 4.8.3.6.I.

4.8.3.6.1 Butt joint test assembly for testing of weld metal resistance to ICC.

Testing for resistance of weld metal to ICC shall be carried out by welding of test assemblies having dimensions as shown in Fig. 4.8.3.6.1.

In automatic and mechanized welding types the beginning and the end of the weld shall be executed on extended backing strips with dimensions ensuring steady welding procedure and absence of inadmissible defects on the controlled length of the test assembly (but not less than 100 x 100 x 10 mm).

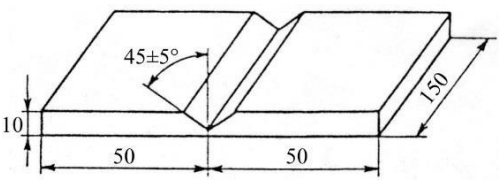


Fig. 4.8.3.6.1
Weld test assembly for the selection of specimens for testing for resistance against the ICC

The backing strip edge preparation shall have a depth of not less than 6 mm and groove angle similar to that of the test assembly (90°).

Used as the base metal shall be a corrosion-resistant steel complying in its grade and chemical composition with the filler material to be approved. The following limitations shall be observed in the process:

the corrosion-resistant steel shall be also resistant to ICC, even after provoking heating;

the base metal shall provide satisfactory results in bend-over tests when using a mandrel of the required diameter;

the mechanical properties of the base metal shall ensure uniform distribution of the residual plastic strain over the weld and near-weld area when testing static bending specimens.

To fully meet the above requirements to the base metal, it is permitted to use plates of corrosion- resistant steels differing in grade from the filler material under condition that plate edges are buttered previously with tested filler materials (or materials similar in chemical composition).

The Register may require heat treatment after welding, if this appears necessary for the range of approval requested by the manufacturer of the materials.

4.8.3.6.2 Test assembly for deposited metal testing for resistance to ICC.

The checking of deposited metal in the cladding layer for resistance to ICC shall be conducted on the checking test assemblies prepared with the use of welding consumables to be certified. General requirements for welding of the test assemblies are similar to those indicated in 4.8.3.2 and 4.8.3.5. The test assemblies are manufactured by downhand arc deposition of metal to a plate with thickness of at least 20 mm made of steel of any grade/brand.

Dimensions of the checking test assemblies shall ensure stability of the deposition process, as well as a possibility to produce four specimens to be tested for resistance to ICC and a possibility of repeated testing of the twice this number of specimens.

Arrangements for cuttings of specimens for ICC and deposition dimensions shall be as in Fig. 4.8.3.6.2.

The need for heat treatment of the test assemblies before testing for resistance to ICC depends on the range of approval requested by the applicant (as required in 4.8.3.5.2).

The conditions and quantity of heat treatments for test assemblies to be tested for resistance of the deposited metal to ICC shall be additionally approved by the Register.

As a rule, if a heat treatment after deposition of the main layer is permitted by the manufacturer of welding consumables or by the documentation for their application, the checking test assembly or blanks of specimens (prior to mechanical finishing) shall be subjected to two-time tempering at 630 to 650 °C during 40 min with subsequent cooling in the air.

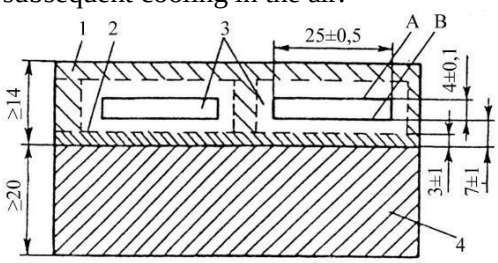


Fig. 4.8.3.6.2 Arrangements for test assembly cutting for deposited metal testing for resistance to ICC:
1 - deposited metal of the base layer;
2 - deposited metal of the sublayer;
3 - pieces for specimen manufacture;
4 - base metal (plate);
A and B - specimen surfaces

4.8.4 Testing methods and evaluation of results.

4.8.4.1 Determination of mechanical properties of deposited metal and welds.

The test assembly of deposited metal shall be used to produce and to test longitudinal cylindrical proportional specimens under Fig. 2.2.2.3 (*a*) of Part XIII "Materials" dimensioned as follows:

d_0 = 10 mm, L_0 = 50 mm, L_c = 60 mm and $r \geq 5$ mm.

The longitudinal axis of the specimen shall coincide with the centre of the weld and the middle point of the metal deposit thickness.

One specimen is required (when testing specimens with working part diameter of 6 mm, three specimens from each test assembly shall be tested).

The impact energy for deposited metal is determined on V-notch specimens meeting the requirements of 2.2.3, Part XIII "Materials".

The plan of specimens cutting out is shown in Fig. 4.2.3.2.2-1.

Three specimens are taken from each test assembly.

A butt weld test assembly is employed for preparation and testing of:

2 transverse flat fracture specimens with dimensions as shown in Fig. 4.2.3.2.1;

transverse static bend specimens in accordance with Fig. 2.2.5.1, Part XIII "Materials" complying with the directions of 4.2.2.2.2 (specimen dimensions: $a_0 = t$ - the thickness of the specimen metal; b_0 = 30 mm);

Charpy impact test specimens.

They shall be cut out as shown in Fig. 4.2.3.2-1, their type shall meet the requirements of 2.2.3, Part XIII "Materials".

For dissimilar welded joints, made with the use of welding consumables of Grade A-9sp or A-10sp, in static bending tests instead of transverse specimens longitudinal specimens shall be used, in compliance with Fig.

The length of the test assembly in this case shall be sufficient to ensure the manufacture of such specimens.

General requirements for the procedure for testing and assessment of results are set out in 4.2.3; the criteria for evaluating the test results are provided in Tables 4.8.4.1-1 and 4.8.4.1-2.

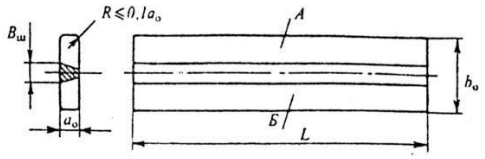


Fig. 4.8.4.1 Specimen with longitudinal weld for static bend testing of metal of dissimilar welded joint:

A — part of the test assembly made of corrosion-resistant steel;

B — part of the test assembly made of higher or high strength hull structural steel;

$a_0 = t$ — thickness of base metal;

b_0 = 30 mm but not less than (B_w + 24) mm;

$L \geq D_{opr} + 9a_0 \approx 12a_0$,

where D_{opr} - the diameter of the mandrel at bending tests.

4.8.4.2 Static bending test of specimens with cladding depositions.

Static bending tests shall apply to three specimens of cladding depositions whose load arrangements provides for the application of the load parallel to the bond surface (lateral bending) and perpendicular to the direction of welding when depositing.

Dimensions of the specimens with cladding depositing and test parameters shall conform to Fig. 4.8.4.2.

Specimens for testing should be selected by mechanical cutting. When using plasma cutting for sampling, the allowance for machining shall be sufficient to ensure the complete absence of a heat affected zone in the specimen.

Testing methods shall provide for two stages of testing:

static bending to the angle of about 90 degrees with fixation of the obtained intermediate result (without removing the specimen);

continued testing until the final bending angle of, at least, 120 degrees; removal of specimens; and fixation of the obtained result.

If an unacceptable crack appears in the bending zone before the required angle is reached, testing shall be terminated. The following cracks shall be deemed unacceptable for this type of testing:

transverse cracks with a length of 3 mm or more;

longitudinal lack of completeness that is detected at specimen bending and that has a length of 20% or more of the width of the specimen.

4.8.4.3 Test of resistance to intercrystalline corrosion (ICC).

4.8.4.3.1 Testing intended to determine resistance of the weld metal and the deposited metal to intercrystalline corrosion shall be conducted in accordance with national or international standards that provide for curing of specimens in boiling a water solution of copper sulphate and sulphuric acid in the presence of metallic copper followed by bending of specimens at an angle of 90 degrees in order to detect signs of intercrystalline corrosion (the Strauss method).

Table 4.8.4.1-1 **Requirements for mechanical properties of deposited metal**

Grades of welding consu-	Designation of steel being welded	Static stress test				Impact test		Range of approval	
		$R_{p0.2}$, MPa	$R_{p1.0}$, MPa	R_m, MPa	A_5, %	Temperature,	*KV*, J, min	AISI/UNS	national

mable		min				°C			
1	2	3	4	5	6	7	8	9	10
M-1	x20Crl3; x30Crl3	440	–	650	16	+20	60	410 420	20X13 30X13
	x7 CrNiNb 16 4	735	–	850	13	+20	60	–	07X16H4Б
MF-2	x10 CrNi 13 1	380	–	540	16	–10	20	414, 410S	08X14НДЛ 05X12H2T
	x10 CrNi 15 4 x15 CrNi 17 2	550 540	– –	750 690	12 16	–10 +20	30 60	429 431	08X15H4ДМЛ 14X17H2
F-3	x8 CrTi 17	360	–	480	16	+ 20	60	430T	08X17T
AM-4	x8 CrNiTi 17 6	630	–	730	12	+ 20	60	–	08X17H6T
A-5 and A-6	x2 CrNi 19 11 x10 CrNiTi 18 10 x10 CrNiNb 18 10 x2 CrNiMo 17 13 2 x2 CrNiMo 18 13 3 x10 CrNiMoTi 17 13 3	270	310	510	30	+ 20 –196[1]	80 50[1]	304, 304L 316, 316L 317, 317L 308, 308L	08X17H13M2T 03X17H14M3 10X17H13M3T 03X16H15M3
	x6 CrNiMoTi 17 12 2	290	330	550	30	+20 –196[1]	80 50[1]	Ditto and 321, 347	Ditto and 08X18H10T 08X18H12Б
	x6 CrNiMoNb 18 16 3	305	–	580	30	+20	60	Tecame and 316LN, 317LN	Ditto
A-7	x2 CrNiMoCu 20 18 6 x2 CrNiMoCu 20 25 4 2	300 270	340 310	650 510	30 30	+20 +20	60 80	S31254 N08904	– –
AF-8	x2 CrNiMo 22 5 3	480	–	680	25	+20 –60[1]	80 40[1]	S31803	03X22H6M2
	x2 CrNiMo 25 7 4 x2 CrNiMo 25 7 3	550	–	780	20	+20 –60[1]	80 40[1]	S32750 S32760 S32550 S31260	08X21H6M2T Ditto Ditto Ditto
A-9sp (special)	Weld metal: x2 CrNi 24 12 x10 CrNi 24 12 x10 CrNiCb 24 12 and similar	350	470	520	30	+20	80[2]	For welding: of heterogeneous welds; intermediate passes of connections of cladding steel; deposition of the intermediate (transitional) sublayer, steel categories 309L, 309S, 309SCb	
A-10sp (special)	Weld metal: x8 CrNiMoV 16 25 6	390	–	610	26	+20 –80[1]	80 60[1]	For welding: heterogeneous welds; of intermediate passes of cladding steel; of welding of filling passages with steel of grades M-1, MF-2, F-3 and AM-4	
	x8 CrNiMoVN 16 25 6	490	–	680	26	+20 –80[1]	80 60[1]		
	xl CrNi 26 22	390	–	550	30	+20	60		

End of Table 4.8.4.1-1.

[1] Testing at temperatures below zero shall be performed upon special requirement of the Register in accordance with the scope of approval declared by the manufacturer.

[2] In the initial state after welding (without heat treatment)

Table 4.8.4.1-2 **Requirements for mechanical properties of butt welded joint metal**

Grades of welding consumables	Base metal for testing		Static stretching (transverse specimens) R_m, MPa, min	Impact test		Bend test		
	Designation	Grades according to AISI/UNS		Temperature, °C	*KV*, J, min	Specimen type	Diameter of the mandrel	Bend angle, deg. min
M-1	x20 Cr13	410	650	+20	60	Transverse	4*t*	120
	x30 Cr13	420	650	+20	60	Transverse	4*t*	120
	x7 CrNiNb 16 4	–	850	+20	60	Transverse	6*t*	120
MF-2	x10 CrNi 13 1	414, 410S	540	–10	20	Transverse	4*t*	120
	xl0 CrNi 15 4	–	740	–10	30	Transverse	4*t*	120
	xl5 CrNi 17	431	690	+20	60	Transverse	4*t*	120
F-3	x8 CrTi 17	430Ti	440	+20	60	Ditto	4*t*	120
AM-4	x8 CrNiTi 17 6	–	730	+20	60	Ditto	4*t*	120
A-5 and A-6	x2 CrNi 18 10 x2 CrNiMo 17 13 2 x2 CrNiMo 18 13 3 x6 CrNi 20 11	304, 304L 316, 316L 317, 317L, 308, 308L	440	+20 –196[1]	80 50[1]	Ditto	2*t*	120
	x10 CrNiTi 18 10 x10 CrNiNb 18 10	321, 347	490	+20 –196[1]	80 50[1]	Ditto	2*t*	120
	x2 CrNiMoN 17 13 2 x2 CrNiMoN 18 13 3	316LN, 317LN	540	+20	60	Ditto	3*t*	120
A-7	x2 CrNiMoCu 20 18 6	S31254	620	+20	80	Ditto	3*t*	120
	x2 CrNiMoCu 20 25 4 2	N08904	510	+20	80			
AF-8	x2 CrNiMo 22 5 3	S31803	650	+20	80	Ditto	4*t*	120
	x2 CrNiMo 25 7 4	S32750	720	+20	60			
	x3 CrNiMo 25 7 3	S32760	720	+20	60			
A-9sp	Heterogeneous, for example, A-6 + D36		>= R_m^{min} of the base metal	+20	80[2]	Longitudinal	3*t*	120
A-10sp	Ditto		Ditto	+20 –80[1]	80 60[1]	Longitudinal	3*t*	120

[1] Refer to Note 1 to Table 4.8.4.1-1

At initial approval of welding consumables a variety of this method shall be used, in which the specimens are immersed in the boiling solution for at least 24 h.

at repeated tests it is permissible, by agreement with the Register, to employ an accelerated test procedure, with the specimens kept in the boiling solution for a period from 8 to 15 h.

4.8.4.3.2 Unless otherwise agreed upon with the Register, the dimensions of specimens for ICC testing (refer to Fig. 4.8.4.3.2) and diameters of bending mandrels shall correspond to values in Tables 4.8.4.3.2-1 and 4.8.4.3.2-2.

The resistance of weld metal to ICC is evaluated on the basis of test results obtained from three specimens subjected to tensioning of the weld top layer, which corresponds to testing of the base metal plate initial surface (not subjected to machining intended for reduction of specimen thickness). The area of application of the bending load (the mandrel axis) shall coincide with the centre line of the weld.

Note. Bending with application of the load within the heat affected zone is employed for testing of corrosion-resistant steels and for approval of welding procedures.

The resistance of cladding layer metal to ICC is evaluated on the basis of test results obtained from four specimens cut out in accordance with the directions of Fig. 4.8.3.6.2; of these specimens:

two specimens are tested by tensioning the top surface A (top surface) of the deposit;

two specimens are tested by tensioning the top surface B (bottom surface) of the deposit.

4.8.4.3.3 The bent specimens shall be inspected using a magnifying glass with 8-12X magnification. Absence of cracks in the specimen, apart from longitudinal cracks and cracks directly on the edges, is a proof of resistance to ICC.

In questionable cases the resistance to ICC is additionally estimated by a metallographic method.

In this case from a non-bent portion of the specimen after corrosion testing a wafer is cut to obtain a microsection; the plane of the cut shall be normal to the weld and contain the weld metal and heat affected zone. The presence and depth of intercrystalline corrosion is established on etched sections using 200X magnification.

The maximum depth of corrosive attack is revealed in six fields of vision, which shall include portions with largest depth of ICC. The specimen is considered corrosion (ICC) — resistant, if the decay at grain boundaries has the maximum depth not exceeding 30 micron.

4.8.4.3.4 The result of the test for resistance to ICC is considered satisfactory, if the ICC is not detected on any of the tested specimens.

If one of the tested specimens yields unsatisfactory results, the tests shall be repeated, as required by national or international standards.

If at the initial tests more than one specimen proved to be unsatisfactory, or if the repeated tests produced negative results, the weld or deposited metal is considered as having failed the tests for resistance to ICC.

Note. In ambiguous cases for materials susceptible to cracking it is recommended to carry out, as a reference check, bending tests for specimens, similar to ICC-tested, but not subjected to boiling in aqueous solution of sulphuric acid and copper sulphate.

4.8.4.4 Cheek of a-phase (ferrite component).

Inspection of α-phase (ferrite component) in the weld metal and

cladding layer is determined in welding consumables of Grades A-5, A-6, AF-8 and A-9sp using the following methods of measurement:

.1 local non-destructive testing method, where the a- phase content is estimated as the mean value of at least 10 measurements for butt-welded joint assemblies, also for assemblies with cladding deposits, as specified in and 4.8.3.6;

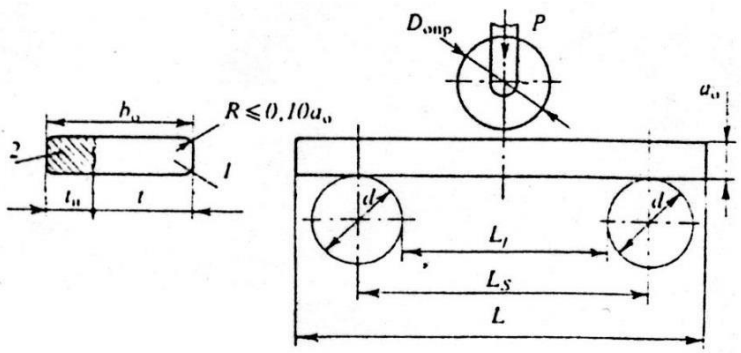


Fig. 4.8.4.2 Specimen with cladding deposition for lateral bending tests:
1 – base metal; 2 – cladding deposition; $a_0 = 10^{+0.1}$ mm – the thickness of the specimen, $b_0 = t + t_н \leq 35$ mm – the width of the specimen (where t – the thickness of the base metal; $6 \leq t_н \leq 10$ – the thickness of cladding deposition); $D_{opr} + 3a_0 = 30$ mm – the diameter mandrel for bending; $d = 30$ mm – the diameter of bead bearing; $L_1 = D_{opr} + 3a_0 = 60$ mm – clearance between the beads; $L \geq 160$ mm – the length of the specimen; $R \leq 0.1a_0$ – the permissible rounding radius of the free edge of the specimen; P – created load

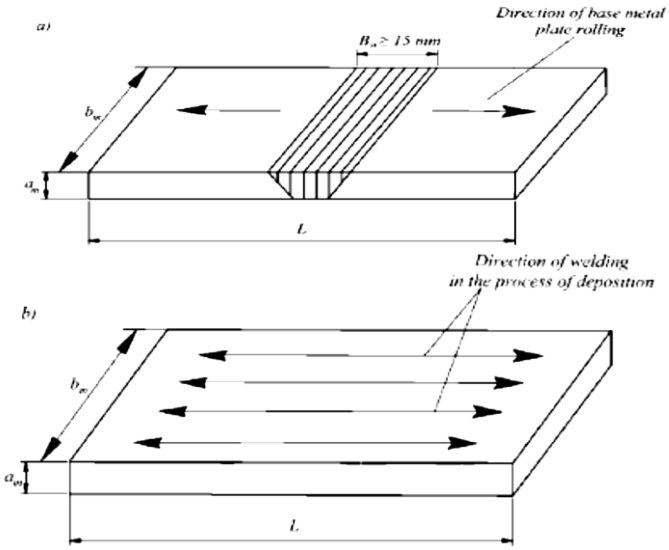


Fig. 4.8.4.3.2 Specimens tested for resistance to intercrystalline corrosion.
a – the weld metal as part of the weld;

b - the deposited metal of the cladding layer

Table 4.8.4.3.2-1. **Specimen size and curvature diameters of mandrels during weld metal tests for resistance to ICC**

Grades of welding consumables	Specimen thickness a_0, mm	Specimen width b_0, mm	Specimen length L, mm	Diameter of mandrel, mm
A-5, A-6, A-7, A-9sp	6 ± 0.1	20 ± 0.5	≥ 100	20
AF-8	5 ± 0.1	20 ± 0.5	≥ 100	20
F-3	5 ± 0.1	20 ± 0.5	≥ 100	30
AM-4, MF-2, M-1	3 ± 0.1	20 ± 0.5	≥ 80	20

Table 4.8.4.3.2-2. **Specimen size and curvature diameters of mandrels during deposited metal tests for resistance to ICC**

Grades of welding consumables	Specimen thickness a_0, mm	Specimen width b_0, mm	Specimen length L, mm	Diameter of mandrel, mm
A-5, A-6, A-9sp	4 ± 0.1	20 ± 0.5	≥ 100	20
AF-8	4 ± 0.1	20 ± 0.5	≥ 100	20

.2 if the above measurement method produced inadequate results, or in accordance with a special requirement of the Register, a check analysis is performed by the volumetric magnetic method with the use of ferritemeters, which make measurements with error not exceeding +10 per cent of the measured value.

The analysis for determination of a-phase content with the aid of volumetric magnetic method requires a seven-layer deposition with welding consumables analysed to a corrosion-resistant steel plate, which in its grade and chemical composition corresponds to the above consumables.

From the two top layers of deposited material pilot cylindrical specimens are cut having a length of (60+1) mm and diameter of (5 + 0.1) mm, as shown in Fig. 4.8.4.4).

The controlled values of a-phase content shall meet the requirement of technical documentation approved by the Register or specified by respective national standards for particular welding consumables.

The results of check measurements of a-phase content in the weld metal and/or cladding layer shall be recorded in the Test Report.

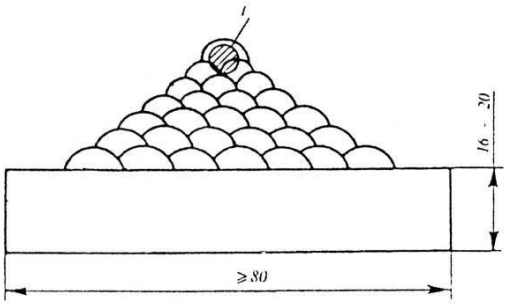


Fig. 4.8.4.4 The test assemblies for determination of chemical composition of deposited metal shall be taken from metal of two top layers; these are:
1 - site of selection reference specimens

4.8.4.5 Determination of chemical composition of deposited metal.

Selection of test assemblies to determine the chemical composition of deposited metal shall be made using the metal from top two layers:

test assembly of deposited metal;

test assembly of multilayer deposit taken in accordance with Fig. 4.8.3.6.2 (for compositions "strip- flux" the test assemblies for determination of

chemical composition are taken from deposited metal only).

The results of determination of deposited metal chemical composition shall comply with tolerances claimed by the manufacturer and shall be recorded in the Test Report.

4.8.5 Tests for confirmation of Certificate of Approval for Welding Consumables.

The program of annual re-approval test of welding consumables for corrosion-resistant steels welding and deposition shall include:

.1 manufacture of deposited metal assembly and testing of specimens, static tensile and impact bend as well as checking chemical analysis of the deposited metal;

.2 determination of resistance of weld metal or deposited metal to ICC, if this is required for a particular brand of welding consumable.

If required by the Register, the scope of annual tests may be extended and supplemented by other types of testing or preparation of additional test assemblies.

4.9 WELDING CONSUMABLES FOR ELECTRIC-SLAG AND GAS-ELECTRIC VERTICAL WELDING

4.9.1 General.

4.9.1.1 The requirements of this Section specify the conditions of approval and survey of welding consumables intended for vertical electric-slag and gas-electric welding with a forced weld formation with or without the use of a melting rod for ship-construction steels, steel forgings and castings of the relevant grades, and also comparable steels for the construction of ship's structures.

Requirements for the approval of welding consumables for the two-pass welding technique corresponding to requirements of 4.4.3 shall also apply to the approval of the above welding consumables other than features pertaining mainly to the number and the type of specimens for mechanical testing that are selected from butt weld specimens as listed in 4.9.2.

4.9.1.2 The welding consumables for electric-slag and gas-electric welding depending on the strength level of the deposited or weld metal (R_{eH}, min) are divided into the following grades:

1, 2, 3 for normal strength steels;

1Y, 2Y, 3Y and 4Y for higher strength steels with the specified yield stress of up to 355 MPa, inclusive;

2Y40, 3Y40, and 4Y40 for higher strength steels with the specified minimum yield stress of up to 390 MPa inclusive.

Approval of welding consumables for grades 1Y, 2Y, 3Y, 4Y, 2Y40, 3Y40, and 4Y40 may be limited by the ability of their application with special higher-strength types of steel only, which allow welding at higher linear energy values.

Typically, these types of steel shall be tested under the program and the methods approved by the Register and shall have a corresponding entry in the grade designation (-W...).

In this respect, steel (usually alloyed with niobium) corresponding to the used technological process in terms of linear welding energy shall be used during approval testing.

It shall be borne in mind that the requirements for the subdivision of the above welding consumables into grades

may not fully apply to technical reasons.

4.9.1.3 Where welding consumables approval is required for welding normal and higher strength steels, two test assemblies of higher strength steel shall be manufactured and tested.

Two additional specimens of normal-strength steel can also be tested upon the specific requirements of the Register.

4.9.1.4 Information and documentation to be submitted for review.

A manufacturer shall generally submit for review the information and technical documentation attached to the request for approval containing the following data:

commercial name, type of welding wire, limits of chemical composition in the case of bare wires and information on additives in the case of flux-cored wires (or reference to a relevant normative document), and range of wire diameters to be approved;

the name of the producer, supplier, conditions of supply (surface condition, type, diameters and weight of standard coils);

welding technique and grading, under which the approval is requested;

properties, composition and requirements relevant to the shielding gas;

commercial brand and a manufacturer, in the case of gas mixtures of special types;

the type of flux and other consumables, if applicable;

type of current and maximum current values, for which the approval is requested;

main characteristics of the welding equipment;

typical chemical composition of deposited metal

basic welding technological properties of and requirements for the welding technique associated with general and specific guidelines and restrictions for the application (such as edge preparation and welding modes);

information on manufacturing capacity, facilities and quality control procedure;

packaging and labeling (marking);

recommendations for the storage and preservation of wire and flux;

information on approvals granted by other classification societies or supervisory bodies with copies of the required document attached.

The technical documentation to be approved by the Register:

manufacturer's technical specifications or specifications for welding consumables, including the current catalogue editions of manufacturers;

instructions on the products manufacture, acceptance and quality control.

4.9.2 Tests of butt welded joint

4.9.2.1 Preparation of test assemblies.

Approval of welding consumables intended for electric-slag and gas-electric welding shall require the performance of tests of two butt weld specimens (one in a thickness range of the base metal of 20 to 25 mm and the other in the range of 35 to 40 mm or more) (refer to Fig. 4.9.2.3-1).

The grade of steel for each of these specimens shall be selected according to Table 4.4.3.2.1 for two-run welding technique.

The chemical composition of the base metal for the specimens, including

the content of modifying (grain-crushing) elements, shall be given in the test report.

4.9.2.2 Radiographic testing.

Prior to the preparation of mechanical test specimens, the radiographic testing of the butt weld test assemblies is recommended for checking the presence of any internal defects.

4.9.2.3 Mechanical tests.

According to Fig. 4.9.2.3-1, the test specimens shall be taken from each butt weld test assembly. The length of the test shall be sufficient for the selection and the preparation of all the following testing assemblies:

2 longitudinal cylindrical tensile test specimens (2 LT);

two transverse flat tensile test specimens (2TT);

2 two traverse side bending test specimens (2TB);

2 series of 3 impact test specimens each notched according to Fig. 4.9.2.3-2:

1 series of specimens notched along the axis (3KVCL); one series of specimens notched along the weld metal at a distance of 2 mm from the fusion line (3KV+2FL); 1 transverse macrosection (1 M).

The results of all tests shall comply with the requirements of Table 4.4.2.2.4 for longitudinal cylindrical tensile specimens and in Table 4.4.2.3.4 for the other types of specimens in accordance with the grade of the welding consumables to be approved.

The requirements for test procedure and results evaluation shall comply with the provisions in 4.2.

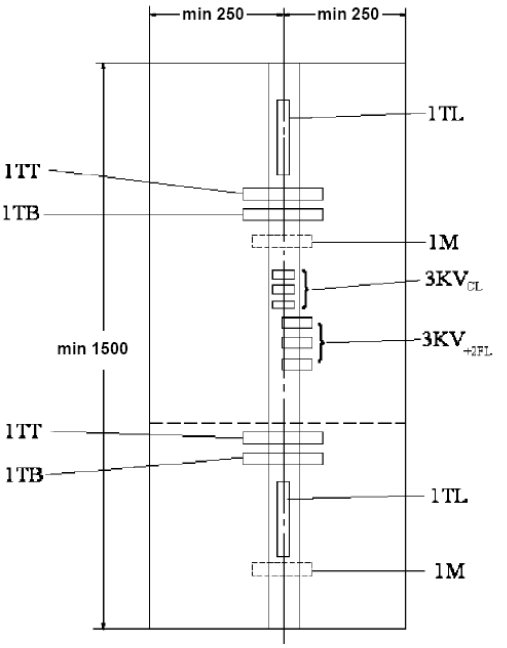


Fig. 4.9.2.3 - 1 Butt weld test assembly for the approval of electric-slag and gas-electric welding. Symbols for testing assemblies shall meet 4.9.2.3 (all dimensioned in mm unless specified otherwise)

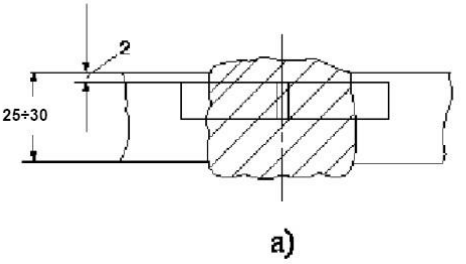


Fig. 4.9.2.3-2 Cutting arrangements and notch location for

for impact bending tests of butt weld specimens during tests for the approval of electric-slag and gas-electric welding. Symbols for testing assemblies shall meet 4.9.2.3 (all dimensioned in mm unless specified otherwise)

a) - notched along the weld axis (KV_{CL});
b) - notched along the weld metal at a distance of 2 mm from the fusion line (KV_{+2FL})

4.9.2.4 Chemical analysis of deposited metal.

Test specimens shall be taken from each test assembly for chemical analysis of the deposited metal, and the results shall be recorded in a test report if the chemical composition is regulated by the manufacturer's documentation.

4.9.3 Annual and upgrading tests.

4.9.3.1 Annual tests and re-approval surveys of the welding consumables manufacturers.

All the organizations recognized by the Register as electric slag and gas-electric welding consumables manufacturers shall be annually surveyed and their products be tested.

The extent of the annual tests shall include the preparation and tests of one butt weld test assembly of 20 to 25 mm thick according to 4.9.2.

The volume of testing shall include preparation and testing of the following types of specimens:

1 longitudinal cylindrical tensile test specimen;

1 transverse flat tensile test specimen;

2 traverse side bending test specimens;

3 impact test specimen notched along the weld axis (as in Fig. 4.9.2.3-2 a));

3 impact test specimen notched along the weld metal at a distance of 2 mm from the fusion line (as in Fig. 4.9.2.3-2 b));

1 transverse macrosection (1M);

The results of all tests shall comply with the requirements of Table 4.4.2.2.4 for longitudinal cylindrical tensile specimens and in Table 4.4.2.3.4 for the other types of specimens in accordance with the grade of the welding consumables to be approved.

4.9.3.2 Upgrading tests.

Tests on upgrading are conducted only on the manufacturer's request and shall be preferably combined with the annual tests.

Usually when upgrading welding consumables, all tests of butt weld specimens that are required for the approval of electric-slag and gas-electric welding shall be performed in accordance with 4.9.2. The results of tests for specific welding consumables that are derived from their use in approving other methods of welding shall be discarded.

5. APPROVAL TEST FOR WELDERS

5.1 GENERAL

5.1.1 The requirements of the Section set down the general conditions of the approval test for welders (operators) who shall weld structures listed under 1.1.1.

5.1.2 The approval test for welders is a compulsory procedure used by the Register for confirmation of the qualification of welders engaged in manufacture of objects and structures to be surveyed by the Register.

5.1.3 Upon compliance with the requirements of this Section, a Welder Approval Test Certificate will be issued

by the Register to testify approval of the welder for welding, under conditions stipulated therein (material, welding process, welding position, etc.), structures subject to survey by the Register.

5.1.4 Successful passing by a welder of theoretical and practical examinations is the grounds for issue of a Welder Approval Test Certificate.

5.1.5 The procedure for welders' tests and for issue of the Welder Approval Test Certificates shall meet the requirements of international standards and/or national standards (EN 287, ISO 9606, ASME Sec. IX, ANSE AWS D1.1)
recognized by the Register, with due regard to the provisions given below.

5.1.6 Recognition of documents confirming qualification of welders and issued by other classification organization or authorized competent body is decided by the Register in each particular case during technical supervision of ship construction or manufacturer of products in the scope sufficient for confirmation of these documents compliance with the requirements of the present Section.

5.2 REQUIREMENTS FOR PROCEDURE FOR CARRYING OUT AND ORGANIZATION OF WELDERS' CERTIFICATION

5.2.1 Approval testing of welders shall be conducted in a centralized order by the request of works-employers in certifying centres, which competence has been verified by the Register.

5.2.2 Certifying centres may be established at works, educational institutions, specialized organizations and institutions where qualified welding specialists and the training and testing base for welders are available.

5.2.3 Structure of a certifying centre shall provide the following key components ensuring the centre functioning:

management;

certifying commission;

service personnel to ensure carrying out of all the tests and equipment functioning;

main and auxiliary production equipment for carrying out practical tests;

equipment, tools and instrumentation for carrying out practical and theoretical tests of welded joints;

spaces for carrying out practical and theoretical tests of welders.

5.2.4 The working body of the certifying centre directly carrying out welders' certification is a standing certifying commission.

The surveyor to the Register carrying out the survey during tests is the member of the certifying commission and to be present during the performance of all kinds of tests, which results he surveys.

5.2.5 Where the certifying centre is organized on the base of industrial facilities performing the welding of structures under the Register technical supervision, and its activity is limited by the certification of its own welders, the procedure for compulsory centre recognition by the Register with issue of the relevant documents may be unnecessary.

5.2.6 All the certifying centres engaged in training and/or certification of welders from outside organizations on a

commercial basis irrespective of their entity are subject to the compulsory recognition by the Register.

5.2.7 Welders' certification is classified as initial, additional, periodical and occasional.

To initial certification are subject the welders aged 18 years and over who did not previously pass an approval test for the welding of objects and equipment to be surveyed by the Register, have a welder's qualification certificate and the relevant welding experience of at least 12 months, as well as the special theoretical and practical training according to the programs individually compiled for each type of works and each welding process with due regard to the specific nature of the works, for which the welder shall be certified.

Additional certification of welders who underwent the initial certification is carried out prior to approval for the works not specified in a Welder Approval Test Certificate, as well as after the break in performance of the relevant welding works for over 6 months.

All welders are subject to periodical certification to confirm the level of their professional qualification and to extend the validity of the Welder Approval Test Certificate according to the provisions of 5.6.

The periodical certification is conducted at least once in two years.

To occasional certification are subject welders prior to approval for welding works performance after their temporary removal from working for poor qualify and non-observance of a welding procedure.

The time period for preparation to the occasional certification (for additional training) is at least one month since the date of the removal from working.

The scope of special theoretical and practical training for the additional, periodical and occasional certification is established by a certifying commission and subject to the Register individual approval.

5.2.8 In order that the Register could carry out activities on the approval test for welders, the works administration shall send to the Register Branch Office, surveying the welding at this works, the request specifying:

name and address of a certifying centre where welders will be certifying;

list of welders to be certified with their (for each person) full names, year and place of birth, place of work, speciality and skill category, experience of work to be certified;

copies of documents confirming the professional qualification of workers for the type of works to be certified;

welding process, welding positions and other information necessary for certification and filling in the form of a Welder Approval Test Certificate;

guarantee of payment for the Register services according to the current tariffs.

Note. Request for the Register performance of works on the approval test for welders may be also submitted by certifying centers operating on behalf of the works administration.

5.3 DEFINITIONS, TERMS AND SYMBOLS USED IN APPROVAL TEST FOR WELDERS

5.3.1 Definitions and terms.

Certifying commission is the group of specialists of the certifying centre who are responsible for the organization and

validity of the results of welders' certification activities.

Certifying centre is a competent organization authorized by the Register to conduct tests on welders' certification in compliance with the requirements of the Register Rules.

Certification means the set of activities on determination of a welder's qualification level to ascertain the possibility of welder's approval for performance of the specific kind of welding works.

Approval means a special procedure to determine the welder's qualification through his certification and issuance of an official document, i.e. a Welder Approval Test Certificate, which verifies the permission to carry out welding works on the objects to be surveyed by the Register within the range of approval established by the Certificate.

Filling run(s) is the bead(s) of the multilayer weld applied after root run and prior to the facing run.

Root run is the first layer bead(s) in the weld root during the multilayer welding.

Welder means a person welding metals. General definition for a manual welder of different welding methods and a welding operator of units for semi-automatic and automatic welding.

Root pass: in multilayer welding, bead(s) of the first layer deposited in the root of the weld.

Scope of approval: limits of recognition of a welder's qualifications by the Register on the basis of the testing performed during certification.

Capping pass: in multilayer welding, bead(s) visible on the weld surface after welding.

Backup plate: a material that is placed on the back side of the connection prepared for welding in order to support the molten weld metal.

Test assembly: a welded detail that is used for welder certification testing.

Welder Approval Test Certificate is a Register document verifying that the welder has successfully passed the certification tests within the scope of the requirements of the Register Rules and is approved for welding on the structures to be surveyed by the Register, within the range of approval specified in the Certificate.

Thickness of the weld metal is the thickness of the weld metal except weld reinforcement

5.3.2 Symbols of welding processes shall comply with the provisions of ISO 4063 (refer to Table 6.2.2.1).

5.3.3 Welders' certification is conducted separately for each of the following welding types, which vary by the degree the welder's labour is mechanized:

MW = manual welding wherein the filler wire feed and welding gun movement along and across the weld are carried out by a welder manually;

SA = semi-automatic welding wherein the welding wire feed is mechanized, but a welding gun is moved manually along and across the weld by a welder;

A = automatic welding wherein the process of the welding wire feed and welding gun movement manipulation are automated and carried out without direct participation of a welder.

5.3.4 While specifying the range of approval for the welding processes 111, 114, 131, 135, 136, 137, symbols

indicating types of electrode covering, types of wire and core of flux cored wire shall be used in accordance with the provisions below.

In accordance with ISO 2560 and EN 499 , depending on the composition, the types of electrode covering (welding process 111) are indicated by symbols:

A — acid (oxidizing)covering;
B — basic covering;
C — cellulosic covering;
R — rutile covering;
RA (AR) — rutile-acid covering;
RB — rutile-basic covering;
RC — rutile-cellulosic covering;
RR — rutile thick covering.

The use of a solid wire for welding methods 131 and 135 shall be indicated by S.

In accordance with ISO 17632 depending on the type of the filler of the welding wire powder (welding methods 114, 136, and 137): indicated according to Table 5.3.4.

Table 5.3.4 **Symbols of core types of flux cored wire (ISO 17632)**

Symbol	Characteristic	Types of welds	Shielding gas
R	Rutile, slow freezing slag	Single-run and multirun	Required
P	Rutile, slow freezing slag	Single-run and multirun	Required
B	Base	Single-run and multirun	Required
M	Metal powder	Single-run and multirun	Required
V	Rutile or basic/fluoride	Single-run	Not required
W	Basic/fluoride, slow freezing slag	Single-run and multirun	Not required
Y	Basic/fluoride, fast slag	Single-run and multirun	Not required
Z	Other types	–	–

5.3.5 For designation of the composition of a shielding gas applied in welders' practical tests, alpha-numeric indices consistent with EN 439 are used.

5.3.6 For designation of the type and composition of a flux applied in welders' practical tests, letter indices consistent with EN 760 are used.

5.3.7 For designation of the presence of filler metal involved in forming of a weld, the following symbols are used in welders' certification:

wm = welding with filler metal;

nm — welding without filler metal wherein a weld is formed only at the expense of the melting of base metal.

5.3.8 Symbols relating to base metal and joint type.

5.3.8.1 Welder’s certification as per the results of practical tests is carried out to fit the groups/subgroups of a type composition of base metal according to the international standard CR ISO/TR 15608.

Table 5.3.8.1 provides information on compliance of consumables regulated by Part XIII "Materials" with the classification according to the

international standard CR ISO / TR 15608.

5.3.8.2 The following specific types of welded joints shall be put into separate groups and coded with the following indices:

.1 butt welds BW:

ss nb - single-side welding without a backup plate;

ss mb - single-side welding with a backup plate;

bs - double-sided welding;

.2 fillet welds FW:

sl— single-layer welding;

ml— multilayer welding.

5.3.9 Symbols relating to types of test assemblies and welding positions.

5.3.9.1 For practical tests of welders, unified check welded joints/test assemblies shall be used according to the relevant international standards.

Geometric parameters and dimensions of test assemblies shall be specified using the following indices:

P — plate;

T — tube;

D — external diameter of pipes;

t — thickness of the test assembly material (plate or pipe wall);

t_1 — thickness of the test assembly material (welding process 1);

t_2 — thickness of test assembly material (welding process 2);

l_1 — length of the test assembly;

l_2 — half length of the test assembly;

l_f — credited length of the test assembly weld;

s_1 — thickness of the weld metal (welding process 1);

s_2 — thickness of the weld metal (welding process 2);

a — design thickness of the fillet weld;

z — leg length of the fillet weld.

5.3.9.2 The welding of welded joint test assemblies is carried out in unified welding positions consistent with the provisions of ISO 6947 (refer to Fig. 6.2.2.4-1 to 6.2.2.4-3).

5.4 PROCEDURE FOR APPROVAL TESTS FOR WELDERS

5.4.1 General requirements for the test performance procedure.

The procedure for welders certification includes the passing of theoretical and practical examinations by a welder to be certified.

The certification shall begin with a practical examination.

Welders who do not pass practical testing shall not be allowed to take subsequent tests and shall be deemed to have failed the certification.

Table 5.3.8.1

Name and designation of the base metal grade in accordance with Part XIII "Materials"	Designation and characteristics of the base metal group/subgroup as per CR ISO/TR 15608
1	2
	Steels
Normal strength hull structural steels, grades A, B, D, E	Group 1: Steels with the rated yield stress R_{eH} [1] ≤ 460 MPa and chemical composition, weight per cent: [2] C ≤ 0.25; Si ≤ 0.60; Mn ≤ 1.70; Mo ≤ 0.70; S ≤ 0.045; P ≤ 0.045; Cu ≤ 0.40; Ni ≤ 0.5; Cr ≤ 0.3 (0.4 castings); Nb ≤ 0.05; V ≤ 0.12; Ti ≤ 0.05.
	Subgroup 1.1: Steels with the rated yield stress R_{eH} ≤ 275 MPa
Higher strength hull structural steels, grades A32, D32, E32, F32, A36, D36, E36, F36	Subgroup 1.2: Steels with the rated yield stress 275 MPa < R_{eH} ≤ 360 MPa
Higher strength hull structural steels, grades A40, D40, E40, F40 in the condition of supply:	
N	Subgroup 1.3: Normalized fine-grained steels with the rated yield stress R_{eH} > 360 MPa
TM, TMCP	Group 2: Thermo-processed fine-grained steel and steel castings with the rated yield stress of R_{eH} > 360 MPa
	Subgroup 2.1: Thermo-processed fine-grained steel and steel castings with the rated yield stress of 360 MPa < R_{eH} ≤ 460 MPa
QT	Group 3: Thermo-improved (tempered) steel and dispersion-hardened steel other than stainless steel, with a rated yield stress of R_{eH} > 360 MPa
	Subgroup 3.1: Thermo-improved (tempered) steel with the rated yield stress of 360 MPa < R_{eH} ≤ 690 MPa
High strength steels, grades A420, D420, E420, F420, A460, D460, E460, F460 in condition of supply:	
TM, TMCP	Subgroup 2.1 (see above)
QT	Subgroup 3.1 (see above)

Continued Table 5.3.8.1.

1	2
High strength steels, grades A500, D500, E500, F500, A550, D550, E550, F550, A620, D620, E620, F620, A690, D690, E690,	
TM, TMCP	Subgroup 2.2: Thermo-processed steel and steel castings with the rated yield stress of R_{eH} > 460 MPa
QT	Subgroup 3.1 (see above)
Propeller casting steel of martensitic grades 12Cr1Ni, 13Cr4Ni, 16Cr5Ni	Group 7: Ferritic, martensitic, or dispersion-hardened stainless steel containing C ≤ 0.35% and 10.5% ≤ Cr ≤ 30% Subgroup 7.2: Martensitic stainless steel
Austenitic grade	Group 8: Austenitic stainless steel
Corrosion-resistant (stainless) steel:	
type M-1, MF-2, F-3	Group 7 (see above)
type AM-4	Group 7 (see above)
type A-5, A-6, A-7	Group 8 (see above)
type AF-8, including	Group 10: Austenitic-ferritic stainless steel (duplex steel)
S3183; 08X22H6T;	Subgroup 10.1: Austenitic-ferritic stainless steel containing Cr ≤ 24.0%
S31260; S32550; S32750; S32760;	Subgroup 10.1: Austenitic-ferritic stainless steel containing Cr ≤ 24.0%
Cold-resistant nickel-alloyed steel (for gas carriers) containing: Ni ≤ 3.0% Ni ≤ 8.0% 8.0%< Ni ≤ 10.0%	Group 9: Nickel alloy steel containing Ni ≤ 10.0% Subgroup 9.1: steel with content of Ni ≤ 3.0% Subgroup 9.2: steel with content of Ni ≤ 8.0% Subgroup 9.3: steel containing 8.0% < Ni ≤ 10.0%

Copper and copper alloys	
Propeller castings CU1, CU2; CU 3 CU 4	Group 32: Copper-zinc alloys Subgroup 32.2: Copper-zinc alloys, complex Group 34: Copper-aluminium alloys Group 38: Other copper alloys

End of Table 5.3.8.1.

1	2
Aluminium and Al alloys	
Cast alloys	
Grade 1 Grade 2 Grade 3 Grade 4	Subgroup 23.1: Al-Si alloys Subgroup 23.1: Al-Si alloys Subgroup 23.1: Al-Si alloys Group 24: Aluminium-silicon alloys containing Cu ≤ 1.0% Subgroup 24.2: Aluminium-silicon-magnesium alloys containing Cu ≤ 1.0%, 5.0% < Si ≤ 15%, and 0.1% < Mg ≤ 0.8%
Grade 5	Subgroup 24.1: Aluminium-silicon alloys containing Cu ≤ 1.0% and 5% < Si ≤ 15%

Wrought aluminium alloys

International	National	
5754	1530	Group 22: Non-hardened alloys Subgroup 22.3: Aluminium-magnesium alloys containing 1.5% < Mg ≤ 3.5%
5083, 5383, 5059, 5086	1550, 1561, 1561H, 1573	Subgroup 22.4: Aluminium-magnesium alloys containing Mg > 3.5%
6005A, 6061, 6082	–	Group 23: Hardened alloys Subgroup 23.1: Al-Mg-Si alloys

[1] In accordance with the requirements of specifications and standards for product delivery, the normalized yield stress value R_{eH} may be replaced with $R_{P0.2}$ or $R_{P0.5}$

[2] The maximum total value of the content of alloying elements shall be limited to Cr + Mo + Cu + Ni + V ≤ 0.75%.

In the course of passing a theoretical examination, the welder shall answer at least 15 questions covering the basic sections of common and special (by speciality) issues. The questions are selected by the certifying commission for each welding process.

An examination is conducted by the certifying commission using one of the following methods or their combination:

knowledge verification in writing; oral questioning;

knowledge verification with a computer;

written description with the follow-up demonstration on the equipment.

The examination results are assessed by a certifying commission according to a system: passed/not passed.

The note "passed" means correct answers of a welder for at least 80 per cent of questions asked.

The welder is considered to be certified if he has successfully passed practical and theoretical examinations.

If a welder has passed a practical examination and failed a theoretical one,

he is allowed to resit it by an additional request within half a year since the day of the first examination, but nor earlier than in two weeks after the initial date of the theoretical examination.

With the repeated negative result of the theoretical examination, the welder is considered to have failed the certification.

5.4.2 Requirements for the practical test performance procedure.

5.4.2.1 The practical tests of welders are conducted by means of welding of check welded joints, which are consistent with the requirements of the relevant international standards.

The performance of test assemblies welding shall be witnessed by at least three members of a certifying commission:

one certified welding engineer;

one representative of a technical control service whose qualification level allows him making a conclusion on the results of an external examination and measurements;

one representative of the Register.

5.4.2.2 The test assemblies of welded joints shall be marked with the identification number entered in the test report before welding starts. Additionally, test assemblies shall be marked with the welding position for all types of test assemblies, and for pipes welded in a fixed position the position corresponding to 12 h shall be marked.

Assembly of joint parts for welding is carried out by a welder to be certified. The permit for test assembly welding is given by the member of a certifying commission after the acceptance of quality of assembly for welding.

The certifying commission may abort a practical examination if welding conditions and procedure are not observed or, if it is obvious that the welder is unable to perform the welding of a test assembly in compliance with the requirements of a specification and the Register Rules.

5.4.2.3 The test assemblies welding during practical qualification tests on welders' approval shall be performed proceeding from a Welding Procedure Specification of an established pattern, which is executed in accordance with actual conditions of welding performance in production.

In so doing, the following requirements shall be met:

the welding of test assemblies shall be carried out with welding types to be used in production;

filler material shall be compatible for the particular welding type and positions;

the structural components of edge preparation for welded joints of test assemblies for testing (a groove angle, root face value, joint gap) shall be used in production;

the dimensions of test assemblies shall be given in a Specification and to meet the requirements of the Rules;

the welding equipment shall be similar to that used in production;

the welding of test assemblies shall be carried out in the positions and for angles of pipes connection corresponding to those normally used in production;

welding conditions and welding

sequence in the groove shall comply with those used in production;

the combination of base, filler and auxiliary metallic shall correspond to the normal conditions in production;

the time spent by a welder for test assembly welding shall correspond to normal standards set in production;

the credit length of the test assembly shall feature at least one complete "stop–start" operation for the root pass and the upper capping pass with mandatory marking of the place of the operation. This requirement is mandatory for manual and semi- automatic welding;

where in production, specific welded joints (combinations of base metal and welding consumables) need preheating, controlled heat input, or the requirement for a minimum/maximum interpass temperature is specified, than these conditions of the procedure shall be ensured in welding of test assemblies for welders' approval;

where in production, post-weld heat treatment for specific welded joints is stipulated, the execution of this operation is mandatory in welding if test program provides for the bend test of specimens. For other cases, the post- weld heat treatment of welded joint test assemblies may be omitted if agreed by the Register;

welded specimens must be clearly identified;

if approved by the surveyor to the Register, it is allowed to remove minor surface defects of the beads of inner layers of the weld by mechanical dressing or any other method used in production.

Elimination of defects on the surface layer of a weld, as well as the continuous dressing or gouging of a root run on the side of reinforcement are not allowed.

5.4.2.4 The thickness of metal of test assemblies to be welded, their diameter for pipelines welding testing shall be specified with due regard to the actual range of these characteristics values in compliance with the request of the works, and for the range of the Register approval according to provisions of 5.5.9.

The assembly and welding of butt joints of plates shall ensure the absence of an angular deformation of the welded joint (its flatness).

Where T-joints of plates and pipes are joined by a single-sided single-pass fillet weld, designed fillet weld thickness shall be within the following range depending on the effective throat thickness of a base metal *t*:

$$0.5\,t \le a \le 0.7\,t$$

For pipe joints the weld minimum check length shall be 150 mm. If the pipe circumference is less than 150 mm the total number of test assemblies during tests shall not exceed three for one welding position.

5.4.3 The number of check welded test assemblies for practical tests, their dimensions and structural components shall be specified by a certifying commission depending on the range of works set in the application, for which a welder shall be certified.

5.4.4 After welding, each welded

test assembly shall be visually tested.

The scope of tests by other methods is specified according to the requirements of international standards in use.

Prior to mechanical testing, backing strips, where used, shall be removed.

For further checks, the test assembly can be sectioned by thermal or mechanical cutting, depending on the type of used material, discarding the first and last 25 mm of the test assembly at the end of the plates.

5.4.5 Criteria for test results assessment.

5.4.5.1 Assessment of welded joints quality by visual testing.

5.4.5.1.1 General.

Visual testing is applicable directly to the weld surface and the adjacent base metal zone spaced for at least 20 mm from a fusion line along the entire welded joint.

Visual testing shall be usually carried out without use of special optical instruments. In doubtful cases, magnifying glasses with not more than 10X magnification may be used.

Where cracks or their indications are detected during visual testing of a welded joint, it is recommended to continue non-destructive testing:

magnetic particle or penetrant testing;

grinding of the surface followed by chemical cleaning with the reagent used for revealing a macrostructure.

Undercuts depth, pimpling and scaling height shall be checked by comparison with weld standards using special templates or by making a mould. The latter is cut so that the dimension to be checked is in the plane of a notch. In this case, drops between beads and between the weld and base metal shall be measured on a base of 12 mm, the pimpling and scaling are measured between the tops of pimples and scales.

The measurements of welded joints shall be carried out at points where deviations from specified dimensions are suspected after a visual testing. At least three measurements of geometric parameters of the welded joint shall be made on the length of the check test assembly.

Universal or special templates (fit/unfit) approved by the surveyor to the Register shall be used for measurements.

5.4.5.1.2 Criteria for defects assessment.

The following external defects of check welded joints are considered as impermissible:

cracks in the weld and near-weld area, lacks of fusion, bums, blowholes, rolls, aggregates of inclusions and pores, surfaced unfilled craters and stains of short circuits on the surface of the completed weld and base metal;

non-conformity of the weld form and dimensions in excess of that allowed by the relevant national standards;

separate pores sized over 0.1 the minimum thickness of welded components for thickness up to 20 mm and pores sized over 2.0 mm for component thickness 20 mm and over, as well as the pores of this and lesser size if their number exceeds 3 pieces per any 100 mm of the weld or 6 pieces per

any 300 mm of the weld;

undercuts of the base metal over 0.3 mm deep for metal thickness up to 20 mm inclusive and over 0.5 mm deep for metal thickness over 20 mm. The maximum length of the single undercut shall not be more than 0.5 the thickness of welded metal, while the total extent of undercuts shall not exceed 10 per cent of a weld length;

shrinkage in the root of a single-sided weld over 0.1 the thickness of welded metal for edge thicknesses up to 10 mm inclusive and 1 mm, over 10 mm;

drops between beads, as well as between the weld and base metal (non-smoothness of weld transition to base metal) exceeding 1.5 mm.

Tolerances for weld dimensions shall be within the requirements of a Welding Procedure Specification and in any case shall meet the requirements of the national standards.

5.4.5.2 Assessment of welded joints quality during radiographic testing.

The assessment of welded joints quality proceeding from the results of radiographic testing shall be carried out according to the requirements of 3.3 for steel welded joints and of 3.4 for welded joints of aluminium alloys while specifying permissible dimensions of defects corresponding to Marks HI and HI A1 respectively.

5.4.5.3 Assessment of welded joints qualify based on ultrasonic testing results.

Ultrasonic testing shall be carried out according to the national standards recognized by the Register or approved procedures.

The criteria for assessment of the testing results are subject to individual approval by the Register.

5.4.5.4 Assessment of welded joints qualify based on static bend tests results.

Testing specimens of welded joints of shipbuilding and high-strength steel for static bending shall be covered by the requirements of Table 5.4.5.4-1.

Cases not regulated by requirements in Table 5.4.5.4-1 shall be covered by the following:

.1 For steels with a rated elongation value of $A_5 \geq 20\%$, the diameter of the punch or the internal bead d shall be equal to 4 t_s and the bending angle, to 180 degrees; the base metal with the elongation of $A_5 < 20\%$, shall be covered by the following:

$$d = (100/A_5 - 1)\, t_s,$$

where d - the diameter of the punch or the internal bead, mm;

t_s - the thickness of the specimen subjected to bending;

A_5 - the minimum value of tensile elongation according to the specifications for the material (the rated value), %.

.2 For copper and copper alloys, the inner diameter of the punch or the bead d shall be equal to $4t_s$, and the bending angle to 180 degrees unless the low ductility of the base metal or weld metal imposes other restrictions.

.3 For shipbuilding aluminium alloys, the diameter of the punch or the internal bead d shall meet the requirements of Table 5.4.5.4-2.

After bending the test assembly to the desired angle, the assembly surface shall be free of defects longer than 3.0

mm in any direction.

Defects that are formed at the edges of the assembly and do not exceed 3.0 mm shall be discarded and not entered in the test report.

5.4.5.5 Assessment of welded joints qualify based on bend tests results.

5.4.5.5.1 Bend tests of welded joint specimens shall be followed by external inspection and measurement of the fracture surface.

Weld defects that come to the fracture surface shall be considered unacceptable if their type, number, and dimensions do not meet the criteria set for internal weld defects for radiographic control.

Table 5.4.5.4-1. **Requirements for bend tests of shipbuilding aluminium alloys**

Base metal grade	Correlation d/t_s	Angle of bending, deg.
A–E	4	180
A32−F32	4	180
A36−F36	4	180
A40−F40	4	180
A420−F420	5	180
A460−F460	5	180
A500−F500	5	180
A550−F550	6	180
A620−F620	6	180
A690−F690	6	180

Table 5.4.5.4-2 **Requirements for bend tests of shipbuilding aluminium alloys**

Aluminium alloy grade	The correlation d/t_s for the condition for supply				Angle of bending, deg.
	O/H111	H112; H116; H32; H36;	T4	T5; T6	
International alloys					
574	3	4	–	–	180
5086; 5083;5383; 5456; 5059	6	6	–	–	180
6005A; 6061; 6082	4	–	6	7	180
National alloys					
1530	3	4	–	–	180
1550; 1561; 1575	6	6	–	–	180

5.4.5.5.2 During fracture testing of T-welded joints made by a single-run fillet weld, the absence of impermissible internal defects including poor penetration of the root part of the weld shall be confirmed.

Minor defects like small pores and slags may be ignored if then- relative area does not exceed six per cent of the cross section in question.

Note. Pores and slags are considered as minor if their largest linear dimension in the plane of destruction does not exceed 0.2*Z*, but not more than 2 mm (where Z = leg of a fillet weld).

5.4.5.6 Check of macrosections.

Macrosections shall be made so that their working surface covers the entire weld area and the part of base metal at least 15 mm wide adjacent to the fusion line.

The reagent used for etching shall allow to clearly identify the boundaries of the weld and separate beads, the fusion line, affected zone, as well as the adjacent part of base metal.

In the examination of macrosections, the following shall be checked:

shape and geometric dimensions of the weld;

shape and dimensions of the penetration of the base metal;

presence of base metal undercuts and shrinkage in the root of a single- sided weld;

presence of inadmissible internal defects in the weld and near-weld area at a distance of 10 mm from the boundary of the affected zone.

The macrosections may have defects, which type and dimensions are not beyond the scope of the requirements in 5.4.5.1 and 5.4.5.2. In this case, the sum of all defects (external and internal) projections in the direction of a design thickness shall not exceed 0.15*t* or 0.15*a*, but shall not be more than 4.0 mm for all steel and aluminium alloy groups.

5.4.6 Procedure for retests performance.

5.4.6.1 In cases when a certifying commission has reliably ascertained that the unsatisfactory result of initial practical tests is due to causes not associated with the welder's qualification (e.g. malfunctions of welding equipment, defects of the welding electrode covering, etc.), the welder may be approved for retests on the same number of test assemblies. In this case, the quality of base metal and welding consumables, as well as serviceability of welding equipment shall be thoroughly checked by certifying commission members.

5.4.6.2 Where ascertained that the unsatisfactory result of initial tests is attributed to the welder's inadequate qualification and had been caused by the unsatisfactory results of testing on more than one test assembly, the welder may be approved for the repeated certification after additional training for at least during a week.

5.4.6.3 Where the testing results for one of the specimens tested do not meet the requirements set for the given type of tests, the doubled number of the same specimens shall be fabricated and tested.

The specimens for additional tests may be selected among stored test assemblies or a new test assembly shall be fabricated under similar conditions.

5.4.6.4 If two additional specimens fabricated according to 5.4.6.3 have demonstrated the satisfactory results, the tests are considered as completed with the satisfactory result

With the unsatisfactory results of retesting of even one of additional specimens, the welder is recognized to have failed the practical tests and shall undergo retesting in the established order.

5.4.6.5 With additional tests of bend specimens, as well as of microsections fabricated from fixed butt pipe joints (positions PF, PG and H-L045, J-L045), the point of test assembly sampling, which corresponds to the position of a welding sector, for which unsatisfactory results in initial tests were obtained, shall be retained.

5.4.6.6 In case, when the extent of initial tests provided for the fabrication of several test assemblies (one type for various welding positions or of the different type) and the unsatisfactory

results were obtained only for one of these test assemblies, the retesting as per 5.4.6.2 may be performed only to fit the test assembly the negative result was attributed to. In addition, the Register may double the extent of retesting as compared with the initial one.

5.4.6.7 The welder is considered to have failed the certification if the results of the practical retesting are unsatisfactory.

The procedure for welder's approval for the new certification is established by the certifying commission individually with due regard to professional shortcomings revealed.

In any case, the time period between certifications for training and gaining pertinent practical skills shall be at least one month.

5.5 RANGE OF APPROVAL

5.5.1 Assessing welders' qualification during practical tests and specifying the range of approval of the Welder Approval Test Certificate, the following main variable parameters of the welding procedure shall be taken into consideration:

.1 welding process and type;

.2 type of product/structure (plate/pipe);

.3 type of weld (butt weld or fillet weld);

.4 base metal group;

.5 welding consumables;

.6 structural dimensions of a welded joint (metal thickness and pipe outside diameter);

.7 welding positions;

.8 particulars of the welding procedure (backing, single-sided welding, welding from both sides, single layer, multi-layer, left-sided and right-sided welding).

Upon the Register request the following may be performed as additional tests:

welding of pipes under conditions of limited access;

welding of piping joint assemblies;

repair of defects of casts and forgings.

As a rule, test assemblies are welded using one value of all the above main variable parameters of the welding procedure for each practical test.

An exception is the combination of two or more welding processes on one test assembly (refer to 5.5.2) as well as size of the test assembly and welding positions (refer to 5.5.7 and 5.5.8).

5.5.2 Each practical test is usually limited by the range of approval for one welding process/type

Change of welding process in production requires new tests of welders.

An exception is the change of solid wire active shielding gas arc welding (process 135) by flux cored wire with metal core (index M) active shielding gas arc welding (process 136) and vice versa which do not require new tests of welders.

If welding of a specific joint in production is performed by one welder using combination of two welding processes and more, practical tests may be performed in the following way:

.1 test assembly during tests is fabricated using a combination of two welding processes and more as in production (e.g. weld root - single-sided tungsten inert-gas welding without backing, groove filling - manual welding with covered electrodes);

.2 during tests, two test assemblies are welded for the welder's separate certification for each welding process.

The range of approval of the Welder Approval Test Certificate by the base metal thickness for the combination of two welding processes/types is set forth in Table 5.5.2 (also refer to Table 5.5.7.1).

It is necessary to take into account that use of any type of certification for the combination of two welding processes/types and more shall not reduce the scope of requirements for the welded joint assemblies testing established by the requirements of applicable international and/or national standards.

Note. Preparation and testing of test assemblies with the combination of two welding processes and more by different welders following variants other than 5.5.2.1 and 5.5.2.2 is a matter of the special consideration by the Register.

5.5.3 Test assembly type for practical tests shall be chosen in relation to the type of a product/structure (plate or pipe) for the welding of which the welder is approved.

It is necessary to follow Table 5.5.8 in respect of the range of approval considering the following:

.1 approval for welding of pipes with the outside diameter $D > 25$ mm covers plate welding as well;

.2 approval for plate welding covers pipe welding as well:

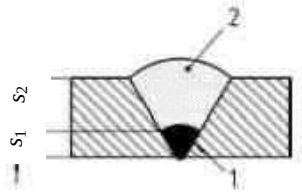
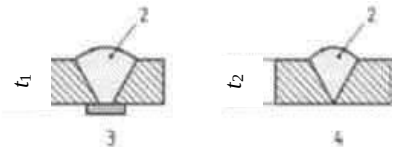
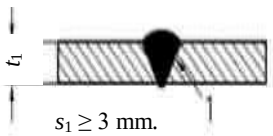
with outside diameter $D \geq 150$ mm for welding positions PA, PB and PC;

with outside diameter $D \geq 500$ mm for other welding positions.

5.5.4 The range of approval of the Welder Approval Test Certificate by the weld type (butt weld or fillet weld) shall be determined considering the following:

Table 5.5.2 **The range of thicknesses of metal subject to approval for the combination of two methods/processes of butt joint welding**

Welding arrangements (combination of welding processes) during tests	Range of thickness for approval	
	of each welding method/process	combination of two welding methods/processes

 1- welding process 1 (*nb*) 2- welding process 2 (*mb*)	According to Table 5.5.7-1 For welding process 1: $t = s_1$ For welding process 2: $t = s_2$	According to Table 5.5.7-1 $t = s_1 + s_2$
 2- welding process 2 (*mb*) 3- welding with backing strips (*mb*) 4- welding without backing strips (*nb*)	According to Table 5.5.7-1 For welding process 1: $t = t_1$ For welding process 2: $t = t_2$	According to Table 5.5.7-1 $t = t_1 + t_2$ Welding process 1: only for weld root area welding
 1- welding process 1 (*nb*)		

.1 approval for welding of butt welds may be extended to welding of all types of butt joints and welds except cases requiring additional types of tests (refer to 5.5.1);

.2 approval for welding of butt welds, as a rule, may be extended to welding of fillet welds. It is necessary to carry out separate testing of fillet welds in the following cases:

according to the manufacturer's request the welder is certified only for these types of joints;

upon the Register request in case the major part of the welder's work in production is fillet welds;

Note. This requirement doesn't cover welding by fillet welds with partial or full penetration when edge preparation for welding is provided. Condition of approval for welding by such welds is, as a rule, extension of the range of approval to the welding of butt welds under similar conditions.

.3 range of approval of the Welder Approval Test Certificate by additional types of tests is determined following general procedure on the main variable parameters considering the following:

approval for welding butt joints of pipes on the basis of test results of the test assembly with the restricting ring in positions H-L045 and J-L045 covers welding of pipe joints (branch pipes) with an angle between axis not less than 60°;

the range of approval for pipe joints (branch pipes) is based on the outside diameter and wall thickness according to 5.5.7;

.4 if the type of weld can't be approved by means of type test assemblies (e.g. welding of tube plates etc.) special types of test assemblies shall be applied.

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5.5.5 In order to reduce the number of tests of welders the materials with similar characteristics are united into groups in accordance with the CRISO/TR 15608 (refer to Table 5.3.8.1).

Tests performed with use of any specific grade of material from one of the groups have the range of approval for all other materials of this group, as well as other groups according to Tables 5.5.5-1 − 5.5.5-3.

Range of approval of the Welder Approval Test Certificate by dissimilar joints (different groups) is defined according the following:

the welder may be approved for welding dissimilar joints in any combination of groups of type compound of the base metal for the welding of which he is approved according to Tables 5.5.5-1 − 5.5.5-3. The welding consumable shall correspond to the group one of the welded materials;

if welding consumables intended for the austenitic (group 8) or austenitic-ferritic (group 10) stainless steels are used for dissimilar joints then any combination of materials of group 8 or 10 with materials of other groups are allowed.

The approval test made on the wrought material of the group has the range of approval also for the cast material and combination of the cast and wrought metal within this group.

Separate tests shall be performed for base metals which are not covered by the classification grouping of CR ISO/TR 15608.

5.5.6 When specifying the range of approval of the Welder Approval Test Certificate the type of electrode covering and the core type of flux cored wire used for welding of test assemblies

during practical tests shall be considered.

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Table 5.5.5-1 **Range of approval of the Welder Approval Test Certificate by base metal (steel) groups**

Test assembly material group[1]		Range of approval according to test results												
		1.1; 1.2; 1.4	1.3	2	3	4	5	6	7	8	9		10	11
											9.1	9.2 + 9.3		
1.1; 1.2; 1.4		×	–	–	–	–	–	–	–	–	–	–	–	–
1.3		×	×	×	×	–	–	–	–	–	×	–	–	×
2		×	×	×	×	–	–	–	–	–	×	–	–	×
3		×	×	×	×	–	–	–	–	–	×	–	–	×
4		×	×	×	×	×	×	×	×	–	×	–	–	×
5		×	×	×	×	×	×	×	×	–	×	–	–	×
6		×	×	×	×	×	×	×	×	–	×	–	–	×
7		×	×	×	×	×	×	×	×	–	×	–	–	×
8		–	–	–	–	–	–	–	–	×	–	×	×	–
9	9.1	×	×	×	×	–	–	–	–	–	×	–	–	×
	9.2 + 9.3	×	–	–	–	–	–	–	–	–	–	×	–	–
10		–	–	–	–	–	–	–	–	×	–	×	×	–
11		×	×	–	–	–	–	–	–	–	–	–	–	×

Symbols:
X means base metal groups for which the welder is approved according to test results;
– means base metal groups for which the welder is not approved according to test results.

[1] Materials groups are in compliance with CR ISO/TR 15608.

Table 5.5.5-2 **Range of approval of the Welder Approval Test Certificate by base metal (aluminium alloys) groups**

Test assembly material group[1]	Range of approval according to test results					
	21	22	23	24	25	26
21	*****	×	–	–	–	–
22	×	*****	–	–	–	–
23	×	×	*****	×	×	×
24	×	×	–	*****	×	×
25	×	×	–	×	*****	×
26	×	×	–	×	×	*****

Symbols used in Table 5.5.5-2:
X means base metal groups for which the welder is approved according to test results;
– means base metal groups for which the welder is not approved according to test results.

[1] Materials groups are in compliance with CR ISO/TR 15608.

Table 5.5.5-3 **Range of approval of the Welder Approval Test Certificate by base metal (copper and copper alloys) groups**

Test assembly material group[1]	Range of approval according to test results							
	31	32	33	34	35	36	37	38
31	*	–	×	×	×	–	–	–
32	–	*	–	–	–	×	–	–
33	–	–	*	–	–	–	–	–
34	–	–	–	*		–	–	–
35	–	–	–	–	*	–	–	–
36	–	×	–	–	–	*	–	–
37	–	–	–	–	–	–	*	–
38	–	–	–	–	–	–	×	*

Symbols:
X means base metal groups for which the welder is approved according to test results;
– means base metal groups for which the welder is not approved according to test results.

[1] Materials groups are in compliance with CR ISO/TR 15608.

Relevant range of approval of the Welder Approval Test Certificate by types of electrode covering and core of flux cored wire are specified in Table 5.5.6.

Practical tests with filler metal, for instance, for welding processes 141, 15 and 311 have the range of approval for the same welding process without filler metal but not vice versa.

5.5.7 The range of approval of the Welder Approval Test Certificate shall be specified regarding the following structural dimensions of a welded joint:

thickness of base metal and weld;

outside diameter of welded pipes.

The design thickness of a fillet weld shall be also considered (refer to Table 5.5.9-2).

Every practical test of welders shall have the range of approval of the Welder Approval Test Certificate in accordance with the requirements of Tables 5.5.7-1 to 5.5.7-3.

For pipe joints (branch pipes), criteria shall be applied as listed in Tables
5.5.7-1 and 5.5.7-2 taking into account the following requirements:

dead joint thickness and outside diameter are taken equal to the welded pipe;

through joint thickness is taken by the main pipe or shell, and the outside diameter is taken equal to the welded (connected) pipe.

Range of approval of the Welder Approval Test Certificate is specified separately for test assemblies with different outside diameter of pipes and thickness of base metal:

for the minimum and the maximum material thickness — according to Table 5.5.7-1;

for the minimum and the maximum outside pipe diameter — according to Table 5.5.7-2.

Table 5.5.6 **Range of approval of the Welder Approval Test Certificate by types of welding consumables**[1]

Welding method	Welding consumables used for tests		Range of approval according to test results			
			A, RA, RB, RC, RR, R	B	C	
111	A, RA, RB, RC, RR, R		×	–	–	
	B		×	×	–	
	C		–	–	×	
–	–		Solid wire (S)	Core type of flux cored wire		
				(M)	(B)	(R, P, V, W, Y, Z)
131	Solid wire (S)		×	×	–	–
135 136 141	Core type of flux cored wire	(M)	×	×		–
136		B)	–	–	×	×
114 136		(R, P, V, W, Y, Z)	–	–	–	×

Symbols:

X means welding consumables types (electrode covering, core of flux cored wire) for which the welder is approved according to test results;

– means welding consumables types (electrode covering, core of flux cored wire) for which the welder is not approved according to test results.

[1] Symbols of welding consumables types correspond to 5.3.2.3.

[2] Type of welding consumables used for approval tests for welding of root runs without backing with back weld formation (*ss nb*) is a type of welding consumables covered by approval for root run welding in production.

5.5.8 Range of approval of the Welder Approval Test Certificate by the welding positions is defined in accordance with Table 5.5.8.

Welding of test assemblies during practical tests shall be performed at nominal values of angles to horizon in accordance with ISO 6947 (refer to Figs 6.2.2.4-1 to 6.2.2.4-4).

Welding positions H-L045 and J-L045 for welding of pipes during practical tests have the range of approval for all angles of pipe axis.

Welding of two pipes with equal outside diameter, one in the PF position and another in the PC position, also extends the welder's approval to welding of pipes in the H-L045 position.

Table 5.5.7-1 **Range of approval of the Welder Approval Test Certificate by base metal and weld metal thickness for butt joints**

Material	Thickness of test assembly material t, mm	Range of approval by base metal and weld metal thickness, mm[1]
Steels	$t \le 3$ $3 < t \le 20$ $t > 20$	From t to $2t$[2] From 3 to $2t$[3] Over 3
Aluminium and its alloys	$t \le 6$ $6 < t \le 15$	From $0.7t$ to $2.5t$ $6 < t \le 40$[4]
Copper and copper alloys	t	From $0.5t$ to $1.5t$[5]

[1] For the combination of two welding processes S_1 and S_2 is adopted according to Table 5.5.2.

[2] For gas (oxy-acetylene) welding from t to 1.5t.

[3] For gas (oxy-acetylene) welding from 3 mm to 1.5t.

[4] For base metal thickness over 40 mm, the separate certification is required entered in the Welder Approval Test Certificate and in the test report.

[5] For gas (oxy-acetylene) welding tests, tests shall be performed for the minimum and maximum base metal thickness for which a welder is approved in production.

Table 5.5.7-2 **Range of approval of the Welder Approval Test Certificate by welded pipes outside diameter**

Material	Outside diameter of test assembly pipe, mm	Range of approval by welded pipes outside diameter, mm
Steels	$D \le 25$	From D to D
	$25 < D \le 150$	From 0.5D to 2D, but at least 25
	$D > 150$	From 0.5D and over
Aluminium and its alloys	$D \le 125$	From 0.5D to 2D
	$D > 125$	From 0.5D and over
Copper and copper alloys	$D \le 25$	From D to D
	$25 < D \le 150$	From 0.5D to 2D, but at least 25

Note: For hollow building structures having a box section, a dimension D is determined as to the dimension of the smallest side.

Table 5.5.7-3 **Range of approval of the Welder Approval Test Certificate by base metal thickness of fillet welds**

Thickness of test assembly metal t, mm	Range of approval by base metal, mm
$t < 3$	From t to 3
$t \ge 3$	From 3 and over

Notes: 1. Fillet weld thickness shall be within a range $0.5t \le a \le 0.7t$.

2. Refer also to limitations according to Table 5.5.9-2.

Welding of two pipes with equal outside diameter, one in the PG position and another in the PC position, also extends the welder's approval to welding of pipes in the J-L045 position.

It is allowed to weld pipes with the outside diameter $D > 150$ mm in two welding positions using only one test assembly: PF or PG — ⅔ of circumference; and PC — ⅓ of circumference.

5.5.9 It is necessary to consider the provisions of the following Tables when specifying the range of approval of the Welder Approval Test Certificate by technological details of welding (refer to 5.3.8.2): 5.5.9-1 and 5.5.9-2.

For the flame (oxy-acetylene) welding, change of the welding procedure from the right-hand welding to the left-hand welding and vice versa re- quires new tests of welders.

5.6 ISSUE, TERMS OF VALIDITY AND EXTENSION OF WELDER APPROVAL TEST CERTIFICATE

5.6.1 Proceeding from the results of welders' practical and theoretical tests, the certifying commission draws up a report.

Attached to the report are:

the copy of a certificate on assignment of a welder's qualification and the reference of the personnel department of a works on the welder's professional experience (during the initial certification) or the copy of a welder's certificate with other types of certification;

the copy of a document of an educational institution on welder's special training;

copies of certificates for base metal and welding consumables;

reports, conclusions and other documents on the results of quality control for test assemblies of welded joints.

Note: It is allowed to draw up one report for a group of welders made as a table with all pertinent information and data entered.

5.6.2 The report on welder's certification is drawn up in two copies.

One copy is kept in an examination centre and another is sent to the Register Branch Office supervising test performance.

5.6.3 Based on the report on welders' certification and provided that all the above requirements are met, the Register draws up and issues a Welder Approval Test Certificate of a standard pattern.

5.6.4 The issued Welder Approval Test Certificate is valid for two years provided it is endorsed every six months by the employer's responsible personnel.

The entry on endorsement put in the relevant columns of the Certificate is a confirmation by the employer of observance of the following requirements in the welder's labour activity during the reported period of time:

the welder shall be continuously engaged on welding work within the current period of approval; breaks in work for over six months are not permitted;

welding works performed by the welder in production shall be consistent with complexity of the range of approval specified in the Welder Approval Test Certificate.

Table 5.5.8 **Range of approval of the Welder Approval Test Certificate by types of welding positions**

Welding positions during tests	Range of approval according to test results[1]										
	PA	PB	PC	PD	PE	PF (plate)	PF (pipe)	PG (plate)	PG (pipe)	H-L045	J-L045
PA	×	×	–	–	–	–	–	–	–	–	–
PB[2]	×	×	–	–	–	–	–	–	–	–	–
PC	×	×	×	–	–	–	–	–	–	–	–
PD[2]	×	×	×	×	×	×	–	–	–	–	–
PE	×	×	×	×	×	×	–	–	–	–	–
PF (plate)	×	×	–	–	–	×	–	–	–	–	–
PF (pipe)	×	×	–	×	×	×	×	–	–	–	–
PG (plate)	–	–	–	–	–	–	–	×	–	–	–
PG (pipe)	×	×	–	×	×	–	–	×	×	–	–
H-L045	×	×	×	×	×	×	×	–	–	×	–
J-L045	×	×	×	×	×	–	–	×	×	–	×

Symbols:
X means welding positions for which the welder is approved according to test results;
– means welding positions for which the welder is not approved according to test results.

[1] Additional requirements according to 5.5.3 and 5.5.4 shall be taken into account.

[2] PB and PD welding positions, which are only used for fillet welds, have a range of approval only

for fillet welds that are performed in other positions.

Table 5.5.9-1 **Range of approval of the Welder Approval Test Certificate by the butt joints welding procedure**

Butt joints welding procedure during tests	Range of approval		
	Single-sided weld/no backing (*ss nb*)	Single-sided weld/with backing *(ss mb)*	Welding from both sides *(bs)*
Single-sided weld/no backing (*ss nb*)	×	×	×
Single-sided weld/with backing *(ss mb)*	–	×	×
Welding from both sides *(bs)*	–	×	×

Symbols used in Table 5.5.9-1:
X means welded joints for which the welder is approved according to test results;

– means welded joints for which the welder is not approved according to test results.

Table 5.5.9-2 **Range of approval of the Welder Approval Test Certificate by the fillet welds welding procedure**

Test assembly welding procedure[1]	Range of approval according to test results	
	Single layer welding (*sl*)	Multi layer welding (*ml*)
Single layer welding (*sl*)	×	–
Multi layer welding (*ml*)	×	×

Symbols:
X means welding procedure for which the welder is approved according to test results;
– means welding procedure for which the welder is not approved according to test results.

[1] Fillet weld thickness shall be within a range $0.5t \le a \le 0.7t$.

There shall be no specific reason to question the welder's skill and knowledge during the working process.

If any of these conditions is not met, the Register cancels the Welder Approval Test Certificate, and its renewal or the issuance of the new Certificate is done individually in each case.

Note: In accordance with the practice adopted by the national legislation, the welder shall pass periodical medical examination and to have the conclusion of a medical commission on professional competence.

5.6.5 The Welder Approval Test Certificate validity may be extended by the Register for the following period of up to two years without new practical tests and without changing the range of approval.

The Register extends the Welder Approval Test Certificate for the following two years, provided the requirements listed in 5.6.6 are complied with, on the basis of the report (conclusion) of the certifying commission showing compli-

ance with all main variable parameters of the welding procedure (refer to 5.5.1) with documentary evidence to be attached.

It is necessary to prove compliance with the following requirements:

.1 all reports and documents confirming extension of the Welder Approval Test Certificate refer to a specific welder and are identical to the welding procedure specification used in production;

.2 quality of welds performed by a welder in production complies with requirements of Section 3;

.3 documents confirming extension of the Welder Approval Test Certificate shall be volumetric (radiographic or ultrasonic testing) and for destructive testing (fracture or static bending) at least two welds shall be tested within previous six months.

Documents related to the extension of the Welder Approval Test Certificate shall be kept for at least two years;

.4 the results of the above tests (refer to 5.6.5.3) shall witness that the welder reproduced conditions of initial testing except structural dimensions of the welded joint (material thickness and pipe outside diameter).

Note: The following deviations from the initial test conditions are allowed for the extension of the Welder Approval Test Certificate:

to draw up one report for a group of welders made as a table with all pertinent information and data entered;

material thickness may vary within initial range of approval;

pipe outside diameter shall he within ±50 % of initial test diameter.

5.6.6 The performance of monitoring over the welder's production activity rests with the work-employer, which shall designate a responsible person/performer that is in charge of this work.

A file for each certified welder shall contain:

copy of a document on education;

copy of a document on special training;

reference on uninterrupted service in welding;

reports on passing the examinations with indication of certifying commission members, marks received, the date of the examination performance, the results of a practical examination;

conclusion of the commission on the examination results;

copies of test reports of welded joints made by the welder over an accountable period with the conclusion of the responsible person of a works-employer on the possibility to extend the Welder Approval Test Certificate for the next 6 months.

5.6.7 On agreement with the Register, for works-employers having the system of products quality assurance approved by the Register, the extension of the period of validity for the Welder Approval Test Certificate may be effected within the framework of the special survey of a works quality system in whole.

5.6.8 Where the welder shall be approved for works beyond the limits of the initial range of approval, the new tests for welder's approval in accordance with the above requirements are needed.

If the welder's qualification or knowledge is questioned in any way (refer to 5.6.4, 5.6.5 and 5.6.6), the surveyor to the Register may cancel the valid Welder Approval Test Certificate and/or demand the performance of unscheduled approval tests.

5.6.9 The extension of the period of validity for the Welder Approval Test Certificate according to the provisions of 5.6.5 for the next two-year period may be effected not more than two times in sequence.

The welder's periodical certification in flail extent shall be conducted on the expiry of three two-year periods of the Certificate validity.

6. APPROVAL OF WELDING PROCEDURES FOR WELDING OF STEEL STRUCTURES AND PRODUCTS

6.1 GENERAL

6.1.1 The welding procedures (WP) adopted for the manufacture of structures subject to survey by the Register, which are mentioned in 1.1.1, shall be approved by the Register and shall comply with the following requirements.

6.1.2 Welding procedures may be approved by the Register on the basis of review of relevant documentation and results of tests performed according to the programme approved by the Register.

Documentation and programme shall be attached to the application of the manufacturer that aims to receive the approval from the Register.

6.1.3 The documentation that is provided to the Register shall contain the following information:

.1 main materials used for the manufacture of structures (trademarks, grades, conditions of supply, types of semi-finished products, dimensions etc.);

.2 types of structures, their designation, labour conditions, and assembly sequence;

.3 methods of welding (including welding procedures);

.4 equipment (brief description, certification, frequency of inspections etc.);

.5 welding consumables (types, trademarks, grades, conditions of supply and storage);

.6 welding position and, if necessary, the direction of welding, types of joints, necessary preparatory work, availability of primer, bead application sequence, welding mode, current polarity etc.;

.7 information about required backings and other accessories and the tacking procedure;

.8 conditions of welding (temperature, atmospheric impact prevention, preheating, post-welding heat treatment etc.).

6.1.4 In addition to the information specified in 6.1.3, the documentation shall include information on the existence of a quality control system for the works performed according to the provided technology at the manufacturer. Requirements for testing of materials and works, as well as sources of quality assessment criteria, shall be indicated.

6.1.5 Documentation that contains technical requirements for welding and evaluation methods and criteria shall have a relevant and unique designation (number) and shall be approved by the Register.

6.1.6 Only welding procedures and welding methods shall be used for welding of structures to be surveyed by the Register which ensure high stability of obtaining of welded joints an assured

quality, which can be confirmed by the manufacturer of such welded structures by testing for approval or by other means in accordance with the requirements of the Rules or by a separate agreement with the Register.

6.1.7 The main type of approval of welding procedures shall be the performance of testing for approval. This testing may be standard (i.e., covered by approval requirements established in this section) and preliminary before production.

Types of testing and the implementation procedure shall be established in each case and shall be subject to special consideration by the Register.

In this case, preliminary testing before production shall be carried out in compliance with the following basic requirements:

.1 welding tests shall be performed in conditions as close to the conditions of welding of the real structure and shall model the complex impact of factors that influence the quality of the welded metal;

.2 welding tests shall use assembly devices, units, manipulators etc. that are similar to those used in production;

.3 tacking welds shall, if necessary, be subject to tests as part of the performed joint;

.4 the extent of assembly tests shall include visual control, control of the presence of surface cracks (magnetic or capillary), hardness determination, control of macrosections, and certain types of destructive tests approved by the Register;

.5 the range of approval by the thickness of the base metal shall be usually restricted by the thickness of specific units for which tests were performed.

Preliminary testing before production shall be used if standard tests cannot recreate the features of welding of real structures. Units of real structures or technological imitators can be used as test assembly pieces.

Preliminary tests before production shall usually be the main method of approval of welding procedures and deposition of ship engineering articles.

6.1.8 In some cases the Register may require additional welding procedure testing during production. This type of testing is resorted to when there are some doubts about stability of the product quality, or some changes in the procedure parameters, or when the standard or preliminary (pre-production) tests are insufficient, in the Register opinion, for a particular welding procedure.

Such welding procedures with higher probability of deviations in quality of welded joints include:

vertical downward welding;

one-side (single side) welding without backing (with free back-formation) of the weld by coated electrodes or flux cored wire;

welding processes with high level of heat input (electro gas arc welding, electro slag welding, etc.);

welding processes highly susceptible to the quality of parts assembling and bevelling, e.g. electron beam and laser welding.

6.1.9 The use of schemes of approval of welding procedures that do not involve testing in accordance with this section by the manufacturer of welded structures shall be subject to special consideration by the Register.

In this case, the use of the following approval schemes shall be allowed:

on the basis of the standard welding procedure regulated by EN 288-7;

on the basis of previous experience of similar works on manufacturing products or structures according to the requirements of EN 288-6.

6.1.10 Approval of welding procedures by using the standard welding procedure according to EN 288-7 shall be based on the use of completely identical specifications for welding procedures by several manufacturers of welded structures. However, after testing, certification, and approval of the welding procedure at one of the manufacturers by the Register, the relevant WP shall be classified as standard.

The use of this scheme of approval shall be possible under the following conditions:

restrictions of the range of approval and the use of technology are in effect according to EN 288-7;

stability of the welding procedure must be documentarily confirmed by so-called tests in production.

6.1.11 Approval of welding procedures on the basis of previous experience shall apply consistently with all requirements of EN 288-6.

The use of this scheme is not recommended for welding procedures for welding of structures of high-strength steels of grades D32 to D40 and is not allowed for welding of structures of steels of grades E, E32 to E40, and high-strength steels of all grades.

For ship engineering articles, restriction for the use of the scheme of approval on the basis of previous experience shall apply on an individual basis taking into account all possible circumstances.

Provision of information about the quality of welded joints by the manufacturer in accordance with EN 288-6 can be viewed by the Register as a reason for reducing the amount of testing carried out in accordance with this section.

6.1.12 The decision on recognition of the welding procedure qualification test results (WPQR) surveyed by another classification society or an authorised competent body is made by the Register in each particular case on the basis of sufficiency of submitted documents for evaluation of the welding procedure compliance with the requirements of 6.7.3.1.

6.2 DEFINITIONS, TERMS AND SYMBOLS

6.2.1 Definitions, explanations and terms.

For the purpose of this Section the following definitions have been adopted.

Welding procedure qualification tests mean the tests conducted under technical supervision and within the scope of the Register requirements to confirm the capability of the manufactur- er to carry out welding of particular structures; the tests closely simulate actu- al working conditions and are performed in accordance with the WPS require- ments.

Production tests mean the tests, including destructive tests, which are based on welding of specimens obtained directly in the course of product manufacture and subjected to the same treatment, as the actual products. Besides, depending on particular conditions and possibilities, the specimens may be cut out of extra lengths (allowances) of structures or be

manufactured in conditions identical with those of product manufacture and using the same WPS.

Welding procedure qualification record (WPQR) means the documents in the established by the Register form or based on the acceptable standards containing complete information on testing for approval of welding procedure. WPQR includes the following forms (records) Details of Weld Test and Test Results.

Pre-production welding tests mean the tests for approval of welding procedure based on the use of non-standard specimens and test assemblies and simulating welding in actual production conditions.

Welding Procedure Approval Test Certificate means a Register document certifying that the welding procedure applied at the shipyard or firm (manufacturer of welded structures) has passed the tests and is approved by the Register for application.

Welding Procedure Specification (WPS) means a document compiled by the manufacturer of welded structures and containing all the necessary information on welding of a particular joint, including specifications for materials, welding method, bevelling data and all process parameters.

Note: Preliminary WPS (pWPS) means WPS based on the previous welding experience and recommendations of welding consumables and base metal manufacturers, but having no confirmation and approval. Welding of specimens for approval of welding procedure is carried out in accordance with the preliminary WPS.

Standard welding procedure means the welding procedure that has passed all the qualification tests provided by the requirements of this Section and WPS was approved by the Register for use at the specific manufacturer of welded structures. The term “standard welding procedure” therewith is applied to the welding procedure approved by the Register if the last is used at other manufacturers’ of welded structures, which shall be totally identical to those in the WPS approved by the Register (without test performance or with tests of much-reduced scope).

6.2.2 Symbols.

6.2.2.1 The designations for welding processes according to ISO 4063 shall correspond to those given in Ta- ble 6.2.2.1.

Table 6.2.2.1 **Corresponding ISO 4063 reference numbers for the welding and cutting processes**

Reference numbers for the welding processes	Another commonly used designations (acronyms and abbreviations) for the welding processes	Name of welding or cutting processes
1	2	3
111	MMAW (SMAW:USA)	Manual metal arc welding (metal arc welding with covered electrode)
112	–	Gravity (arc) welding with covered electrode
114	–	Self-shielded tubular cored arc welding
12	SAW	Submerged arc welding with:
121	–	one solid wire electrode;
122	–	strip electrode;
123	–	multiple electrodes;
124	–	metallic powder addition;
125	–	cored strip electrode
131	MIG (GMAW:USA)	Metal inert gas (MIG) welding with solid wire electrode
135	MAG (GMAW:USA)	Metal active gas (MAG) welding with solid wire electrode
136	FCAW (USA)	MAG welding with flux cored electrode
137	FCAW (USA)	MIG welding with flux cored electrode
141	TIG (GTAW:USA)	Gas-shielded arc welding with non-consumable tungsten electrode with or without solid filler material (wire/rod)
15	–	Plasma arc welding:
151	–	plasma MIG welding;
152	–	powder plasma arc welding
31	OGW (USA)	Oxyfuel gas welding:
311	–	oxyacetylene welding;
312	–	oxypropane welding;
313	–	oxyhydrogen welding;
511	–	Electron beam welding
52	LBW (USA)	Laser welding
72	–	Electroslag welding
73	–	Electrogas welding
1	2	3
8	–	Cutting and gouging:
81	–	flame cutting;
82	–	arc cutting;
821	–	air arc cutting;
822	–	oxygen arc cutting;

83	–	plasma cutting;
84	–	laser cutting;
86	–	flame gouging;
87	–	arc gouging;
871	–	air arc gouging;
872	–	oxygen arc gouging;
88	–	plasma gouging

6.2.2.2 Approval of welding procedures and assigning of the range of approval on the basis of test results may be done with reference to base metal groups of typical composition in compliance with requirements given in Table 6.2.2.2 unified with EN 288-3.

Table 6.2.2.2 **Steel groups according to EN 288-3**

Steel group according to EN 288-3	Steel type
1	Steels with the minimum yield stress $R_e \leq 355$ N/mm^2 or temporary resistance $R_m \leq 520$ N/mm^2 and the chemical composition, %: C ≤ 0.24 Si ≤ 0.55 Mn ≤ 1.60 Mo ≤ 0.65 S ≤ 0.045 P ≤ 0.045 Any other alloy element — ≤ 0.3 %; all other elements in total — ≤ 0.8 %
2	Fine-grained construction steels with the yield stress $R_e > 355$ N/mm^2 supplied in conditions N and TM (TMCP)
3	High-strength steels with the yield stress $R_e > 500$ N/mm^2 supplied in the conditions Q + T
4	Heat-resistant steels containing Cr ≤ 0.6 %; Mo ≤ 0.5 %; V ≤ 0.25 %[1]
5	Steels containing Cr ≤ 9; Mo ≤ 1.2 %[1]
6	Steels containing Cr ≤ 12 %; Mo ≤ 1 %; V ≤ 0.5 %[1]
7	Steels containing Ni ≤ 9 %[1]
8	Ferrite or martensitic stainless steels containing Cr from 12 to 20 %[1]
9	Austenitic stainless steel

[1] For groups 4-8, the content of alloy elements shall be attributed to ladle samples.

6.2.2.3 When preparing documentation for the approval of welding procedures, coding of types of welded joints similarly to the system referred to Fig. 7.2.2. is recommended.

6.2.2.4 Welding of reference test assemblies and the range of approval of welding procedures shall apply to unified welding positions whose symbols are shown in Figs. 6.2.2.4-1 to 6.2.2.4-3 in compliance with ISO 6947.

6.3 TYPES OF WELDED JOINT TEST PIECES AND REQUIREMENTS FOR THEIR PREPARATION

6.3.1 Classification of test assemblies, their purpose and dimensions.

6.3.1.1 Test assembly of welded butt joints for plates and the diagram of test specimens' cutting-out shall meet Fig. 6.3.1.1-1.

Notes: 1. In testing automatic single-side welding procedures in specialised assembling and welding stands equipped with clamping devices, the test assembly length shall be at least 3,000 mm.

2. In testing automatic vertical welding procedures, including welding with forced weld formation, the test assembly length shall meet the specifications of the equipment used in production.

The thickness of the test assembly metal shall be within the range of the nominal thickness of the base metal under the WPS subject to approval and shall meet its requirements for the range of approval. However, be aware that:

qualification certification of welding processes narrowly outside the range of approval (refer to footnotes 1-3 to Table 6.6.2.2.2) may require several assemblies to be welded;

use of test assembly thickness outside the actual thickness range but within the range of approval according to 6.6.2.2.1 (for example, thicknesses of 20-28 mm are welded according to WPS and test assembly pieces with the thickness of 14 mm are welded according to the range of approval) is not allowed.

Bevelling and weld structural elements shall comply with the WPS subject to approval.

Strips for butt test assemblies of flat products shall be made taking into account the latest rolling direction and the orientation of the axis of impact test assemblies whose test results are given in supporting documents for the main material.

During impact tests on longitudinal specimens, KV_L (usually for all normal and high-strength hull steels), test assemblies are welded so that the weld is perpendicular to the last rolling direction.

During impact tests on the transverse specimens, KV_T, the weld shall be parallel to the last rolling direction (e.g., for improved-weldability steels).

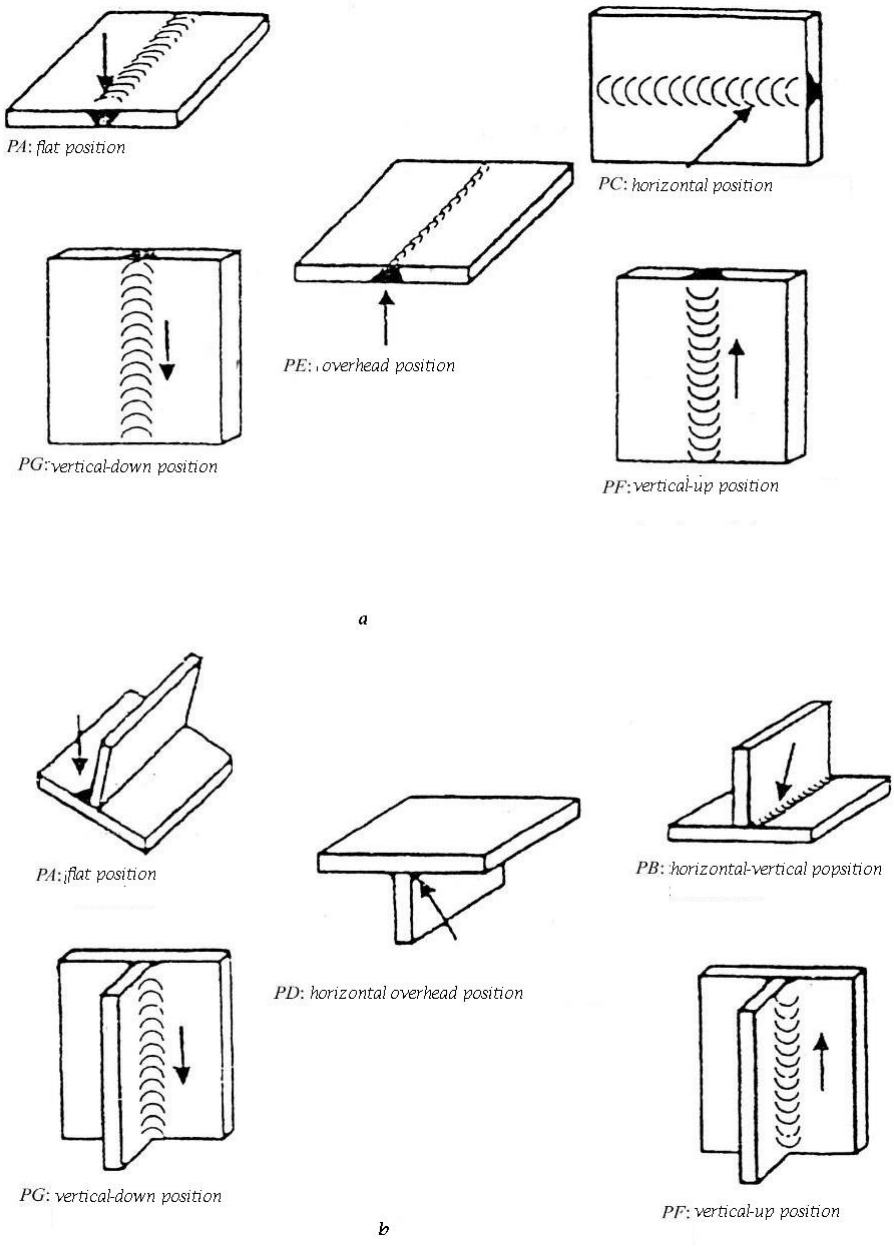
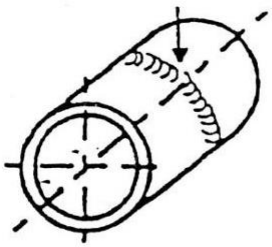
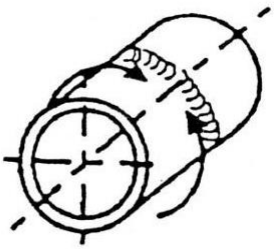


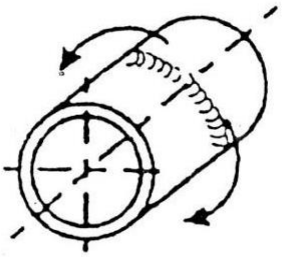
Fig. 6.2.2.4-1 Unified plate welding positions:
a — butt welds; ***b*** — fillet welds



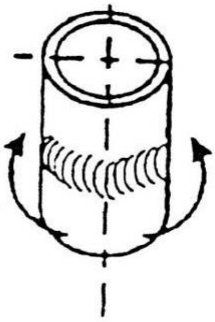
PA: flat
Pipe: rolled
Axis: horizontal



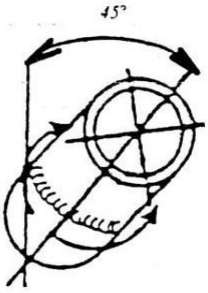
PF: vertical-up
Pipe: fixed
Axis: horizontal



PG: vertical-down
Pipe: fixed
Axis: horizontal



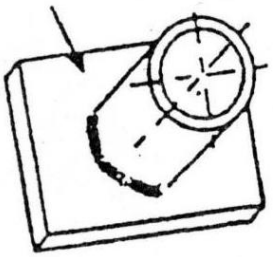
PC: horizontal
Pipe: fixed
Axis: vertical



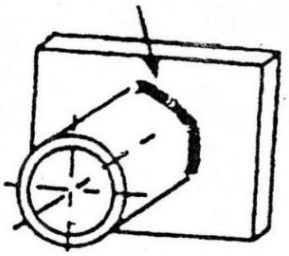
H-L045 inclined-up
Pipe: fixed
Axis: inclined

J-L045 inclined-down
Pipe: fixed
Axis: inclined

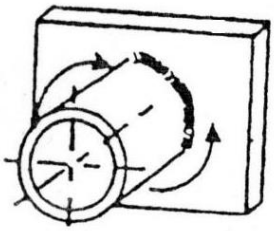
Fig. 6.2.2.4-2 Unified pipe welding positions (butt welds)



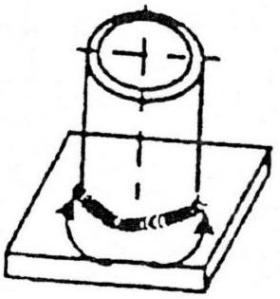
PA: flat
Pipe: rolled
Axis: inclined



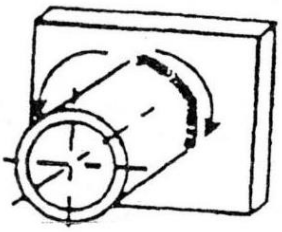
PB: horizontal-vertical
Pipe: rolled
Axis: horizontal



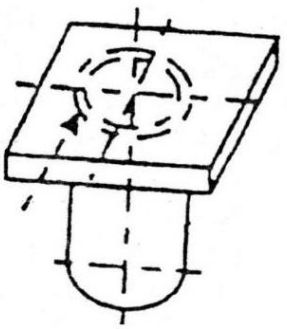
PF: vertical-up
Pipe: fixed
Axis: horizontal



PB: horizontal-vertical
Pipe: fixed
Axis: vertical



PG: vertical-down
Pipe: fixed
Axis: horizontal



PD: horizontal-overhead
Pipe: fixed
Axis: vertical

Fig. 6.2.2.4-3 Unified pipe welding positions (fillet welds)

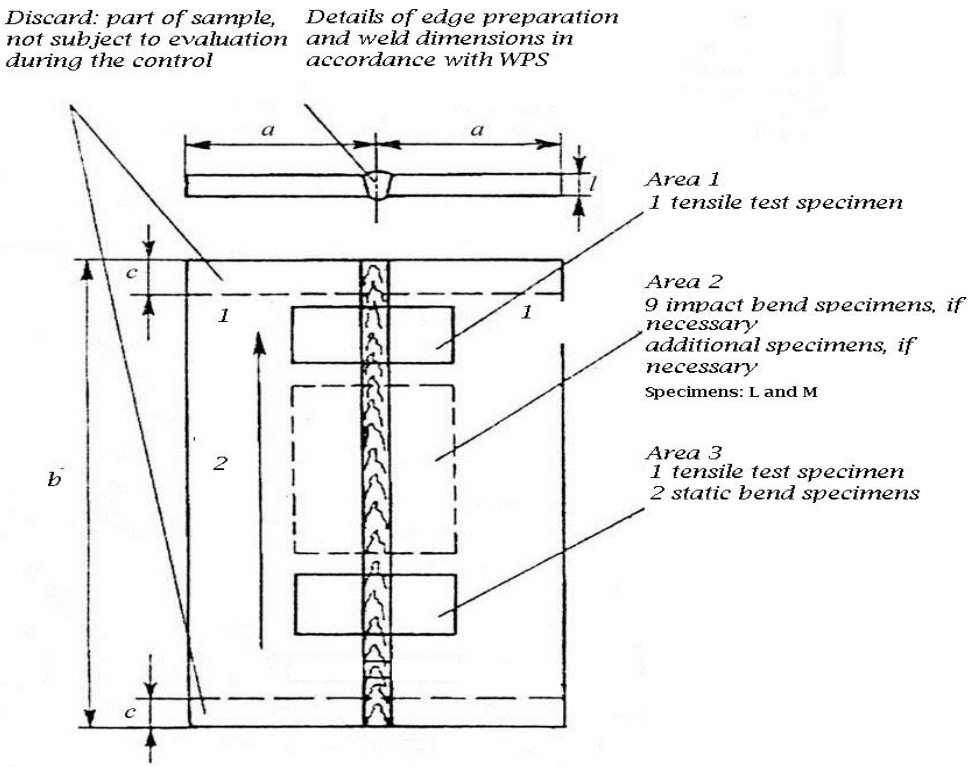


Fig. 6.3.1.1 Test assembly of welded butt joint and the diagram of test specimens' cutting-out:

1 — orientation of the direction of the roll of plates with the normalization of the impact on longitudinal specimens KV_L;

2 — orientation of the direction of the roll of plates with the normalization of the impact on transverse specimens, KV_T;

a and *b* dimensions of the test assembly piece adopted depending on the welding method:

for manual and mechanized welding with dimensions: $a \geq 150$ mm, but not less than $3t$; $b \geq 350$ mm, but not less than $6t$;

for automatic welding with dimensions: $a \geq 400$ mm; $b \geq 1{,}000$ mm ($\geq 3{,}000$ mm in the cases referred to in Note 1 to 6.3.1.1);

$c \approx 50$ mm — waste.

Zone 1 T_1 — transverse tensile flat specimen;

P_1 and P_3 — static bending specimens for the top of the weld or two transverse bending specimens.

Zone 2 KV_{WM} — impact test specimens with a notch on the weld centre;

KV_{FL} — impact test specimens with a notch along the fusion line;

KV_{HAZ} — impact test specimens with a notch in the heat affected zone;

L — a longitudinal cylindrical tensile specimen (if necessary);

M — a transverse macrosection to control the macrostructure and to measure the hard-

ness.

Zone 3 T_2 — transverse tensile flat specimen;

P_3 and P_4 — static bending specimens for the top of the weld or two transverse bending specimens.

6.3.1.2 Plate T-joint (tee-welded joint) test assembly shall be as in Fig. 6.3.1.2.

Note: In case of qualification certification of automatic welding procedures on specialized assembly and welding stands, the specimen length shall be no less than 3,000 mm.

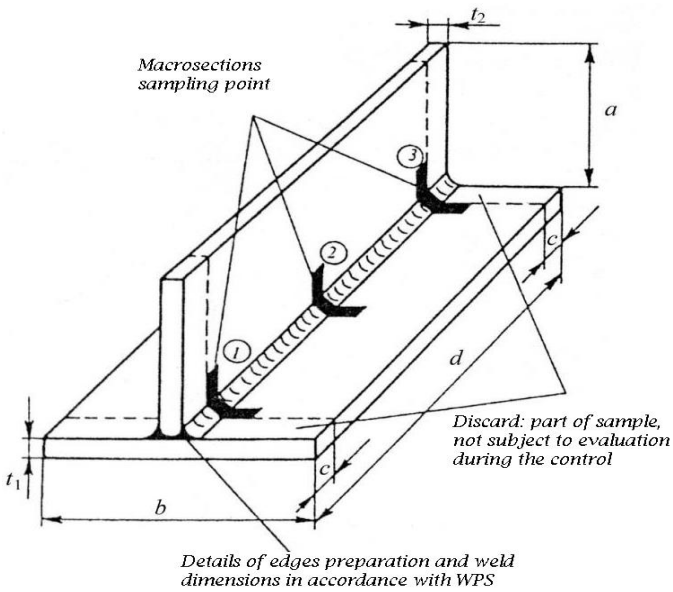


Fig. 6.3.1.2 Test assembly of tee-welded joint and the diagram of test specimens' cutting-out:

a) for manual and semi-automatic welding with dimensions:
$b \geq 150$ mm, but not less than $3t_1$ for joints without bevelling;
$b \geq 350$ mm, but not less than $6t_1$ for joints with bevelling;
$c \approx 25$ mm; $a \geq 150$ mm, but not less than $3t_2$; $d \geq 350$ mm, but not less than $6t_1$;
macrosection selection in zones 1 and 2 ("stop-start" operation);

b) for automatic welding with dimensions:
$b \geq 150$ mm, but not less than $3t_1$ for joints without bevelling;
$b \geq 350$ mm, but not less than $6t_1$ for joints with bevelling;
$c \approx 50$ mm; $a \geq 150$ mm but not less than $3t_2$;
$d \geq 1{,}000$ mm;
macrosection selection in zones 1, 2, 3.

According to the specification of the welding process (preliminary) being certified, the T-joint testing assembly for plates can be performed in two ways:

without bevelling (fillet welding);

with bevelling (with full penetration or a constructive lack of penetration).

Application of the plate T-joints is restricted by the following cases of approval of the welding procedure:

approval cannot be performed (or is impractical to perform) within the restrictions for the range of approval;

for the approval of welding processes for fillet welds with deep penetration (estimated fillet weld thickness exceeds the nominal one);

at the separate requirement of the Register for certification of welding procedures with the use of single-run fillet welding without removing the interoperational protective coating.

6.3.1.3 Plate cruciform joint test assembly shall be as in Fig. 6.3.1.3.

Notes: 1. For the certification of the automatic welding procedure in specialised stands that provide for two-way fillet welding, the length of the assemblies shall be not less than 3,000 mm.

2. In case of certification of the automatic vertical welding procedure with four cruciform welds at the same time, the length of the cruciform test assembly shall comply with the maximum height of welds performed in production using this type of equipment.

According to the specification of the welding procedure, the cruciform test assembly can be performed in two ways:

without bevelling (fillet welding);

with bevelling (with penetration).

The use of cruciform test assemblies is required for the approval of:

.1 welding procedures for high-strength steels with the yield stress of more than 460 N/mm^2, cladding steels, and non-ferrite alloys;

.2 vertical downward welding procedures;

.3 welded joints of increased- and high-strength steels with the estimated thickness of fillet welds that is much less than the thickness of the elements being welded.

The condition for the application of this requirement is the value of the estimated fillet weld thickness

$$a_{\min} \le 0{,}7\sqrt{t_1 + t_2},$$

where t_1 — the thickness (smaller) of the element being welded;

t_2 — the thickness (larger) of the main plate;

.4 welding procedures that are used to produce cruciform joints with the middle plate of steel without a normalisation of the properties in the thickness direction;

.5 if the structure provides for ultrasonic control of cruciform welds in the thickness direction in order to identify delamination of metal;

.6 welding procedures that provide for work at ambient temperatures below zero.

This requirement applies to increased- and high-strength steels upon the separate indication by the Register when the manufacturer cannot confirm that the welds are not susceptible to the formation of cold, hot, and under-bead cracks.

The thickness of the base metal and the calculated fillet weld thickness shall be within rated ranges of these parameters according to the WPS subject to approval and shall comply with the requirements for the range of approval (also refer to 6.3.1.1).

Bevelling and weld structural elements shall comply with the WPS subject to approval.

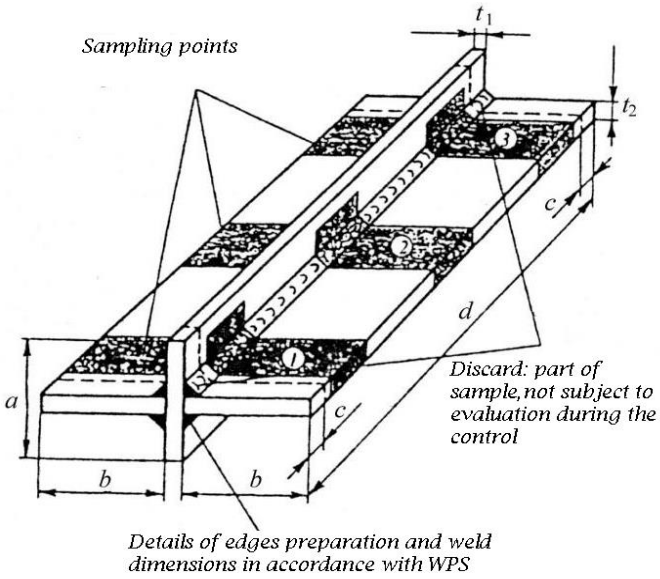


Fig. 6.3.1.3 Test assembly of cruciform-welded joint and the diagram of test specimens' cutting-out:

a) for manual and semi-automatic welding with dimensions:
$a \geq 100$ mm, but not less than $4t_1$;
$b \geq 150$ mm, but not less than $3t_2$;
$c \approx 25$ mm;
$d \geq 350$ mm, but not less than $6t_2$;
sampling for testing in Zone 2;
b) for automatic welding with dimensions:
$a \geq 150$ mm, but not less than $4t_2$;
$b \geq 150$ mm, but not less than $3t_2$;
$c \approx 50$ mm;
$d \geq 1{,}000$ mm; ($d \geq 3{,}000$ mm in the cases referred to in Note 1 to 6.3.1.3);
sampling for testing in Zones *1* and *3*.

6.3.1.4 Approval of welding procedures for butt joints of pipes is performed on the basis of test of the specimen corresponding to Fig. 6.3.1.4.

The outer diameter of the test assembly and the pipe wall thickness during tests shall be within nominal ranges of these parameters according to the WPS subject to approval and shall comply with requirements for ranges of approval according to 6.6.2.2 (refer also to 6.3.1.1).

For the pipes with an outside diameter of more than 500 mm, approval of manual and mechanised welding is possible based on the results of testing of butt joints of plates made in identical conditions (refer to requirements for positions according to Table 6.6.3.2 and other parameters of the range of approval according to 6.3.2.1.1, 6.6.2, 6.6.3 and 6.6.4).

Orientation of the welded test assembly axis and the structural character-

istics of welds shall correspond to the WPS for the real structure.

Note: In agreement with the Register surveyor, the manufacturer may change the design of the test assembly piece according to actual characteristics of welded joints. For example, the pipe can be replaced by a box-shaped profile etc.

6.3.1.5 Approval of welding procedures for pipe connections with the use of a fillet weld and piping joint assemblies shall be carried out on the basis of the test of the specimen corresponding to Fig. 6.3.1.5.

The outer diameter of the pipes, their thickness, and the angle between the axes of the pipes shall be within the nominal range of values of these parameters according to the WPS subject to approval and shall comply with requirements for the range of approval (refer also to 6.3.1.1).

In accordance with the requirements for bevelling of edges that are welded and the thickness of a pipe to be welded on, the test assembly complying with Fig. 6.3.1.5 may be fabricated in two op- tions:

without bevelling in the qualification of welding procedures for fillet welding;

with bevelling for the certification of welding procedures of piping joint assemblies with the provision of penetration.

6.3.1.5.1 When testing approval procedures for welding of piping joint assemblies with bevelling, it is necessary to be guided by the following:

.1 for a manual and semi-automatic welding, the main pipe axis shall be oriented vertically what is sufficient for the approval of all other pipe axis positions in manufacturing practice;

.2 for an automatic welding and robotised systems, the orientation of the main pipe axis shall comply with the actual conditions of welded joints fabrication. The range of approval for the main pipe axis orientation is limited by the angles of ±30° from the nominal axis position;

.3 testing with the use of this type of test assembly is a mandatory requirement:

in certification of manual and semi-automatic welding procedures within the range of the diameter $150 \le D_2 \le 500$ mm of a pipe to be welded on, with its wall thickness $t_2 \ge 12$ mm and for the angle between pipe axes of $\alpha \le 70°$;

in certification of automatic welding procedures and welding with the use of robotic systems;

.4 in other cases (not specified in 6.3.1.5.1) according to the decision of the Register surveyor, the approval procedure without additional testing of the assembly under Fig. 6.3.1.5 is possible by means of approval through spreading the range of approval of testing results for pipe butt welding (where performed).

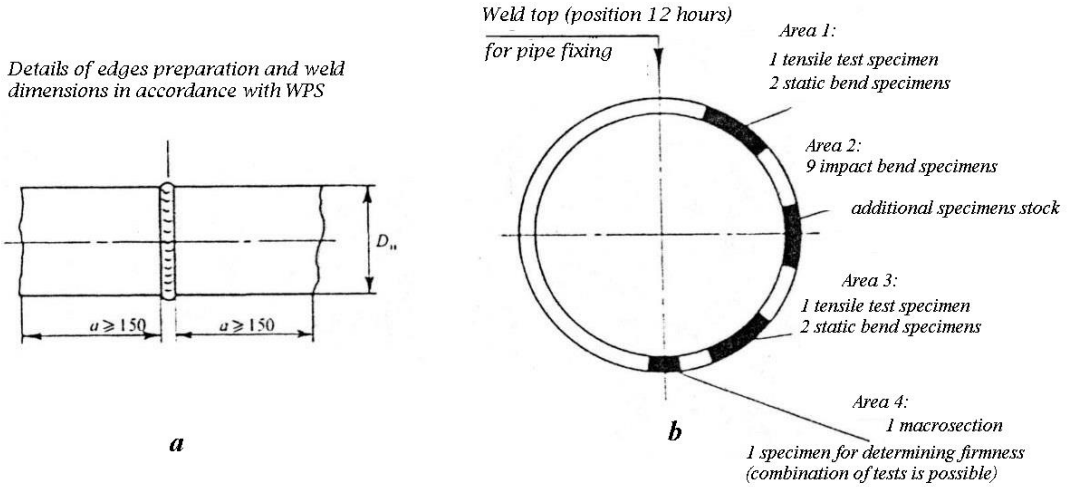


Fig. 6.3.1.4 Test assembly of butt pipe joint:
a — the dimensions of the test assembly;
b — diagram of test specimens cutting-out

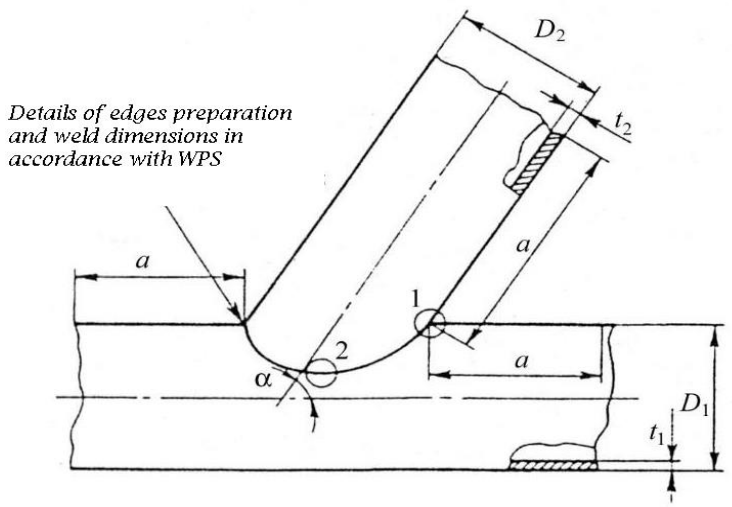


Fig. 6.3.1.5 Test assembly of pipes joint made with a fillet weld and the diagram of test specimens cutting-out:
1 and 2 — macrosection selection sites

6.3.1.5.2 When testing approval procedures for welding of piping joint assemblies with the use of fillet welds without bevelling, it is necessary to be guided by the following:

.1 for manual and semi-automatic welding procedures, the application of a piping joint assembly is usually required where the considered technology cannot be approved without additional testing based on the requirements for the range of approval based on testing results for pipe butt weld test assemblies (which were either not implemented or not fully

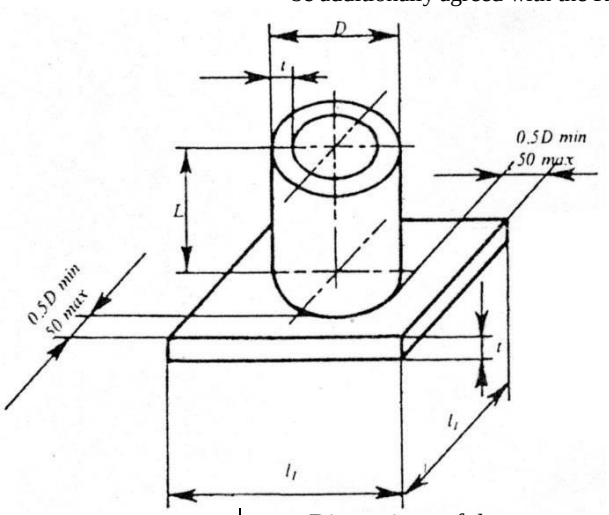
comply with all the requirements for the range of approval for the certification of the fillet weld welding technology);

.2 the application of an assembly is mandatory for the approval of automatic welding procedures with the use of robotic systems;

.3 the application of an assembly is mandatory in case of the use of welding procedures that ensure a deep penetration of the weld root, which is taken into account in the calculation of the fillet weld thickness;

.4 the application of an assembly is mandatory in case of certification of welding procedures that involve downward welding (for pipes, in the direction from 12 to 6 o'clock).

Note: In agreement with the Register surveyor, certification of welding procedures for fillet welding of pipes without bevelling on simplified test assemblies that comply with Fig. 6.3.1.5.2.4 is allowed if the latter comply with the real weld configuration. Dimensions of test assemblies shall be additionally agreed with the Register surveyor.



Type of welding	Dimensions of the test assembly, mm	
	D	*L*
MW, SA, A[1]	≤ 25	≥ 75
	25 < *D* ≤ 150	≥ 125
	> 150	≥ 150

[1] Dimensions of a test assembly shall be sufficient to ensure stable operation of the equipment.

Fig. 6.3.1.5.2.4 Pipe fillet welding test assembly

6.3.2 Requirements for test assembly production.

6.3.2.1 General requirements for the test pieces programme and extent.

6.3.2.1.1 The test program for the approval of welding procedures shall include forms of welding procedure specifications completed by the manufacturer for all the welding procedures to be approved by the Register. In determining the extent of testing, it is necessary to be guided by the following.

6.3.2.1.2 Each procedure to be approved by the Register shall be tested for each welding position in which it will be used under production conditions. The

required welding positions of an assemblies according to approved welding positions of real structures are provided in Table 6.6.3.2.

Combination of PA and PE positions on one test assembly is permitted if the same can occur in real structures.

6.3.2.1.3 For similar welds made by the same welding procedure in identical positions, testing for approval of the welding technology shall cover the whole range of thicknesses of the base metal and/or estimated thicknesses of fillet welds that occur in the production of welded structures while considering ranges of approval under 6.6.2.2.

6.3.2.1.4 For the approval of the manual welding procedure with the use of covered (artificial) electrodes, it is necessary to perform certification testing for each grade of welding materials.

6.3.2.1.5 For the approval of mechanised welding procedures with the use of welding materials of the same hardness group but of different grades, performance of tests for approval only in respect of the materials of the highest grade that have the lower impact test temperature is allowed in agreement with the Register.

6.3.2.1.6 For the approval of mechanised welding procedures (except for electro-gas, electro-slag, and similar welding processes with high values of heat input) with the use of welding materials with the same level of requirements for the impact test temperature but of different groups of hardness, performance of tests only in respect of the materials of the highest hardness group/grade is allowed in agreement with the Register.

6.3.2.1.7 In addition to the specification of welding procedures for materials with limited weldability, the manufacturer shall document to the Register the validity of selected parameters and quality control for the prevention of various forms of cracking. In the absence of such confirmation, the Register may request the inclusion of relevant welding proce- dure test assemblies into the welding procedure test programme.

6.3.2.1.8 The extent of the testing programme shall fully meet the stated range of approval for welding procedures according to specific conditions of welded structures.

6.3.2.1.9 In determining the extent of testing of welded joint assemblies, it is necessary in general to be guided by Table 6.4.1.1. If necessary, the Register may require extending the scope of testing (increase of the number of test assemblies or performance of other types of tests).

6.3.2.2 Requirements for welding procedure and preparation of test an assemblies.

6.3.2.2.1 Preheating is only used if it is specified in WPS for the given material. But even if the preheating is not used, the Register surveyor has the right to require welding of joint test assemblies to be done with simulation of temperature conditions corresponding to the minimum ambient air temperature, at which welding jobs are permitted in accordance with the WPS.

6.3.2.2.2 One shall meet the WPS requirements, if any, with respect to interbead (interpass) temperature.

If WPS does not specify measures in control of this parameter, the temperature in welding of test assemblies shall be

kept within limits normally observed in practice. The actual data of interpass temperature measurements are entered into the specification of welded joint tests.

Note: In case of deviation of the test assembly dimensions from values required by 6.3.1 one shall take into account the change in heat removal conditions to meet the requirements with respect to interpass temperature, as stated above.

6.3.2.2.3 The welding parameters shall comply with the WPS requirements. Besides, the welding of test assembly shall be carried out for the most unfavourable set of welding parameters, e.g. at maximum values of welding current and heat input (in cases, when impact testing is required). Non-observance of this test condition requires additional validation and, if this is not available or not correct, the Register has the right to require from the manufacturer of welded structures limitation of weld conditions (heat input) in WPS down to values actually observed in the tests and corresponding to the range of approval.

6.3.2.2.4 When performing welding tests, it is necessary to take into account all diameters of electrodes or welding wires specified in the WPS; and for welding methods 111 and 114, to be guided by 6.6.4.1.

6.3.2.2.5 Heat treatment of welded joints shall be performed only, if it is specified by WPS. In this case the actual conditions of the welded joint test assembly heat treatment shall be selected aiming at the most unfavourable version from the point of view of obtaining the required properties of the welded joint (refer also to the requirement of 6.6.3.10 concerning the range of approval).

6.3.2.2.6 Welding of test assemblies shall be performed, as far as possible, with the use of production equipment and in workshop conditions.

6.3.2.2.7 The structural elements of bevelling, weld dimensions and the technological features of welding operation shall comply with Welding WPS for the welding procedure to be approved regarding the range of approval. In testing, the most adverse versions of bevelling and fit-up to ensure the quality of welded joints shall be checked.

Note: In order to fulfil this requirement, the Register may demand the extension of a test program (for example, the welding of two test assemblies instead of one for the lower and upper boundaries of the allowance for a root gap, variation in thickness, root faces etc.).

6.3.2.2.8 The test of the T-joint of plates without bevelling shall be made with edge preparation that ensures the absence of a gap in the joint.

Dimensions of a test assembly shall, if possible, ensure acceptable conditions for heat removal that are close to the real conditions.

Preparation of the test assembly and the welding conditions shall meet pWPS being certified.

Fillet welding of test assemblies is performed on one side only.

In this case, manual and semi-automatic welding procedures require the mandatory crater filling and arc re-excitation on the credit length of the test assembly (the “stop-start” operation).

The place the “stop-start” operation is marked for the possibility of further verification of the macrosection.

The test report shall contain a mark on the presence or the absence of an interoperational protective coating on the edges of test assemblies being welded.

6.4 REQUIREMENTS FOR TEST ASSEMBLIES EXAMINATION, TEST SPECIMENS PREPARATION AND TEST RESULTS EVALUATION

6.4.1 Extent of the test pieces examination and testing.

6.4.1.1 Each test assembly after welding shall be subjected to testing within the scope of the requirements specified in Table 6.4.1.1.

At the same time the welded joints examination, test specimens preparation and test results evaluation shall meet the requirements given below.

6.4.1.2 The results of non-destructive quality control of test assemblies for all welding processes shall comply with applicable requirements of technical documentation approved by the Register for the receipt of specific product types, for which the approval process is carried out.

In this case, general requirements specified in Section 3 in respect of control and evaluation of control results shall be complied with.

6.4.1.3 In case where welding of test assemblies of the tee joint is the only type of tests during the certification of the welding process, additional tests shall be performed (refer also to Table 6.4.1.1) in the volume of:

determination of the properties of deposited metal for the certification of T-joint fillet welding procedures without bevelling. This type of testing is mandatory in case of the use of welding materials that do not have a Certificate of approval by the Register (for other cases, testing may be due to specific requirements of the Register);

determination of the properties of butt welds for the certification of T-joint welding procedures with bevelling and provision for penetration. Butt test assembly welding shall be carried out under the conditions as close to the T-joint test assembly welding regarding the range of approval as possible: position, welding modes, the bevelling opening angle etc.

Table 6.4.1.1 **Requirements for extent of testing for approval of welding procedures**

NOS з/п	Type of welded test assembly	Type of test	Extent of testing
1	2	3	4
1	Butt weld on plates and pipes: refer to Figs. 6.3.1.1 and 6.3.1.4	Visual and measurement testing	100 % weld length
		Radiographic or ultrasonic testing	100 % weld length
		Surface crack detection[1]	100 % weld length
		Transverse tensile test of flat specimens	2 specimens
		Transverse static bend test of test specimens[2]	4 specimens

Nos з/п	Type of welded test assembly	Type of test	Extent of testing
1	2	3	4
		Impact test[3]	3 series of 3 specimens each: notched in the weld centre; notched along the fusion line; notched along HAZ at a distance of 2 mm from the fusion line
		Hardness test[4]	Required
		Check of macrosections	1 transverse macrosection
2	T-joints in plate with bevelling (with full penetration): refer to Fig. 6.3.1.2. Pipe branching node with bevelling on branch to be welded on (wit weld penetration): refer to Fig. 6.3.1.	Visual and measurement testing	100 % weld length
		Surface crack detection[1]	100 % weld length
		Ultrasonic testing[5, 6]	100 % weld length
		Hardness test[4]	Required
		Check of macrosections	2 transverse macrosections
		Additional tests[7]	Refer to 6.4.1.3
3	T-joints in plate without bevelling (fillet/joint): refer Fig. 6.3.1.2.	Visual and measurement testing	100 % weld length
		Surface crack detection[1]	100 % weld length
		Check of macrosections	2 transverse macrosections (3 — for the assemblies ≥ 1,000 mm long)
		Hardness test[4]	Required

End of Table 6.4.1.1

1	2	3	4
	Pipe branching node without bevelling on branch to be welded (without penetration): refer to Figs 6.3.1.5 and 6.3.1.5.2.4	Fracture test	2 — for manual and semi-automatic welding, 6 — for automatic welding
		Additional tests[7]	Refer to 6.4.1.3
4	Cruciform joint of plates with and without bevelling: refer to	Visual and measurement testing	100 % weld length
		Surface crack detection[1]	100 % weld length
		Ultrasonic tests (only for joints with processed edges)[5, 8]	100 % weld length

	Fig. 6.3.1.3	Transverse tensile test	3 specimens for test assemblies ≥ 350 mm long, 6 specimens for test assemblies ≥ 1,000 mm long
		Check of macrosections	2 transverse macrosections
		Hardness test[4]	Required
		Additional tests[7]	Refer to 6.4.1.3

[1] Penetrant testing or magnetic particle testing. For non-magnetic materials, penetrant testing.

[2] For base metal thickness $t < 12$ mm, two test specimens of weld root stretching and two test specimens of top weld stretching shall be tested. For thickness $t \geq 12$ mm, four transverse bending test specimens shall be tested.

[3] Impact tests shall be performed if this type of testing must be carried out according to the requirements of the Rules of the Register or the specifications for the basic material approved by the Register. In this case, testing shall not be performed for thickness of welded test assembly metal $t < 6$ mm, which does not allow producing test specimens of standard dimensions. Other requirements — in compliance with 6.4.5.

[4] Hardness test is not required:

for hull steel of normal strength, as well as other steels of group 1 with $R_m \leq 420$ N/mm^2 and $R_e \leq 275$ N/mm^2;

for austenitic stainless steels of group 9.

[5] Ultrasonic testing shall be used for steel groups 1, 2, 3 and 4 (refer to Table 6.2.2.2) at welded pipe wall thickness of $t \geq 12$ mm.

[6] For outside diameter ≤ 50 mm no ultrasonic test is required. For outside diameter > 50 mm and where it is not technically possible to carry out ultrasonic testing, a radiographic testing shall be carried out on the maximum weld length available.

[7] In cases when the welding procedure according to WPS is not subjected to approval testing by other methods, additional tests to check the mechanical properties (mechanical tests) shall be conducted on a butt joint test piece with identical bevelling.

[8] If the control of welded joints in industrial conditions requires ultrasonic control of the base metal in the thickness direction in order to identify the possible delamination of metal, this requirements shall also be carried out for the control of the test assembly of a cruciform joint.

6.4.1.4 If welding materials that do not have the Register Certificate of Approval of Welding Materials have been used for butt welding of test specimens, tensile test specimens shall be further tested as directed in 6.4.2.2.

6.4.2 Tensile test.

6.4.2.1 Two flat specimens taken from the test pieces for butt joints in plate and pipe having dimensions as shown in Fig. 4.2.4.2 and/or 2.2.2.3, Part XIII "Materials" shall be tested.

The valuesof tensile strength at break for testing shall not be less than the values in Table 4.2.1.2-2 for normal steels and increased-strength steels or in Table 4.6.2 for high-strength steels.

In other cases, tensile strength at break for testing shall not be less than minimum valuesin Part XIII "Materials" and recognised by the Register as national standards for the relevant base metal, taking into account its thickness.

6.4.2.2 If welding consumables that do not have Certificates of Approval for Welding Materials have been used to weld test specimens, one or two (depending on the method of welding) longitudinal cylindrical tensile test specimens with the working diameter of 10 mm shall be

additionally manufactured and tested according to 2.2.2.3, Part XIII "Materials".

On agreement with the Register the following version of specimens preparation for testing is acceptable:

cutting from the butt-joint test assembly, if the dimensions of the specimen effective part are fit for weld cross-section;

cutting from additionally prepared deposited metal test assembly meeting the requirements of Section 4 for relevant welding consumables and welding processes.

Note: When the specimens are taken from the butt-welded joint test assembly, proportional round tensile test specimens with 6 mm diameter of effective part may be used, if the effective part of 10 mm diameter does not fit the weld cross-section.

6.4.2.3 Three or six (depending on the method of welding) transverse tensile test specimens shall be made and tested from the cruciform joint.

Dimensions and the test specimens' cutting-out diagram shall be as in Fig. 6.4.2.3.

Testing of transverse test assemblies shall be carried out in order to determine the following characteristics of the weld:

the actual valuesof the strength of the weld metal Z_S for joints without bevelling;

the uniform strength of the weld to the base metal for joints with bevelling.

6.4.2.3.1 Evaluation of testing results for joints without bevelling.

Indicator of the shear strength of the fillet weld metal is calculated by the formula:

$$Z_S = F_p/S_B b,$$

where F_p is the breaking load, N;

$S_B = S_{1/2}$ or $S_{3/4}$ (where $S_{1/2} = a_1 + a_2$, $S_{3/4} = a_3 + a_4$: refer to Fig. 6.4.7.2) — the total thickness of fillet welds in the weld fracture site (along welds 1 and 2 or 3 and 4), mm;

b — the length of the weld, which corresponds to the width of the test assembly, mm.

Test results shall be deemed satisfactory if:

$Z_S \geq 0.88\ R_m$ — for rolled steel;

$Z_S \geq 0.60\ R_m$ — for rolled aluminium alloys,

where R_m is the minimum value of tensile strength of the deposited metal for welding for the materials used in welding according to the requirements of the Rules or the technical documentation approved by the Register, N/mm^2.

6.4.2.3.2 Evaluation of testing results for joints with bevelling.

Test results shall be deemed satisfactory if weld destruction has occurred in the base metal. In this case, the actual value of tensile strength shall be not less than the minimum value regulated for the base metal of the test assembly by the requirements of Part XIII "Materials" or the technical documentation approved by the Register.

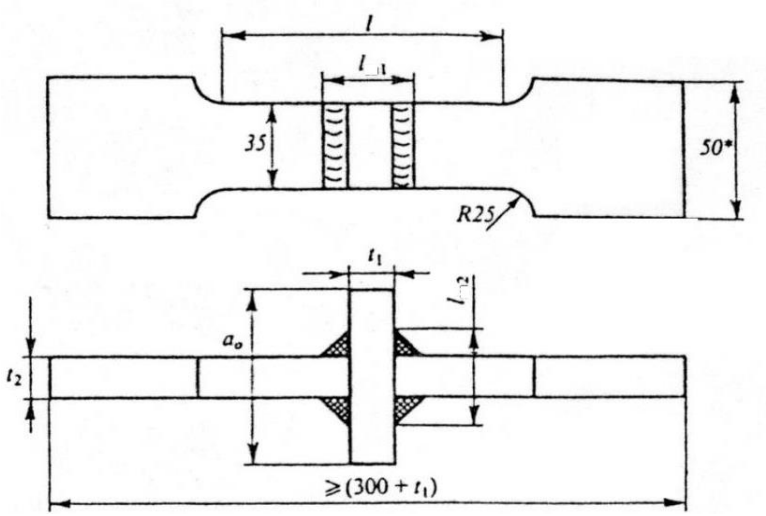


Fig. 6.4.2.3 Transverse tensile strength specimen made of a cruciform test assembly

Note: Dimensions marked with an asterisk may vary depending on the dimensions of grappling unit of the testing machine

6.4.3 Bend tests.

Specimens for the static bend test of the weld side surface shall be produced according to Fig. 2.2.5.1, Part XIII "Materials".

The upper and lower surface of the weld shall be removed by cleaning or machining flush with the base metal surface.

Edge of the specimens on the stretching side may be rounded at the radius of not more than 2 mm.

In case of testing by bending around the mandrel, the length of the specimen may be more than $11a_0$.

In testing specimens for transverse tensile bending in either the top or the root of the weld, the specimen dimensions shall be:

$a_0 = t$, where t — metal plate thickness of the butt weld assembly;

$b_0 = 30$ mm.

If the plate thickness of the test assembly (a_0) exceeds 25 mm, it may be reduced to this size by machining on the compression side of the test specimen.

In testing transverse specimens for side bend, specimen dimensions shall be:

$a_0 = 10$ mm;

$b_0 = t$, where t — metal plate thickness of the butt weld assembly.

In the latter case, for plates with the thickness $t \geq 40$ mm, it is allowed to divide the specimen in two parts of the width $b_0 \geq 20$ mm.

When testing heterogeneous welds, the bending tests for transverse test assemblies is replaced with a longitudinal test in the same quantity and orientation of the stretching area (top and root of the weld) upon agreement with the Register. The dimensions of test assemblies and the testing methods shall be subject to additional approval from the Register.

Ratio of the diameter of the mandrel and the thickness of the test assembly (*D/t*) during tests shall be increased by 1.0 relative to the valuesregulated in Section 4 for the approval of corresponding welding materials. Testing shall be carried out before reaching the bend angle of 180°.

The surface of the test assembly after the tests shall not have defects with dimensions in any direction in excess of 3 mm. Larger defects that have appeared on the edges of the test assembly shall be tested and evaluated individually.

6.4.4 Fracture test.

The lack of internal imperfections in fillet welded T-joints in plate shall be checked by fracture test with extension of the weld root from two (for manual and semi-automatic welding) to six specimens (for automatic welding).

The specimens of 100 to 120 mm in length with a removed fillet weld on one side of the T-joint shall be used for testing. To facilitate destruction of the filler weld, a longitudinal notch may be done on the weld surface or/and additional notches about 5 mm depth on both edges of the fillet weld (side notching) may be done.

The fracture surface of test assemblies shall be controlled for the presence of unacceptable internal defects and the value of the weld root penetration. The fracture surface may contain minor internal defects such as pores and slag inclusions if their dimensions does not exceed 0.2*Z* or 2.0 mm, whichever is smaller (where *Z* is a leg of the fillet weld) and their relative area is less than 1 % of the controlled weld fracture section (the site of local clusters of defects may increase their relative area by up to 3 % subject to restricting their linear dimensions to $\leq 0.08Z$).

6.4.5 Impact test.

6.4.5.1 Test assembly dimensions and the method of testing and evaluation of results shall meet the requirements of 2.2.3, Part XIII “Materials”.

The number of 3-specimen series, as well as the location of the cut on test assemblies of each series shall meet Table 6.4.1.1, Fig. 6.4.5.1-1 or Fig. 6.4.5.1-2 depending on the thickness of the metal of specimens and the heat input regarding the following additional requirements.

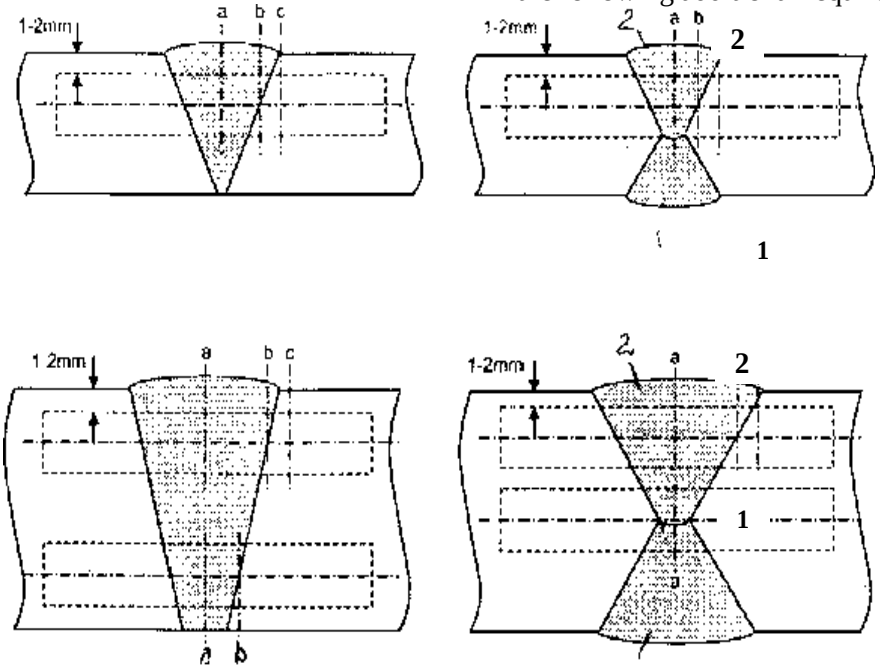


Fig. 6.4.5.1-1 The diagram of cut-out and location of the cut in the impact test assembly with the approval of welding procedures with the heat input of up to 50 kJ/cm inclusive:

1 — weld side to be welded first; 2 — weld side to be welded last;

a — a cut down the weld centre (WM); b — a cut through the fusion line (FL); c — a cut in the heat affected zone (HAZ) at a distance of 2 mm from the fusion line.

Note: (1) When approving single-run welding for test assemblies thicker than 20 mm, an optional second set of test assemblies shall be produced from the weld root with a cut in the weld centre *a*.

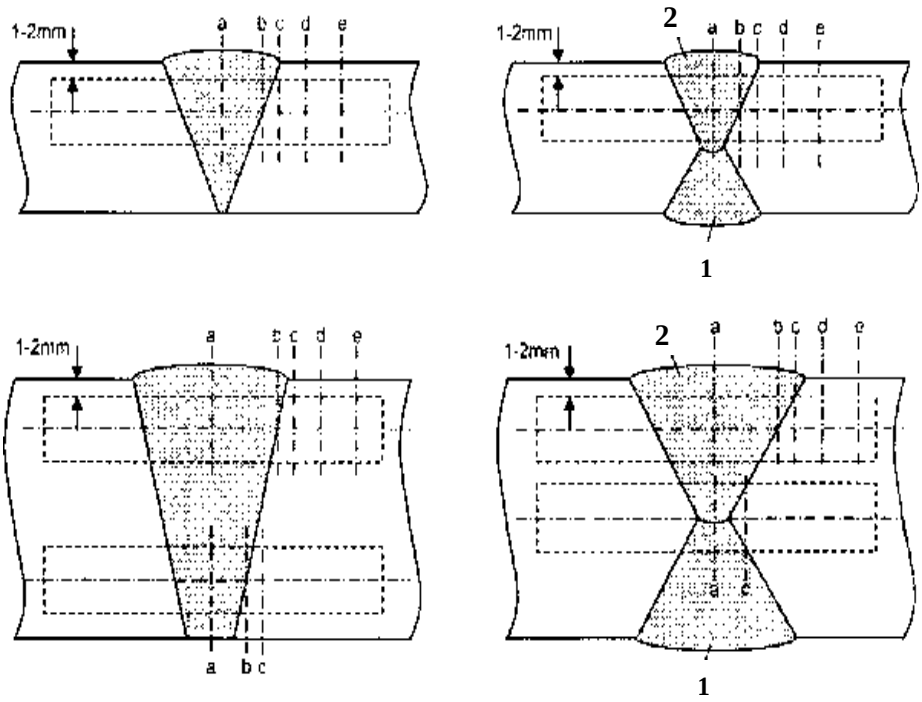


Fig. 6.4.5.1-2 The diagram of cut-out and location of the cut in the impact test assembly with the approval of welding procedures with the heat input of more than 50 kJ/cm:

1 — weld side to be welded first; 2 — weld side to be welded last;

a — a cut down the weld centre (WM); *b* — a cut through the fusion line (FL);

c — a cut in the heat affected zone (HAZ) at a distance of 2 mm from the fusion line;

d — a cut in the heat affected zone (HAZ) at a distance of 5 mm from the fusion line; *e* — a cut in the heat affected zone (HAZ) at a distance of 10 mm from the fusion line.

Note: (1) When approving single-run welding for test assemblies thicker than 20 mm, three additional sets of test assemblies shall be produced from the weld root with a cut along lines *a*, *b* and *c*.

6.4.5.2 For welded joints for normal- and increased-strength steels whose grade of welding consumables corresponds to Table 2.2.4, requirements for impact test results shall be as in Table 6.4.5.2.

For welded joints between different grades of steel, specimens being tested shall be added on the side of the steel of a lower strength grade.

If welding of test assemblies requires more than one method of welding or uses more than one type of welding consumables, impact test specimens shall be selected from each zone of the weld in which these methods of welding or welding consumables are used. This requirement does not apply to methods of welding or welding consumables that are used solely for the performance of the first or the root pass of the weld.

Testing of short test assemblies shall be carried out in accordance with 2.2.3.1, Part XIII "Materials".

In special cases, where the grade of welding consumables does not comply with Table 2.2.4 (for example, for PBU and MSP structures), the results and the temperature of the impact test assembly shall meet the requirements of Section 4 for the relevant grade of welding consumables in relation to the metal of the weld and the fusion line; for metal of the heat affected zone, they shall meet the requirements of Subsection 3.2 and 3.5, Part XIII "Materials" for the respective grade of steel taking into account the rolling direction (refer to 6.3.1.1) when welding the test assembly. In this case, for welds of the F steel, the Register may require testing of additional series of specimens with a cut in the HAZ at 5 mm away from the fusion line regardless of the welding heat input.

6.4.5.3 For welded joints of high-strength steels that comply with requirements of Subsection 3.13, Part XIII "Materials", the results and the temperature of impact tests shall be as in Table 4.6.1 for the relevant grade of welding consumables in relation to the metal of the weld and fusion lines; for metal of the HAZ, as in Table 3.13.3-1, Part XIII "Materials" for the respective steel grade taking into account the rolling direction (refer to 6.3.1.1) when welding the test assembly.

In this case, the Register may require additional testing of series of specimens:

with a cut along HAZ at a distance of 5 mm from the fusion line regardless of the welding heat input;

selected from the middle of the thickness in the number equal to that of the surface at rolled material thickness of over 40 mm.

6.4.5.4 For steel castings and forgings, impact test for the fusion line and the HAZ shall be carried out in accordance with the requirements of Subsections 3.7 and 3.8 of Part XIII "Materials" for the base metal.

Testing of the weld metal is carried out in relation to the grade of welding consumables established by the documentation approved by the Register for a specific product or structure.

6.4.5.5 For corrosion-resistant steels, subject to approval of welding procedures, impact tests are carried out upon agreement with the Register if this type of testing is provided for the base metal by the Rules or by the documentation approved by the Register for a specific

product or structure (for example, for casting of propellers of corrosion-resistant steels as required by Subsection 3.12, Part XIII "Materials").

Unless otherwise agreed by the Register, the temperature and the criteria for evaluation of impact test results correspond to the value regulated for the base metal.

Table 6.4.5.2 **Requirements for impact tests for butt welds of normal- and increased-strength steels (t ≤ 50 mm)[1, 2]**

Welded steel grade	Temperature of testing, °C	Impact energy, *KV*, J, min		
		Electrodes and combinations for semi-automatic welding		Combinations for automatic welding
		Downhand horizontal and overhead positions	Vertical position	
A (3)	20	47	34	34
B (3), D	0			
E	−20			
A32, A36	20			
D32, D36	0			
E32, E36	−20			
F32, F36	−40			
A40	20		39	39
D40	0			
E40	−20			
F40	−40			

Notes: 1. At rolled product thickness of over 50 mm, requirements for impact test results are determined with regard to Table 3.2.3 and Table 3.5.2.3, Part XIII "Materials", and are subject to approval from the Register.

2. Requirements of the table are applicable to test assemblies in which the weld is perpendicular to the rolling direction (that is, the value of KV_L for the fusion line metal and the HAZ is determined).

3. For rolled steel of normal strength of grades A and B, the average value of impact the metal of the fusion line and the HAZ shall be at least 27 J.

6.4.6 Requirements for hardness measurement.

Determination of the hardness of the weld metal *(*HV5 or HV10) shall be performed on transverse macrosections according to the instructions in Figs 6.4.6-1 to 6.4.6-5. In this case, the hardness of each zone of the weld (weld, HAZ, base metal) shall be based on at least three dimensions on either side of the centre line of the weld. In the HAZ, the first measurement point shall be located as close as possible to the fusion line as possible.

In some cases, the Register may require the placement of HAZ hardness measurement sites parallel to fusion lines (in cases where the number of hardness measurement sites does not meet the above requirement).

The distance between hardness measurement sites shall be at least 1.7 mm for the HV5 scale and 1.0 mm for the HV10 scale.

Determination of the hardness is a mandatory test for the certification of welding procedures for hull steels with the yield stress $R_{eH} \geq 355$ MPa and high-strength steels in all grades.

Requirements for the measurement of hardness must also be complied with in the following cases:

for welded joints of piping of steel $C_{equiv} \geq 0.41$ %;

for welded joints of forgings and castings of steel of group 1 (refer to Table 6.2.2.2) containing $C \geq 0.18$ % and the thickness of welded elements, $t > 40$ mm;

for welded joints of steel of groups 2, 3, 4, 5, 6, 7 and 8 (refer to Table 6.2.2.2).

Results of hardness measurements shall meet the following requirements:

for increased- and high-strength hull steel with the yield stress $R_{eH} \leq 420$ MPa, the maximum hardness value shall not exceed 350 HV10;

for high strength steels with yield limit of 420 MPa < $R_{eH} \leq 690$ MPa that comply with requirements of Subsection 3.13, Part XIII "Materials", the maximum hardness value shall not exceed 420 HV10;

in other cases, it is necessary to be guided by Table 6.4.6.

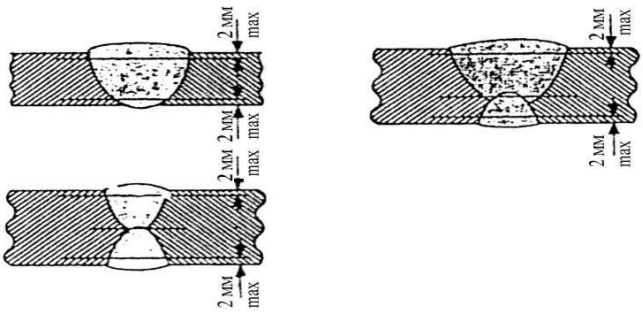


Fig. 6.4.6-1 Arrangement of measurement lines in butt joints

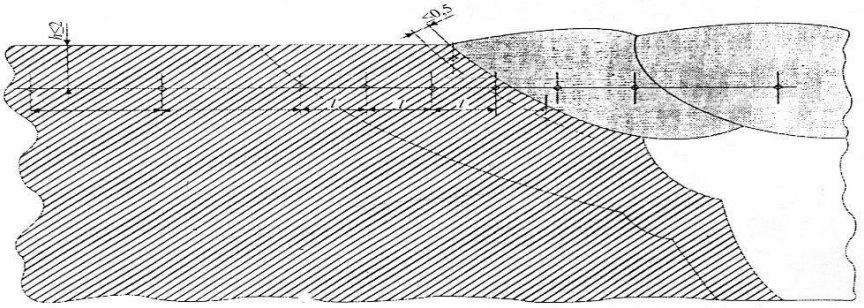


Fig. 6.4.6-2 Arrangement of hardness measurement points in the heat affected zone and in the weld for butt joints:
$l = 0.7$ mm for HV5; $l = 1.0$ mm for HV10

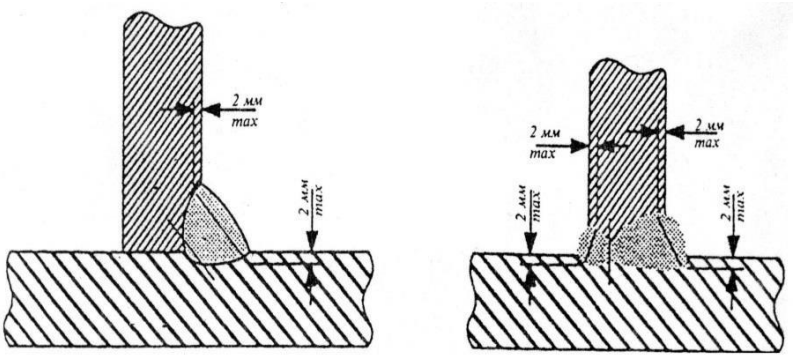


Fig. 6.4.6-3 Arrangement of hardness measurement lines for T-joint test assemblies:
a — completed in one run as a fillet weld without bevelling;
b — for welds performed with full penetration

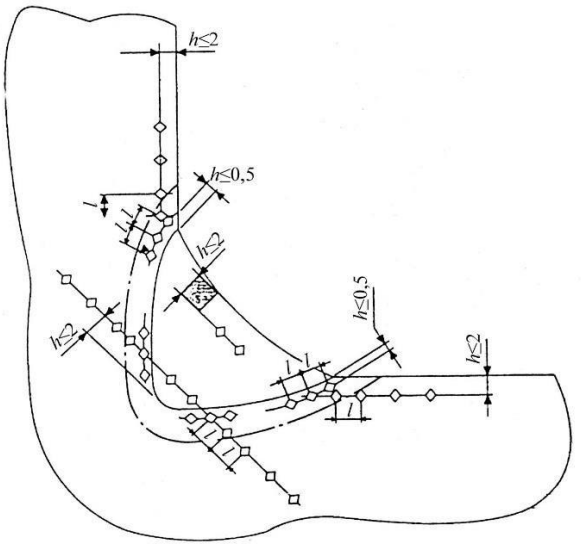


Fig. 6.4.6-4 Arrangement of hardness measurement points in the heat affected zone and in the weld for tee joints completed in one run as a fillet weld without bevelling (restriction for *l* according to Fig. 6.4.6-2)

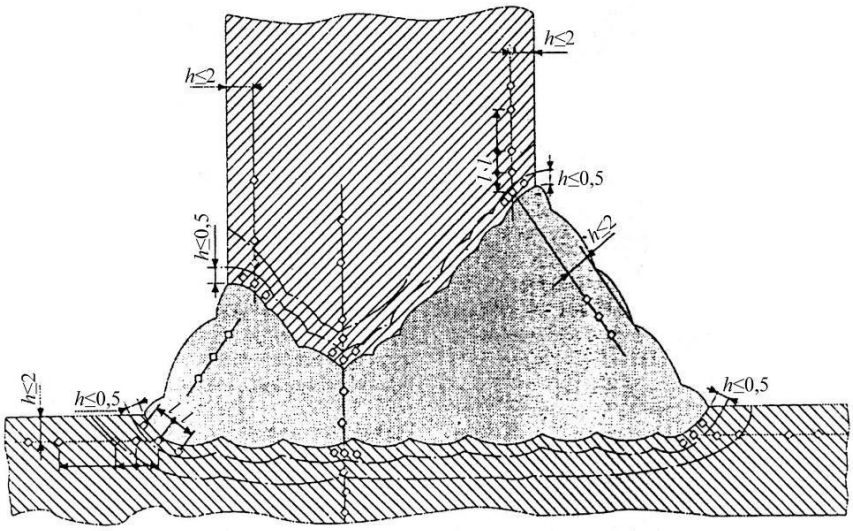


Fig. 6.4.6-5 Arrangement of hardness measurement points in the heat affected zone and in the weld for tee joints performed with full penetration of the weld root (restriction for *l* according to Fig. 6.4.6-2)

Table 6.4.6 **Restriction of the maximum value of the welded joints hardness HV10**

Steel group	Single-run butt and fillet welds		Multi-run butt and fillet welds	
	Without heat treatment	With heat treatment	Without heat treatment	With heat treatment
1[1]	380	320	350	320
2	400	350	370	350
3[2]	450	Subject to the special consideration by the Register	420	Subject to the special consideration by the Register
4.5	Subject to the special consideration by the Register	320	Subject to the special consideration by the Register	320
6	Ditto	350	Ditto	350
7 with Ni ≤ 4 %	Ditto	300	320	300
7 with Ni > 4 %	Ditto	Subject to the special consideration by the Register	400	Subject to the special consideration by the Register

[1] If the determination of the hardness is required.

[2] For steels with $R_e^{min} \geq 885$ N/mm^2: subject to a separate approval.

6.4.7 Requirements for macrosections.

6.4.7.1 Macrosections produced from test assemblies of butt joint of plates and pipes.

Tested transverse macrosections that are cut from test assemblies of butt welded joints need to be polished and etched from one side so that the weld and the heat affected zone are clearly visible.

The sections must be free of unacceptable defects. In this case the defects close to a weld including 10 mm of the base metal outside of the heat-affected zone shall be taken into account.

Inspection of the microstructure of welding joints is performed upon a separate demand of the Register; requirements for the methods of testing and the evaluation of results shall be agreed individually.

6.4.7.2 Macrosections of T-joint and cruciform test assemblies.

Two or three macrosections must be cut from tee test assemblies in accordance with 6.4.7.1.

For manual and semi-automatic welding, one macrosection shall be produced from a site that meets the labelling of the "stop-start" operation on the credit length of the test assembly.

Sections shall be inspected for compliance with the shape and the geometric dimensions of the weld, for the presence of penetration, for the absence of unacceptable undercuts, and for the identification of unacceptable internal defects in the weld and in the HAZ.

In this case the defects close to a weld including 10 mm of the base metal outside of the heat-affected zone shall be taken into account.

Control of transverse macrosections made from a cruciform test assembly shall be implemented similarly to the requirements for T-joint test assemblies. In this case, the thickness of fillet welds shall be subjected to measurement in the section under Fig. 6.4.7.2.

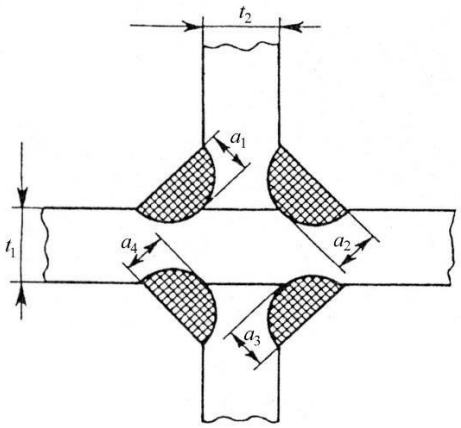


Fig. 6.4.7.2 Diagram of estimated fillet weld thickness measurement for macrosections made of cruciform test assemblies

6.5 REQUIREMENTS FOR RE-TESTING

6.5.1 Where the results of the welded test assembly visual or non-destructive testing are unsatisfactory, one additional test assembly for re-testing shall be welded.

If the additional test assembly does not comply with the relevant requirements, the pWPS shall be regarded as not capable of complying with the requirements without modification.

6.5.2 If a tensile or bending test specimen fails to meet the relevant requirements due to the reasons not associated with weld imperfections, the re-

testing shall be carried out on the doubled number of specimens.

The specimens for re-testing are taken from the same test assembly if there is sufficient material available or from a new test piece.

6.5.3 If any impact test specimens fail to comply with the relevant requirements due to the reasons not associated with specimen imperfections, the re-testing of a farther set of three specimens shall be carried out with the results estimation according to 4.2.3.3.4.

Sampling for additional tests is carried out similarly to the requirements of 6.5.2.

6.5.4 If a test assembly is rejected due to the hardness test results the re-testing shall be carried out on a doubled number of specimens.

Sampling for additional tests is carried out similarly to the requirements of 6.5.2.

6.5.5 If any test specimen has not satisfied a test only due to an improper weld profile or to the presence of surface defects, crater cracks inclusive, two additional test specimens for each one that failed shall be machined for re-testing.

The specimens for re-testing are taken in compliance with the requirements of 6.5.2.

6.5.6 If any test specimen has not satisfied a test due to the presence of permissible slag, or non-metallic inclusions, one additional test specimen shall be machined for re-testing.

The specimens for re-testing are taken in compliance with the requirements of 6.5.2.

6.5.7 The results of re-testing are accepted as final, but even if any test specimen fails to pass the tests in compliance with the requirements of 6.5.2 to 6.5.6, the welding procedure is considered unsuitable for use without modifications ensuring the required quality of the welded joint metal.

6.6 RANGE OF APPROVAL FOR WELDING PROCEDURE BASED ON QUALIFICATION TEST RESULTS

6.6.1 General.

Specifying the range of approval for a welding procedure, each of the requirements given below shall be met. Changes introduced into a WPS by a manufacturer, and which are outside of the ranges specified shall require a new welding procedure test.

The approval of a welding procedure by the Register obtained by a shipyard or welded structures manufacturer is valid for welding in all workshops or sites of that shipyard under the same technical and quality control of the manufacturer.

6.6.2 Base metal-related requirements on range of approval.

6.6.2.1 Properties and chemical composition of base metal.

6.6.2.1.1 Normal and higher strength hull structural steels.

Specifying the range of approval for high heat input processes not exceeding 50 kJ/cm, the following requirements shall be met:

.1 for each strength level of the base metal, the range of approval for a welding procedure is considered applicable to the same and lower toughness grades as that tested;

.2 for each toughness grade of the base metal, the range of approval for a welding procedure is considered applica-

ble to the same and two lower strength levels as that tested.

For high heat input processes over 50 kJ/cm (e.g. two-run technique, electro gas arc and electro slag welding) welding procedure is applicable to that toughness grade tested and one strength level below.

Where steels used for construction are supplied from different delivery conditions from those tested the Register may require additional tests.

6.6.2.1.2 High-strength steels.

When specifying the range of welding procedure approval for high-strength steels complying with the requirements of Subsection 3.13, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, the following requirements shall be met:

.1 for each strength level of the base metal, the range of approval for a welding procedure is considered applicable to the same and lower toughness grades as that tested;

.2 for each grade of the base metal toughness grade, the range of approval for a welding procedure is considered applicable to the same and one lower strength level as that tested;

.3 the approval of quenched and tempered steels does not qualify thermomechanically rolled steels (TM steels) and vice versa.

6.6.2.1.3 Forged steel.

When specifying the range of approval for the welding procedure based on test results for weldable C and C-Mn hull steel forgings complying with the requirements of Subsection 3.7, Part XIII "Materials", the following requirements shall be met:

.1 the range of approval is considered applicable to forgings with the same and lower strength level as that tested;

.2 the range of approval of quenched and tempered hull steel forgings does not apply to those in other delivery conditions and vice versa.

6.6.2.1.4 Cast steel.

When specifying the range of approval for the welding procedure based on test results for weldable C and C-Mn hull steel castings complying with the requirements of Subsection 3.8, Part XIII "Materials", the following requirements shall be met:

.1 the range approval is considered applicable to the castings with the same and lower strength level as that tested;

.2 the range of approval of quenched and tempered hull steel castings does not apply to those in other delivery conditions and vice versa.

6.6.2.1.5 In other cases the requirements given below which are identical with the requirements of EN 288-3 shall be met.

Depending on a chemical composition, properties and a type of heat treatment, for the unification of the requirements for the range of welding procedures approval, the steel in accordance with EN 288-3 is subdivided into groups given in Table 6.2.2.2.

The tests conducted with the use of particular steel belonging to one of those groups given in Table 6.2.2.2 obtain the range of approval:

for other steels of the same group with a lower content of alloy elements;

for other steels of the same group with lower guaranteed hardness characteristics.

Range of approval for the welding procedure shall be additionally limited to the range of application of a particular welding consumable used in tests for other steels of this group (or a lower group).

6.6.2.1.6 Usually, the range of approval of procedures for welding steels of group 2 also applies to steels of group 1.

6.6.2.1.7 A separate approval procedure is required for each grade of steel or their combinations that do not fall under the classification according to Ta- ble 6.2.2.2.

6.6.2.1.8 If a specific steel grade that is used for testing can be classified under two groups, it shall be classified under the lower group when determining the range of approval.

6.6.2.1.9 For heterogeneous welds, the range of approval of welding procedures shall be determined in accordance with Table 6.6.2.1.9.

If a heterogeneous joint cannot be classified under Table 6.6.2.1.9, the range of approval and the testing programme shall be subject to special consideration by the Register in each case.

Table 6.6.2.1.9 **Range of approval for heterogeneous welds**

Base metal group (refer to Table 6.2.2.2)	
During tests	Range of approval
2	Welded to group 1
3	Welded to group 1 or 2
8 (welded to group 2)	Welded to group 1 or 2
8 (welded to group 3)	Welded to group 1 or 2 or 3
9 (welded to group 2 or 3)	Welded to group 1 or 2 or 3

6.6.2.2 Base metal thickness and pipe diameter.

6.6.2.2.1 The nominal thickness of a base metal for various types of welded joints shall be determined in compliance with the requirements of Table 6.6.2.2.1.

6.6.2.2.2 Range of approval for base metal thickness depending on thickness *t* of a test assembly metal in qualification tests shall be specified in compliance with the requirements of Table 6.6.2.2.2.

6.6.2.2.3 Approval of the welding procedure for T and fillet joints made with the use of single-run fillet welds without bevelling apply to the range of approval for fillet weld throat thickness *a* depending on its value a in qualification tests (refer to 1.7.5.1, Part II "Hull") from 0.75*a* to 1.5*a* inclusive provided the limitation for the estimate thickness of fillet welds $a < 10$ mm.

Where weld test assemblies have $a \geq 10$ mm, range of approval of welding procedure will apply to welded joints with estimated thicknesses of fillet welds from 10 mm to 1.5*a* inclusive.

For vertical-down welding: the upper limit of the range of approval is limited to estimate thicknesses of fillet welds from 0.75*a* to 1.0*a*, inclusive.

The range of approval based on the results of testing of test assemblies with a protective coating at welded edges also applies to the welding procedure with cleaning of welded edges but not vice versa.

For multi-run fillet welds, restrictions of the range of approval for the value *a* shall be accepted similar to the requirements for the range of approval for the base metal thickness *t* for butt joints made according to the multi-run procedure.

In parallel with standardisation of the range of approval for throat thickness

a of fillet welds, there are also limitations on the range of approval for the thickness *t* of the base metal and the outside pipe diameter *D* (refer to 6.6.2.2.4).

6.6.2.2.4 Range of approval for outside diameter of pipe or branch connections to be welded shall be specified depending on the outside diameter of pipes for welding procedure qualification tests meeting the requirements stated in Ta- ble 6.6.2.2.4.

6.6.2.2.5 A welding procedure test carried out on a branch connection with angle a shall qualify all branch angles α_1 in the range of $\alpha \leq \alpha_1 \leq 90°$.

6.6.2.3 Presence or absence of an interoperational protective coating on the welded edges of a test assembly.

The range of approval based on the results of testing of test assemblies with a protective coating at welded edges also applies to the welding procedure with cleaning of welded edges but not vice versa.

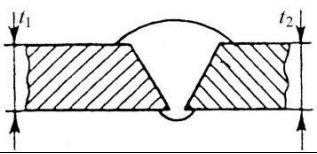
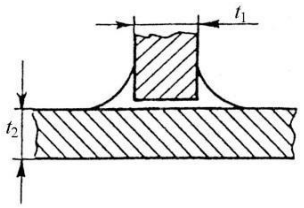
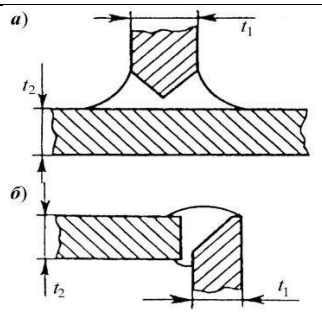
6.6.3 General requirements for the range of approval related to welding procedure.

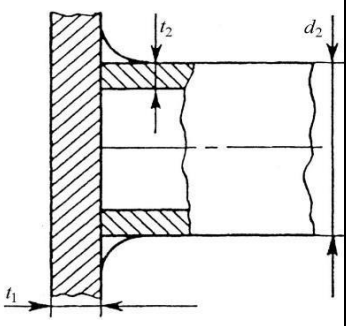
6.6.3.1 Welding process and type.

The approval is only valid for the welding process and welding type used in the welding procedure qualification test.

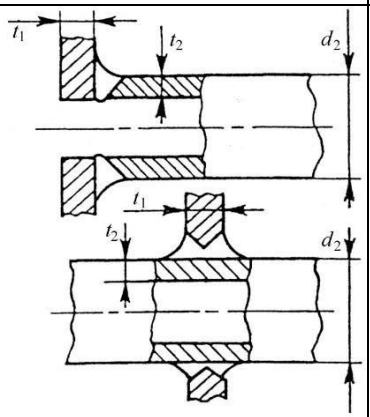
It is not allowed to use a multi-process procedure test to qualify any single process.

Table 6.6.2.2.1 **Determination of base metal nominal thickness**

Type of joint		Nominal thickness of base metal $t_н$
Name	Sketch[1]	
1	2	3
1. Butt joint/plates and pipes		t corresponds to the size of the thinner part for joints of unequal thickness: $t_н = t_1 = t_2$ at $t_1 = t_2$ $t_н$ = min (t_1 and t_2) at $t_1 \neq t_2$
2. Fillet weld/plates without bevelling		t corresponds to the size of the thicker part for joints of unequal thickness. Beside the range of approval for the thickness of parts being connected (refer to Table 6.6.2.2.2), the restriction of the estimated fillet weld thickness *a* is valid according to requirements of 6.6.2.2.3: $t_н = t_1 = t_2$ at $t_1 = t_2$; $t_н$ = max (t_1 and t_2) at $t_1 \neq t_2$
3. Fillet weld/plates with bevelling (with weld penetration)		*a*) For T-joints t is assumed equal to the thickness of the part with full penetration (with bevelling): $t_н = t_1$ *b*) For corner joints (one or two parts can be with bevelling) t is assumed equal to the thickness of the thinner part: $t_н$ = min (t_1 and t_2)

Type of joint		Nominal thickness of base metal $t_н$
Name	Sketch[1]	
4. T-joint in pipes for a set-in branch connection (with or without bevelling)		t is assumed equal to the wall thickness of pipe to be welded: $t_н = t_2$

End of Table 6.6.2.2.1

1	2	3
5. Corner and T-joints in pipe-pipe and pipe-plate set-in or set-through branch connection (with or without bevelling)		t is assumed equal to the wall thickness of main pipe or the plate to be welded: $t_н = t_1$

[1] The form of bevelling is provided as an illustration; the actual bevelling shall meet WPS requirements

Table 6.6.2.2.2 **Requirements for the range of approval by base metal thickness**

Welding procedure (type)	Thickness *t* of test assemblies during tests, mm[4, 5]	Range of approval by thickness, mm[1, 2, 3, 4]	Additional requirements
1	2	3	4
1. Manual metal arc welding (metal arc welding with covered electrode):			Additional restrictions according to 2.2.4.7 and

basic covering	$t \le 3$ $3 < t \le 12$ $12 < t \le 100$ $t > 100$	From t to $2t$ From 3 to $2t$ From $0.5t$ to $2t$ (max 110) From $0.5t$ to $1.5t$	2.2.4.3
Rutile covering	$t \le 3$ $3 < t \le 12$ $12 < t \le 30$	From t to $1.5t$ From 3 to $1.5t$ From $0.5t$ to $1.5t$ (max 30)	
High-performance	$t \le 3$ $3 < t \le 12$ $12 < t \le 100$	From t to $1.5t$ From 3 to $1.5t$ From $0.5t$ to $1.5t$ (max 110)	
2. Metal active gas welding with solid wire electrode			For welding of aluminium and its alloys: according to Section 7
Steels	$t \le 3$ $3 < t \le 12$ $12 < t \le 100$ $t > 100$	From t to $1.5t$ From 3 to $1.5t$ From $0.5t$ to $1.5t$ (max 110) From $0.5t$ to $1.2t$	
Non-ferrous metals	$t \le 3$ $3 < t \le 12$ $12 < t \le 100$	From t to $2t$ From 3 to $2t$ From $0.5t$ to $2t$ (max 110)	

Continued Table 6.6.2.2.2

1	2	3	4
3. Welding with a flux cored wire with additional gas protection			For welding with the use of a wire with uncontrolled diffusion of hydrogen content and a wire that is classified as “H”, the range of approval shall be limited to a maximum thickness in tests for $t > 12$ mm
basic type and slag-free		From t to $2t$ From 3 to $2t$ From $0.5t$ to $2t$ (max 110) From $0.5t$ to $1.5t$	
Rutile type		From t to $1.5t$ From 3 to $1.5t$ From $0.5t$ to $1.5t$ (max 110)	
4. Self-shielded tubular cored welding	$t \le 3$ $3 < t \le 12$ $12 < t \le 30$	From t to $1.5t$ From 3 to $1.25t$ From $0.5t$ to $1.25t$ (max 30)	For the metal with $t > 30$ mm, the range of approval shall be subject to special consideration by the Register in each case.
5. Automatic flux welding	$3 < t \le 12$ $12 < t \le 100$ $t > 100$	From 3 to $2t$ From $0.5t$ to $2t$ (max 110) From $0.5t$ to $1.5t$	
6. Non-consumable electrode inert gas welding			

Steels	$t \le 3$ $3 < t \le 12$ $12 < t \le 100$ $t > 100$	From t to $1.5t$ From 3 to $1.5t$ From $0.5t$ to $1.5t$ (max 110) From $0.5t$ to $1.2t$	
Non-ferrous metals	$t \le 3$ $3 < t \le 12$ $12 < t \le 100$	From t to $2t$ From 3 to $2t$ From $0.5t$ to $2t$ (max 110)	For aluminium and its alloys: according to Section 7
7. Vertical welding with forced weld formation (electroslag and electrogas)	$10 < t \le 100$	According to the actual thickness of test assemblies ranging from $0.9t$ to $1.1t$	Welding shall be performed with the use of metal of test assemblies of the minimum and the maximum thickness
8. Gas welding	$t \le 8$	Up to 8 inclusive according to the actual thickness of test assemblies - ranging from $0.9t$ to $1.1t$.	Ditto

[1] Range of approval of welded test assemblies made by single-run unilateral welding (the single-pass technology) and single-pass bilateral welding (the two-pass technology) is restricted to the thicknesses from $0.7t$ to $1.1t$ inclusive.

[2] Range of approval of vertical test assemblies welded according to the downward technology is restricted to thicknesses ranging from $0.5t$ to $1.0t$, including multirun welds and from $0.5t$ to $1.0t$ for one- or two-pass welding procedure.

[3] Requirements for the range of approval for vertical welding with forced weld formation are also suitable for other methods with the heat input of over 50 kJ/cm.

End of Table 6.6.2.2.2

[4] Notwithstanding the above, the approval of maximum thickness of base metal for any technique shall be restricted to the thickness t of test assembly if three of the hardness values in the heat-affected zone are found to be within 25HV of the maximum permitted, as stated in 6.4.6.

[5] The thickness of the base metal shall be determined in accordance with Table 6.6.2.2.1.

Table 6.6.2.2.4 **Range of approval by welded pipes outside diameter**

Diameter D of tested assemblies, mm[1, 2]	Range of approval by welded pipes diameter, mm
$D < 25$	From D to $2D$ inclusive
$25 \le D < 150$	From $0.5D$ to $2D$, (min 25 mm)
$150 \le D < 500$	From $0.5D$ to $2D$, (min 150 mm)
$D \ge 500$	An agreement with the Register

[1] D is accepted according to the outside diameter of the pipe.

[2] Approval for welding of plates can also be extended to welding of pipes with $D \ge 500$ mm subject to compliance of other requirements for the range of approval (refer to 6.3.2.1.1, 6.3.1.4, 6.6.2 and 6.6.4)

Where the welding procedure used is the combination of several processes/types (e.g., automatic flux welding to fill a groove and a covered electrode manual welding to make a weld root: 12 + 111 only for root passes); the range of approval shall also be restricted to the combination of welding methods that was used during certification testing.

Note: The testing procedure for approval of combinations of different methods/welding procedures can be performed according to a separate (for each one) and combined procedures similar to admission testing for welders. In this case, the relevant range of approval by thicknesses of the welded metal shall be specified for each applied method of welding.

6.6.3.2 Welding positions.

The requirements for the range of approval according to welding positions shall meet the requirements stated in Table 6.6.3.2

To qualify a range of positions for reduction in extent of testing:

the test assemblies of welded joints may be welded for highest heat input position and lowest heat input position. All applicable tests shall be made after welding on each test assembly within the scope of the requirements specified in 6.4.1.1.

6.6.3.3 Type of welded joint.

Range of approval by joint type, depending on the types used during certification testing, shall comply with requirements of Tables 6.6.3.3-1 and 6.6.3.3-2.

6.6.3.4 Grades of welding consumables.

Range of approval for high heat input processes over 50 kJ/cm, inclusive, based on qualification testing the particular brand of the welding consumable approved by the Register, complying with the requirements of 4.2 and 4.6, shall also cover other brands of the welding consumables approved by the Register having the same grade as the tested one, including all additional suffixes specified in 4.2.1.4 and 4.2.1.8.

If a shipyard or a manufacturer of welded structures substitutes one brand of the welding consumable for another one having the same grade, additional tests are required in the following cases:

for high heat input process over 50 kJ/cm;

for welding consumables with grade identification according to the impact test temperature equal to grade 5 (−60 °C), as well as on the Register separate requirement for grade 4 (−40 °C).

Table 6.6.3.2 **Range of approval for welding procedures according to welding positions**

Type of weld in welding the test assembly	Weld position[1] of the test assembly	Range of approval according to welding positions[1]			
		Butt welds		Fillet welds	
		Plates	Pipes	Plates	Pipes
Butt welds in plate	PA	PA	PA[2]	PA	PA[2]
	PC	PA, PC, PE	PA[2], PC[2]	PA, PB, PD	PA[2], PB[2], PD[2]
	PG	PG		PG	
	PF	PF		PF	
	PE	PA, PE		PA, PD	PA[2], PD[2]
	PC + PF	All except PG	All except PG[2]	All except PG	All except PG[2]
Butt welds in pipe[3]	PA	PA	PA	PA	PA
	PC	PA, PC, PE	PA, PC	PA, PB, PD	PA, PB, PD
	PG	PG	PG	PG	

	PF	PA, PC, PE	PA, PF	PA, PB, PD	PA, PB, PD
	PC+PF or H-L045	All except PG	All except PG	All except PG	All except PG
Fillet welds in plate (without bevelling)	PA			PA	PA[2]
	PB			PA, PB, PD	PA[2], PB[2], PD[2]
	PF			PF	
	PG			PG	
	PD			PA, PB, PD	PA[2], PB[2], PD[2]
	PB+ PD			All except PG	All except PG[2]
Fillet welds in plate (without bevelling)[4]	PA			PA	PA[2]
	PB			PA, PB, PD	PA, PB, PD
	PG			PG	PG
	PD			PA, PB, PD	PA, PB, PD
	PF			All except PG	All except PG

[1] Designations of welding positions comply with ISO 6947 and are provided in Figs 6.2.2.4-1 to 6.2.2.4-3.

[3] Approval is valid only for pipes with outside diameter D > 500 mm.

[3] Piping joint assemblies with bevelling are covered by 6.3.1.5.1.

[4] Piping joint assemblies with fillet welds are covered by 6.3.1.5.2.

Table 6.6.3.3-1 **Range of approval by types of welded joints (plates)**

Type of welded test assembly in tests for approval			Plates (P)						
			Butt weld joints				T-joints (BW)		Fillet bead welds without bevelling (FW)
			One-sided welding		Both-side welding		Single-side welding	Both-side welding	
			With backings (mb)	Without backing strips (nb)	With gouging (gg)	Without gouging (ng)			
Butt weld on plates (BW)	Single-side welding (ss)	With backings (mb)	*	–	x	x	–	x	x
		Without backing strips (nb)	x	*	x	x	x	x	x
	Both-side welding (bs)	With gouging (gg)	–	–	*	x	x	x	x
		Without gouging (ng)	–	–	–	*	–	x	x
Butt weld on pipes (BW)	Single-side welding	With backings (mb)	x	–	x	x	–	x	x
		Without backing strips (nb)	x	x	x	x	x	x	x

T-joint of plates with bevelling (BW)	Single-side welding (ss)	–	–	–	–	*	x	x
	Both-side welding (bs)	–	–	–	–	–	*	x
Fillet (gauge) weld (FW)	Plates (P)	–	–	–	–	–	–	*
	Pipes (T)	–	–	–	–	–	–	x

Symbols:

* means types of welded joints, for which WPS is approved directly by test results;

x means types of welded joints, for which WPS may be approved by the range of approval (without additional tests);

– – means types of welded joints, for which WPS are not subject to approval.

Note: designations in parentheses correspond to Fig. 7.2.2.

Table 6.6.3.3-2 **Range of approval by types of welded joints (pipes)**

Type of welded test assembly in tests for approval			Pipes (T)		
			Butt weld joints		Fillet (gauge) weld (FW)
			Single-side welding		
			With backings (mb)	Without backing strips (nb)	
Butt weld on plates (BW)	Single-side welding (ss)	With backings (mb)	–	–	x
		Without backing strips (nb)	–	–	x
	Both-side welding (bs)	With gouging (gg)	–	–	x
		Without gouging (ng)	–	–	x
Butt weld on pipes (BW)	Single-side welding	With backings (mb)	*	–	x
		Without backing strips (nb)	x	*	x
T-joint of plates with bevelling (BW)	Single-side welding (ss)		–	–	x
	Both-side welding (bs)		–	–	x
Fillet (gauge) weld (FW)	Plates (P)		–	–	x
	Pipes (T)		–	–	*

Symbols:

* means types of welded joints, for which WPS is approved directly by test results;

x means types of welded joints, for which WPS may be approved by the range of approval (without additional tests);

– – means types of welded joints, for which WPS are not subject to approval.

Note: designations in parentheses correspond to Fig. 7.2.2.

If the WPS requirements in welding the test assembly during the additional tests are fully met, the extent of testing at substitution of one brand of welding consumables for another one with similar grade may be limited to the determination of impact energy for the weld metal and fusion line.

Range of approval for the welding procedure based on the qualification tests on a particular brand of the welding consumable intended for welding/depositing corrosion-resistant steel and meeting the requirements of Subsection 4.8, shall also cover the other brands of the welding consumables with similar grade approved by Register.

Such welding consumables shall have the same grade as the tested materials, including the designation of the typical chemical composition of deposited metal in accordance with 4.8.1.3.

6.6.3.5 The requirements for the range of welding procedure approval based on the designation in the appropriate national standards are applied to the filler materials and welding processes concerned and not covered by the Register approval for the grades specified by the requirements of 4.2, 4.5, 4.6 and 4.8.

Range of approval for the welding procedure based on testing a particular brand of filler material according to its designation in the appropriate national/international standards may be extended to cover the other brands of filler materials produced by the same manufacturer with designation ensuring:

equivalent values of the impact energy of deposited metal. Changing the type of electrode covering or core of flux cored wire or the classification of welding flux composition shall not be permitted and re-testing shall be performed;

the same nominal chemical composition of wire (wire-gas or wire-flux combinations) or deposited metal (electrodes or flux cored wire).

6.6.3.6 Type of current and polarity.

Welding procedure approval is only valid for the type of current and polarity used in the welding procedure qualification test.

6.6.3.7 Heat input.

Specifying the range of approval for high heat input processes, the following requirements shall be met:

.1 if the requirement for the determination of the impact energy of the weld metal and the welded joint is mandatory, the range of approval of the welding procedure by the upper limit of heat input may exceed the rated value used at test welding during the qualification certification, by 15 % but by not more than 50 kJ/cm. In other cases, the range of approval by the upper limit of heat input may exceed the rated value used at test welding by 25 % but by not more than 55 kJ/cm;

.2 if the requirement for the determination of the hardness of the weld metal and the welded joint is mandatory, the range of approval of the welding procedure by the upper limit of heat input may be 15 % less than the rated value used at test welding during the qualification certification. In other cases, the range of approval by the upper limit of heat input may be 25 % below the rated value used at test welding.

6.6.3.8 Preheating.

The minimum preheating temperature for the range of approval for the welding procedure shall not be less than that used prior to welding the test assembly in qualification test.

6.6.3.9 Interpass temperature.

The maximum interpass temperature for the range of approval for the welding procedure shall not higher than that used in welding the test piece in qualification test.

6.6.3.10 Post-weld heat treatment.

Deviation of heat treatment parameters (both upwards and downwards) from those used in welding procedure qualification tests is not permitted.

The temperature range validated is the holding temperature used in the welding procedure qualification test.

If specified in the WPS, heating and cooling rates, as well as the holding time related to the welded joint at a check temperature shall be additionally specified in the range of approval.

In this case the holding time may be adjusted as a junction of thickness.

6.6.4 Special requirements for the range of approval related to welding procedure.

In determining the range of approval for welding procedures, the classification and the designation of welding methods that meet ISO 4063 and are listed in 6.2.2.1. shall be used.

6.6.4.1 Arc welding with covered electrodes and flux core wires (welding processes 111 and 114).

The field of approval for the welding procedure by the diameter of the applied filler material shall be restricted to an interval of plus to minus one standard dimension with relation to the rated diameter used to weld each pass of the test assembly during certification.

This requirement does not apply to welding procedures for root passes of butt joints without backings (consumables that provide for the reverse weld formation during welding “on weight”), in which the range of approval is restricted only by the diameter used during tests.

6.6.4.2 Submerged arc welding (welding process 12).

Range of approval is limited only to that welding process (welding with one and multiple electrodes and also multi-arc welding) that used in the welding procedure qualification test.

The range of approval for the flux is restricted to the particular manufacturer and designation that were used in the welding procedure qualification tests.

6.6.4.3 Gas metal arc welding (welding processes 131, 135, 136).

Range of approval shall be restricted to:

the shielding gas composition used in the welding procedure qualification test;

the system of welding wire feed, which is identical to the one used in certification tests (single- or multiple-electrode welding).

6.6.4.4 Tungsten inert gas (TIG) welding with solid filler material (wire/rod) (welding process 141).

Range of approval shall be restricted to the composition of the shielding gas similar to that used in the welding procedure qualification test.

6.6.4.5 Plasma-arc welding (welding process 15).

Range of approval shall be restricted to:

the plasma gas composition used in the welding procedure qualification test;

the shielding gas composition used in the welding procedure qualification test.

6.7 ISSUE AND TERMS OF VALIDITY OF WELDING PROCEDURE APPROVAL TEST CERTIFICATE

6.7.1 Issue of the Certificate.

6.7.1.1 When all the requirements of this Subsection are met, the Register draws up and issues the Welding Procedure Approval Test Certificate.

Note: The work on approval of welding procedures, as well as the approval tests for welders, shall generally precede the Register survey of welded structures during their manufacture at the works.

6.7.1.2 The Welding Procedure Approval Test Certificate is drawn up and issued by the Register branch office which carries out the survey during construction of a ship or manufacture of welded structures with the use of welding procedures approved by the Register.

6.7.2 Drawing up attachments to Certificate.

6.7.2.1 Details of Weld Test (DWT).

The Details of Weld Test form is prepared by the RS surveyor who directly carries out technical supervision during tests for approval of welding procedures at the works of welded structures manufacturer.

Note: The responsibility for authenticity and accuracy of the technical information given in the DWT rests with a welding specialist appointed by the manufacturer's administration to be in charge of testing for the approval of welding procedures. The latter is also responsible for supplementing the DWT with required attachments and makes an appropriate entry in the DWT indicating his position, name and initials.

The DWT shall be supplemented by the attachments required for proper specification and control over the range of approval for the Welding Procedure Approval Test Certificate, namely:

copy of the certificate for base metal used for welding test assemblies;

copy of the certificate for the filler material used for welding test assemblies (electrodes, welding wire or rods);

copy of the certificate for the welding flux or shielding gas (the availability of the latter is obligatory when off-the-shelf mixtures of shielding gases supplied by specialised firms are used);

copy of the certificate for the backing material (e.g., ceramic backing).

6.7.2.2 Test Results form.

The Test Results form is prepared by the RS surveyor who directly carries out technical supervision during tests for approval of welding procedures at the works of welded structures manufacturer.

Note: The responsibility for authenticity and accuracy of the technical information given in the Test Results form rests with:

a welding supervisor appointed by the manufacturer's administration to be in charge of testing for the approval of welding procedures, or

an official from the manufacturer's testing laboratory directly carrying out the non-destructive and mechanical tests on test assemblies who is authorised to sign the documents.

The Test Results form shall be supplemented with attachments confirming documentarily the test results which can be lacking in the document, including:

copies of records of tests;

copies of non-destructive test records for compound welding test assemblies etc.

6.7.2.3 Welding Procedure Specification.

This document is compiled by the manufacturer of welded structures in compliance with the requirements of EN 288-2 and requirements in Table 6.7.2.3.

6.7.3 Terms of validity of the Welding Procedure Approval Test Certificate.

6.7.3.1 The period of validity of the Welding Procedure Approval Test Certificate (5 years) and its endorsement (every year) are determined in compliance with the requirements of Section 7, Part I "General Regulations for Technical Supervision" subject to compliance with the below requirements.

6.7.3.2 The manufacturer of welded structures shall meet the requirements of the Register concerning the range of approval for each welding procedure. If this condition is not fulfilled, the Welding Procedure Approval Test Certificate becomes invalid and new qualification tests are required.

Performance of new tests shall be required if the welding procedure has been subjected to the following changes:

changes in the composition and the properties of the base metal (within one group or grade) that are significant according to the Register and that may affect the weldability and the mechanical properties of the welded joint;

changes in the thickness of the base metal that exceed the field of approval;

the use of types of joints or their structural design that require, according to the Register, the performance of a separate certification of the welding procedure.

Table 6.7.2.3 **Requirements for filling-in the WPS form**

Nos	Name of form positions	Requirements for form filling-in
1	2	3
1	Manufacturer	Name of welded structure manufacturer that developed the WPS
2	WPS No.	WPS designation in accordance with the manufacturer's coding system
3	Details of Weld Test and Test Result forms (WPQR)	Designation of Details of Weld Test and Test Result forms on the basis of which the particular welding procedure is approved by the Register
4	Base metal: grade and trade mark; thickness range; pipe's outside diameter range	Grade of base metal in accordance with the Register rules and/or its designation according to national standards, designation of the standard. Minimum and maximum thickness of weld metal. Minimum and maximum outside diameter of pipes to be welded
5	Welding process	Designation of welding process in accordance with ISO 4063

6	Type of welding	Symbols: MW — manual welding; SA — semi-automatic welding; A — automatic welding
7	Joint preparation/Joint design	Sketch of weld preparation details with indication of shape and dimensions, also designation of normative document/standard
8	Elements of weld and Welding sequences	Sketch of welding sequences with indication of size in compliance with the requirements of documentation on product/structure. Also designation of normative document/standard
9	Method of groove preparing	Method of groove preparing or welding shall be indicated and, if necessary, technological particulars of assembling for welding: welding fixture or stand, mounting clamps, assembling with tacking
10	Requirements for groove cleaning	Requirements for groove cleaning and method of cleaning shall be indicated
11	Backing	Necessity of using backing or means of weld root protection shall be indicated: *nb* — welding without backing strips; *mb* — welding with backing; *gb* — welding with gas backing
12	Backing material	Type of backing, its material and dimensions shall be indicated. When the weld root is protected by shielding gas, its composition and consumption shall be indicated

Continued Table 6.7.2.3

1	2	3
	DETAILS OF WELDING CONSUMABLES	
13	Filler materials	The following shall be indicated: trade mark and name of the manufacturer (is given in column “Other information”); grade in accordance with the Register rules, if it is stipulated by the Rules for the given material; classification in accordance with the national standards (group of indexes and designation of the standard); diameter of an electrode/wire or width and thickness of the strip electrode; for welding process 111 the requirements shall be in relation to calcination/drying of electrodes before use (if required) and limitations in time and conditions of storage; designations of normative documents specifying these parameters (if any) shall be indicated

14	Auxiliary materials	The following shall be indicated: for welding process 12 — data on flux employed, including its classification (designation and standard), name of the manufacturer and its trade mark, as well as requirements for flux storage and drying/calcination; for welding processes 131, 135, 136, 137, 141 and 15 — data on actual composition and consumption of shielding gas, including designation of normative documents specifying gas composition. For gas mixtures supplied by the specialised firms the trade mark of the mixture may also be indicated; for welding process 141 — designation of tungsten electrode trade mark with reference to the standard and its diameter
	DETAILS ON WELDING PROCEDURE	
15	Welding position and direction	Symbols according to ISO 6947 (refer to Figs 6.2.2.4-1 to 6.2.2.4-3)
16	String/weaving bead	Presence of weaving movements shall be indicated, and: maximum width of beads for manual and semi-automatic welding; weaving amplitude for automatic welding
17	Back gouging and back grinding	If this operation is employed, method and requirements for its performance shall be indicated (R_{min}): *gg* — welding with back gouging or back grinding of welds, *ng* — welding without (no) back gouging or without (no) back grinding of welds

Continued Table 6.7.2.3

1	2	3
18	Single and multiple-electrode	Quantity of welding electrodes shall be indicated, also (in column "Other parameters") for welding process 12 — shape of wire electrodes and arrangement for their connection to the power source
19	Single run and multirun	Symbols: *sr* — single run; *mr* — multirun welding
20	Orifice/gas cup size (torch nozzle)	For welding processes 131, 135, 136, 137, 141 and 15 the torch nozzle diameter shall be indicated
21	Distance contact tube/workpiece	For welding processes 12, 131, 135, 136, 137, and 15 the distance from the conductive welding torch nozzle to the welded piece surface shall be indicated

22	Preheating	The following shall be indicated: minimum preheating temperature, if any; minimum ambient air temperature at which welding is allowed, if preheating is not used; other conditions at which preheating is required (low ambient temperature, higher than normal hydrogen content in deposited metal etc.)
23	Interpass temperature	Limitations for interpass temperature shall be indicated: minimum value for welding procedure with concurrent heating (including automatic heating); maximum value for welding procedure which does not require concurrent heating
24	Post-weld heat treatment	Necessity of post-weld heat treatment or ageing (age hardening) shall be indicated, as well as (in respective columns) its parameters. If required, WPS may be supplemented with a separate heat treatment specification
	ELECTRICAL CHARACTERISTICS	
25	Type of current and polarity	Symbols: DC+ — direct-current of reverse polarity; DC– — direct-current forward polarity; DC± — direct-current of reverse and forward polarity; AC — alternating current; PAW — pulsed arc welding
26	Run number	Welding conditions for individual runs shall be indicated, if some changes are stipulated by the welding procedure (e.g. different conditions for the root and filler runs)

End of Table 6.7.2.3

1	2	3
27	Size of filler metal	Welding conditions for each diameter of electrode (item 13 of the Table) shall be indicated, as well as welding positions (item 15 of the Table) specified in the WPS
28	Amperage, voltage	Range of rated welding amperage and voltage shall be indicated ±7.5 %
29	Travel speed	Range of rated travel speed for type A shall be indicated (within the rated value ±5.5 %)
30	Welding wire feed rate	For welding types SA and A the range of welding wire feed rate shall be indicated
31	Heat input	Indicated in cases, when for obtaining the required properties of welded joint it is necessary to limit the maximum amount of heat input

32	Additional information	The following shall be indicated: for welding process 111 — nominal length of weld completed with one electrode; if the equipment does not permit to control the welding conditions (refer to items 28, 29 and 30 of the Table) — setting for adjustment of the equipment corresponding to specified welding conditions; for pulsed arc welding — its characteristics (pulse time, pulse current, pulse frequency, "pilot arc" voltage and current, pulse shape etc.).

changes in structural characteristics of the welded joint that extends beyond the range of approval (e.g., replacement of two-sided welding with the cleaning of the root weld by one-sided welding);

changes in the form of bevelling, blunting value, and/or assembly gap, which may affect the depth of penetration or the quality of the penetration zone or may change the percentage of the base metal in the weld metal;

changes of the trade mark and/or classification codes of welding consumables;

changes in welding positions and current types and polarity that extend beyond the range of approval;

the use of welding modes that extend beyond the nominal valuesagreed by the Register by ±15 % for current or voltage and/or ±10 % for welding speed according to the Weld Test Specification;

deviation of the temperature of preheating or inter-bead temperature from the rated values according to the Weld Test Specifications by more than 25 °C;

changes in the parameters of post-welding heat treatment regulated by the Certificate of Approval and specified in the Weld Test Specifications.

6.7.3.3 In the period of validity of the Welding Procedure Approval Certificate, the manufacturer shall constantly implement welding work under the supervision of the Register with the use of approved welding procedures.

In case of interruptions in the work supervised by the Register that last for more than one year, the Welding Procedure Approval Certificate shall become void.

Note: In case of interruptions in the work supervised by the Register that last for more than one year but that not exceeding two years, the Register may decide to renew/re-issue the Welding Procedure Approval Certificate without new testing subject to compliance with all the other certificate validity conditions.

6.7.3.4 During the term of validity of the Welding Procedure Approval Certificate, no issues shall arise relating to the quality of welds performed according to the procedure approved by the Register.

The manufacturer of welded structures shall ensure the systematic control and analysis of the quality of welded joints, including specific welding procedures. In this case, the results of this analysis shall be reported to the Register surveyor during the procedure for the confirmation of the Welding Procedure Approval Certificate by the surveyor according to 6.7.3.5.

At systematically high levels of defects in welds, the Welding Procedure Approval Certificate may be terminated

by the Register, and the corresponding welding procedure shall be reviewed and re-submitted for a new approval test.

6.7.3.5 The Welding Procedure Approval Certificate shall be confirmed by the Register at intervals specified in 6.7.3.1.

The Certificate shall be confirmed by the Register surveyor on the basis of the application filed by the manufacturer and shall not require new or additional testing if the above terms of validity have been complied with.

7. APPROVAL OF WELDING PROCEDURES FOR ALUMINIUM ALLOYS

7.1 GENERAL

7.1.1 Welding procedures used for the fabrication of aluminium alloy structures being subject to survey by the Register shall be approved by the Register and to meet the requirements given below.

7.1.2 The document verifying that the welding procedure used at the shipyard or welded structures Manufacturer has passed tests and approved by the Register is the Welding Procedure Approval Test Certificate.

7.1.3 The requirements of the Section cover the approval procedure for the welding of aluminium alloys through testing of type test assemblies
by weld test. The use of other schemes of approval for the welding procedures of aluminium alloys is, in each case, subject to the special consideration by the Register. The issue of approval scheme change therewith may be taken by the Register for consideration in the following cases:

if the peculiarities of structures welding under working conditions cannot be reproduced on type test assemblies specified by the requirements of 7.3, and the qualification tests prior to the manufacture beginning with the simulation of an actual welding procedure are needed;

if the welded structures manufacturer can submit to the Register the convincing grounds for the possible application of the approval scheme using so-called "standard welding procedure";

if the welding procedures have already passed testing and were previously approved by the competent bodies/classification societies as applied to the specific welding fabrication and the test program used therewith was on a par with the requirements of this Section.

7.1.4 Welding procedures approval tests may be supplemented with tests in the course of a manufacturing process on the separate demand of the Register.

Tests in production are used for monitoring the stability of the welding procedures with the increased degree of defects formation risk (for example, for the procedure of a single-sided welding with free back forming of a weld root) and also in the event of the application of welding processes not provided for in the Section.

7.2 DEFINITIONS, TERMS AND SYMBOLS

7.2.1 Definitions and explanations.

Definitions, explanations and terms used in the present Subsection are given in 6.2.1.

7.2.2 Symbols used in welding procedure approval.

Welding procedure approval for aluminium alloys according to the requirements of the Section is carried out for the following processes welding (the symbols comply with ISO 4063):

131 — metal-arc inert gas welding;

141 — tungsten inert gas welding;

15 — plasma arc welding.

Depending on the degree of welder's labour mechanisation, the welding types/processes are divided into the following groups:

MW — manual welding wherein wire feed and the movement of a welding gun along and across the weld are carried out by the welder (by hand);

SA — partly mechanised (semi-automatic) welding wherein wire feed is mechanised, but the movement of a welding gun along and across the weld is carried out by the welder;

A — fully mechanised (automatic) welding wherein the processes of wire feed and welding gun manipulation are mechanised and carried out without welder's direct participation.

The welding fillers used for the welding of shipbuilding aluminium alloys are classified by categories according to Tables 4.7.1.2-1 and 4.7.1.2-2.

Shielding gases used for welding depending on their composition are divided into groups designated with indices in accordance with Table 4.7.1.4.

Table 7.2.2 **Classification of international shipbuilding aluminium alloys by type composition groups according to CR ISO/TR 15608**

Group	Subgroup	Type of alloy/characteristic	Typical specimen
21	–	**Pure aluminium with admixtures or alloying elements content up to 1 % including**	1050A [Al 99.5] 1200 [Al 99.0]
22	**Non-hardenable alloys**		
	22.1	Aluminium-magnesium alloys	3103 [Al Mn 1]
	22.2	Aluminium-magnesium alloys containing Mg ≤ 1.5 %	5005 [Al Mg 1(B)] 5050 [Al Mg 1.5(C)]
	22.3	Aluminium-magnesium alloys containing 1.5 % < Mg ≤ 3.5 %	525 [Al Mg 2] 5052 [Al Mg 2.5] 5754 [Al Mg 3]* 5154 [Al Mg 3.5]
	22.4	Aluminium-magnesium alloys containing Mg > 3.5 %	5086 [Al Mg 4]* 5083 [Al Mg4.5Mn 0.7]* 5383 [Al Mg4.5Mn 0.9]* 5456 [Al Mg 5]* 5059 [—]*
23	**Hardenable alloys**		
	23.1	Al-Mg-Si alloys	6060 [Al Mg Si] 6063 [Al Mg0.7 Si] 6005A [Al Si Mg(A)]* 6082 [Al Si 1Mg Mn]* 6061 [Al Mg1 SiCu]*

	23.2	Al-Zn-Mg alloys	7075 [AlZn6Mg Cu1.5]*
24	**Aluminium-silicon alloys containing Cu ≤ 1 %**		
	24.2	Al-Si-Mg alloys containing Cu ≤ 1 % and 5 % < Si ≤ 15 % and 0.1% < Mg ≤ 0.8 %	42100 [Al Si7 Mg0.3] 42200 [Al Si7 Mg0.6] 43100 [Al Si10 Mg(b)] 44100 [Al Si12(b)]

Note: * Marks shipbuilding aluminium alloys covered by the classification of Section 5, Part XIII "Materials".

Shipbuilding aluminium alloys, to which the requirements of the Section apply, are classified by grades in accordance with Tables 5.1.2, 5.1.3-1, 5.1.3-2 and 5.1.3-3 Part XIII "Materials". In this case, in the approval of welding procedures, aluminium alloys are additionally grouped according to Table 7.2.2.

In the approval of welding procedures, the symbols of welding positions comply with ISO 6947.

The symbols relating to the type of a welded joint and to the technological peculiarities of its making comply with Fig. 7.2.2.

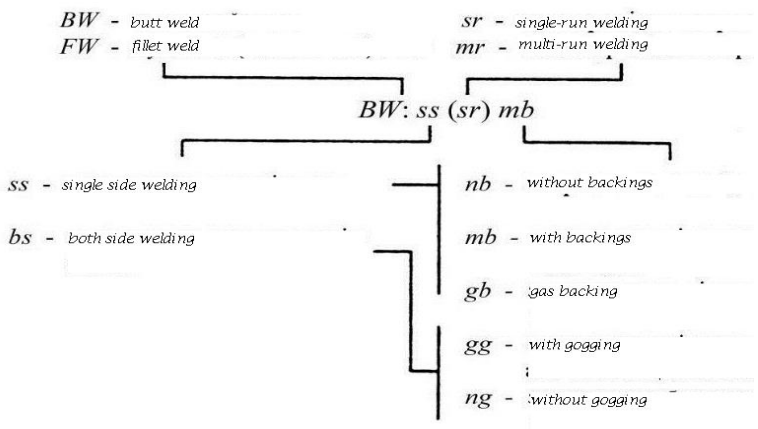


Fig. 7.2.2 Welding Type and Conditions Coding Scheme

7.3 WELDED TEST ASSEMBLIES TYPES AND TEST METHODS

7.3.1 General requirements for test assemblies' preparation.

7.3.1.1 The structural elements of bevelling, weld dimensions and the technological features of welding operation shall comply with pWPS for the welding procedure to be approved regarding the range of approval. In testing, the most adverse versions of bevelling and fit-up to ensure the quality of welded joints shall be checked.

Note: In order to fulfil this requirement, the Register may demand the extension of a test program (for example, the welding of two test assemblies instead of one for the lower and upper boundaries of the allowance for a root gap, variation in thickness, root faces etc.).

7.3.1.2 The welding of test assemblies during tests shall be made with the use of equipment similar to that used in production conditions.

7.3.1.3 The cleaning of components before welding and their fit-up shall be carried out like the procedure used in the product manufacture and specified in pWPS.

7.3.1.4 Where assembly tack welds are the part of structure welds, they shall be included into the test assembly part to be tested.

7.3.1.5 The procedure parameters and welding conditions shall meet the pWPS requirements. In this case, the requirements for the heating temperature, inter-run temperature and for the parameters of welded joints heat treatment/ageing, if any, shall be followed.

7.3.1.6 The dimensions of test assemblies shall assure the obtaining of reliable data on the stability of a welding procedure, and also to take into account the conditions of heat distribution during welding in an actual structure.

7.3.1.7 The thickness of the base metal, the external diameter of pipes joined and also the design thickness of a fillet weld shall be within the range of nominal values of these parameters during welded structures manufacturing, and also to meet the requirements for the range of approval.

7.3.1.8 For the welding of test assemblies, the welding wire (sticks) of the maximum diameter specified in pWPS or, by an agreement with the Register, by one standard size less, shall be used.

7.3.2 Test assemblies' types and test methods.

7.3.2.1 For the approval of welding procedures for butt joints of plates and other types of semi-finished products, the butt joint test assembly, which complies with the directions of Fig. 7.3.2.1 with regard to the requirements of 7.3.1.7, shall be used.

After welding, the test assembly shall be tested in the scope of the Table 7.3.2.1 requirements. The diagram of test specimens' cutting-out from the test assembly of the butt joint of plates for conducting mechanical tests shall comply with Fig. 7.3.2.1.

7.3.2.2 For the approval of welding procedures for the butt joints of assemblies made of aluminium alloys, the test assembly dimensioned according to Fig. 7.3.2.2, ***a***, with regard to the requirements of 7.3.1.7 shall be applied. After welding, the test assembly shall be tested in the scope of the Table 7.3.2.1 requirements.

The diagram of test specimens cutting-out from the test assembly of butt pipe joint for mechanical tests performance shall comply with Fig. 7.3.2.2, ***b***. Where the test assembly dimensions are inadequate to machine the quantity of test specimens needed, two or more test assemblies shall be welded and tested.

7.3.2.3 For the approval of welding procedures for corner and tee-joints of plates and semi-finished products, the tee-test assembly dimensioned according to Fig. 7.3.2.3 with regard to the requirements of 7.3.1.7 may be used.

In accordance with WPS, the tee-joint test assembly may be fabricated:

without bevelling (fillet welding),

with bevelling (with a full or partial joint penetration).

The application of tee-joint test assembly for plates is mandatory in the following cases:

for the approval of an automatic welding of bevelled tee-joints;

for the approval of a welding procedure with a single-run fillet weld without bevelling.

In other cases, the welding procedure approval for the corner and tee-joints of plates and semi-finished products may be carried out within the range of approval according to the directions of Table 7.5.3.3.

After welding, the tee-test assembly shall be tested according to the requirements of Table 7.3.2.3.

The diagram of test specimens' cutting-out from the tee-joint test assembly shall comply with Fig. 7.3.2.3. In so doing, when the tests for the approval of welding procedures for a manual and semi-automatic welding are conducted, at least one operation "stop/restart" shall be made on the test length of a test assembly. The position of that operation shall be marked and subject to a thorough check by non-destructive testing with the follow-up machining and inspection of one macro-section.

7.3.2.4 Pipe joint test assembly.

7.3.2.4.1 The approval of welding procedures for pipe joints with a fillet weld and also for pipes joint assemblies shall be carried out on the basis of the tests of the test assembly corresponding to Fig. 7.3.2.4.1 with regard to the requirements of 7.3.1.7. The angle α between pipes axes shall comply with the minimum value accepted in manufacturing practice.

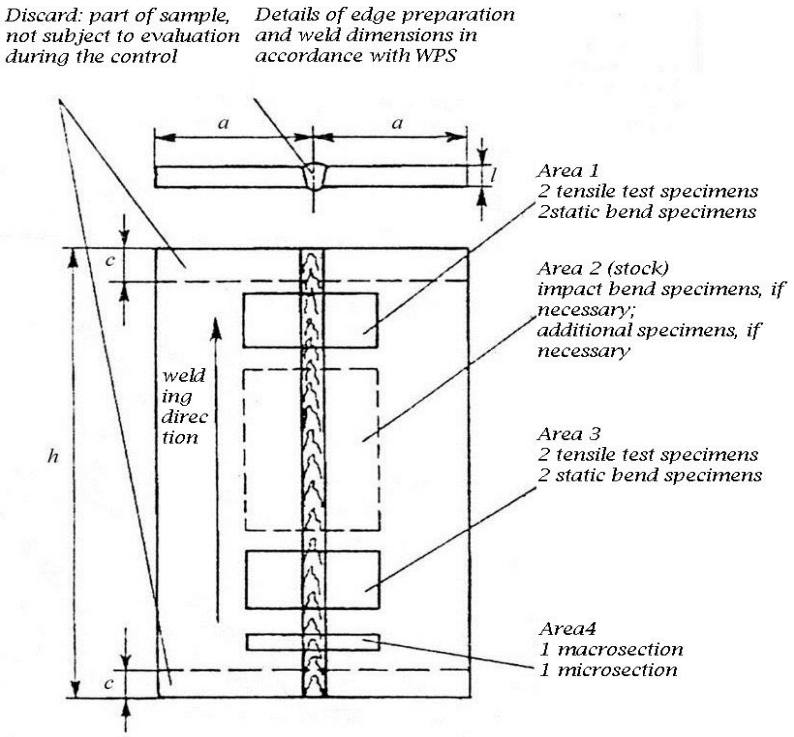


Fig. 7.3.2.1 Test assembly of welded butt joint and the diagram of test specimens' cutting-out:

for manual and semi-automatic welding with dimensions:

$a \geq 150$ mm, but not less than $3t$; $b \geq 350$ mm, but not less than $6t$; $c \approx 25$ mm; for automatic welding with dimensions:

$a \geq 200$ mm; $b \geq 1{,}000$ mm; $c \approx 50$ mm.

Table 7.3.2.1

Examination and testing type	Examination and testing extent	Notes
Visual and measurement testing	100 % weld length	–
Radiographic or ultrasonic testing	100 % weld length	For welded joints having thickness $t < 12$ mm, the radiographic testing shall be used, and for $t \geq 12$ mm it is allowed, by an agreement with the Register, to change the radiographic testing for the ultrasonic one
Penetrant testing	100 % weld length	–

Transverse tensile test of flat specimens	4 specimens	Tests are conducted on 2 tensile test specimens with weld reinforcement removed and on 2 test specimens with the reinforcement complying with the national standard requirements
Transverse static bend test of test specimens	4 specimens	For welded joints having thickness $t < 12$ mm, 2 test specimens each with weld root and surface tension shall be tested, and for $t \geq 12$ mm the test for side bend is conducted on 4 test specimens
Check of macrosections	1 transverse macrosection	–
Microsection examination	1 transverse microsection	–

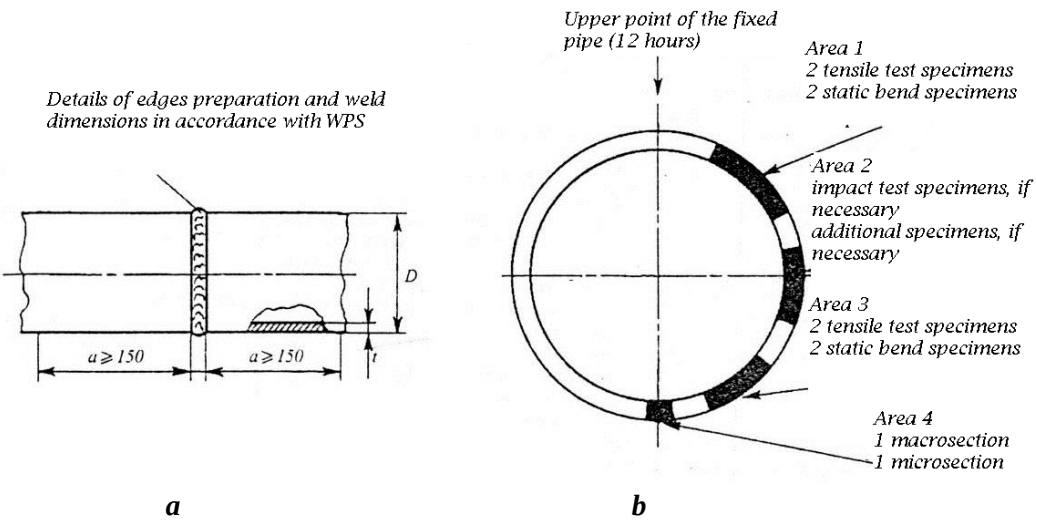


Fig. 7.3.2.2 Test assembly of butt pipe joint: ***а*** — test assembly dimensions; ***б*** — diagram of test specimens cutting-out

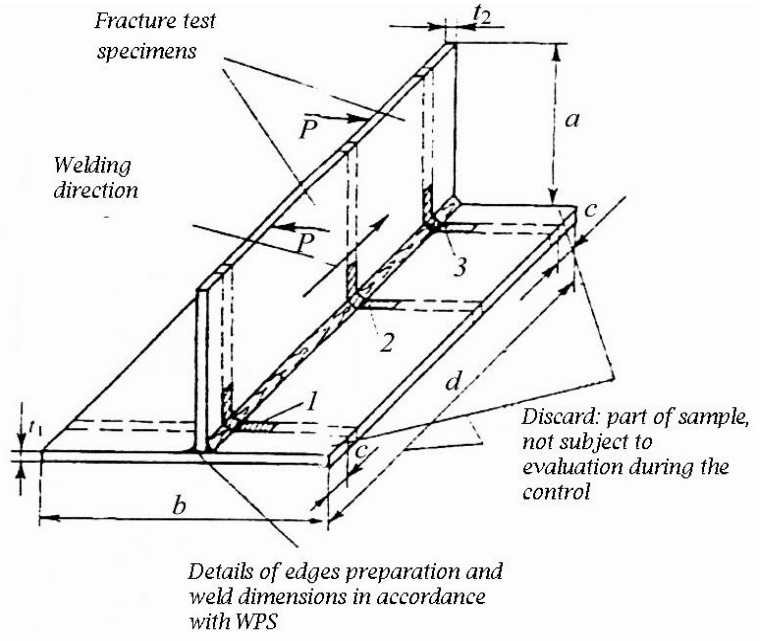


Fig. 7.3.2.3 Test assembly of tee-welded joint and the diagram of test specimens' cutting-out:

for manual and semi-automatic welding with dimensions: $b \geq 150$ mm, but not less than $6t_1$ for joints without bevelling; $b \geq 350$ mm, but not less than $6t_1$ for joints with bevelling; $c \approx 25$ mm; $a \geq 150$ mm, but not less than $3t_2$; $d \geq 350$ mm, but not less than $6t$ (macrosection sampling is made in Zones 2 and 3, microsection sampling — in Zone 3);

for automatic welding with dimensions: $a \geq 150$ mm, but not less than $3t_2$; $b \geq 350$ mm, but not less than $6t_1$; $d \geq 1{,}000$ mm; $c \approx 50$ mm (macrosection sampling is made in Zones 1, 2 and 3, microsection sampling — in Zone 3).

Table 7.3.2.3

Examination and testing type	Examination and testing extent	Notes
Visual and measurement testing	100 % weld length	–
Radiographic or ultrasonic testing	100 % weld length	Radiographic and ultrasonic testing are used for welded joints with full penetration only
Penetrant testing	100 % weld length	–
Check of macrosections	2 (3) specimens	One macrosection for a manual and semi automatic welding shall be machined in the place, which is appropriate for the "stop-restart" operation. Three macrosections are machined from the test assemblies fabricated with an automatic welding.
Microsection examination	1 test specimen	–
Fracture test	2 specimens (≥ 120 mm)	Fracture test is used only for joints without bevelling made with a single-run fillet weld

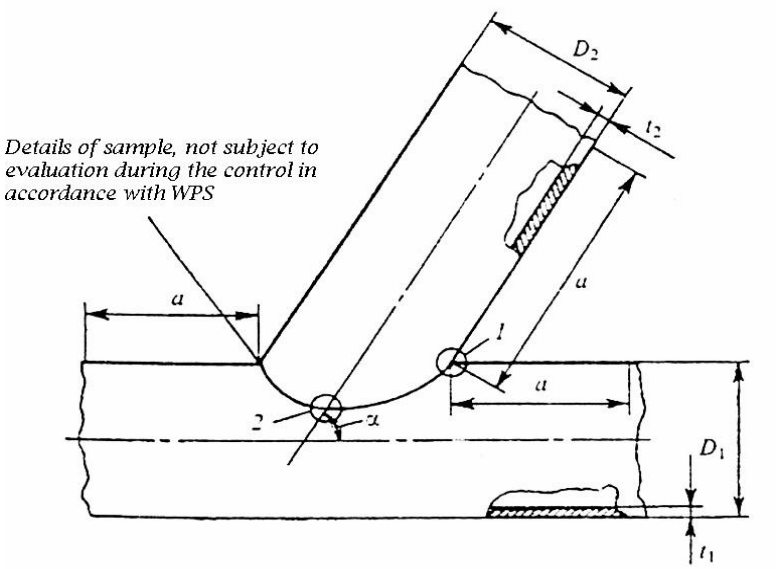


Fig. 7.3.2.4.1 Test assembly of pipes joint made with a fillet weld and the diagram of test specimens cutting-out:
1 and 2 — places of macrosections sampling; 1 — place of microsection sampling; $a \geq 150$ mm

In accordance with the details of bevelling for welding and with the thickness of a pipe to be welded on, the test assembly complying with Fig. 7.3.2.4.1 may be fabricated:

without bevelling in the qualification of welding procedures for fillet welding,

with bevelling ensuring the full or partial penetration.

Depending upon the actual manufacturing practice specified in pWPS, the pipes joint test assembly may be fabricated in the following structural modifications:

as a welded-on element (not communicating with a main pipe);

as a through welded-on element (communicating with a main pipe);

as a straightway welded-on element (through a main pipe).

7.3.2.4.2 The use of a pipes joint test assembly with bevelling is mandatory while conducting tests for the approval of:

welding procedures for a manual and semi-automatic welding within the range of the diameter $168.3 \leq D_2 \leq 500$ mm of a pipe to be welded on, with its wall thickness $t_2 \geq 12$ mm (refer to Fig. 7.3.2.4.1);

welding procedures for an automatic welding including robotised systems.

In this case, the following instructions shall be followed:

for a manual and semi-automatic welding, the main pipe axis shall be oriented vertically what is sufficient for the approval of all other pipe axis positions in manufacturing practice;

for an automatic welding and robotised systems, the orientation of the main pipe axis shall comply with the actual conditions of welded joints fabrication; the range of approval for the main pipe

axis orientation is limited by the angles of ±30° from the nominal axis position.

In all the other cases, applying the approval of the results of butt joint welding tests (if any), the welding procedures for pipes joint assemblies or for welding pipes in a plane bulkhead with bevelling of joined components may be approved.

7.3.2.4.3 The use of a pipes joint test assembly without bevelling is mandatory while conducting tests for the approval of:

welding procedures for an automatic welding including robotised systems;

welding procedures ensuring the deep root penetration, which is taken into account in the effective throat thickness of a fillet weld;

welding procedures providing for welding by the "vertical-downward" method i.e. in the PG or J-LO 45 position.

The requirements for the main pipe axis orientation during tests are similar to the requirements of 7.3.2.4.2.

In all the other cases, on the basis of tests (if any) of butt pipe joint test assemblies according to 7.5.3.3, the approval procedure for fillet welding procedures for pipe joints without bevelling is permitted.

7.3.2.4.4 After welding, a pipe joint test assembly shall be checked according to Table 7.3.2.4.4.

The diagram for the cutting-out of test specimens for tests from a test assembly shall comply with Fig. 7.3.2.4.1.

Table 7.3.2.4.4

Examination type	Examination and testing extent	Notes
Visual and measurement testing	100 % weld length	–
Ultrasonic testing	100 % weld length	Used for welded joints with full penetration only
Penetrant testing	100 % weld length	–
Check of macrosections	2 transverse macrosections	–
Microsection examination	1 transverse microsection	–

7.4 REQUIREMENTS FOR TEST ASSEMBLIES EXAMINATION, TEST SPECIMENS PREPARATION AND TEST RESULTS EVALUATION

7.4.1 General provisions for examination and tests performance.

7.4.1.1 After welding each test assembly shall be tested in the scope of requirements of 7.3. In this case, during welded joints examination, test specimens preparation, tests performance and also in the assessment of the results obtained, the requirements given below shall be followed.

7.4.1.2 All non-destructive testing and examination of welded joints test assemblies shall be carried out after heat treatment (if specified in pWPS), and the

test assemblies from hardenable by heat treatment alloys of the group 23 (refer to Table 7.2.2) shall be subjected to natural or artificial ageing prior to cutting out test specimens for tests.

7.4.1.3 The results of non-destructive quality control of test assemblies for all welding processes shall comply with applicable requirements of technical documentation approved by the Register for the receipt of specific product types, for which the approval process is carried out. In this case, general requirements specified in Section 3 in respect of control and evaluation of control results shall be complied with.

7.4.1.4 The examination and tests of welded joints test assemblies shall be performed in the following sequence:

.1 visual testing;

.2 penetrant testing (penetrant testing is preferable);

.3 radiographic or ultrasonic testing if specified for the joint type concerned;

.4 marking-out of test assemblies and sampling for destructive tests. In doing so, the sampling is permitted from the welded joint zones, in which no defects were identified according to the non-destructive testing results;

.5 test specimens manufacture and non-destructive testing performance, and sections examination as well;

.6 assessment of the obtained results in terms of the provisions in 7.4.1.5 to 7.4.1.10.

7.4.1.5 Where the results of the welded test assembly visual or non-destructive testing are unsatisfactory, one additional test assembly for re-testing shall be welded. If the additional test assembly is rejected due to the same reasons as the first one, the given welding procedure is considered to be unfit for use in production without the modifications ensuring the appropriate quality of welded joints.

7.4.1.6 If the results of tensile or bend test specimens testing fail to comply with the set requirements on reasons not caused by the presence of welding imperfections in the test specimens, the re-test on the doubled number of test specimens shall be conducted. The test specimens for re-testing are taken from the same test assembly, if there is sufficient metal, or from a new test assembly additionally welded.

7.4.1.7 If the results of impact test specimens testing tail to comply with the set requirements on reasons not caused by the presence of imperfections in the test specimens, the re-test of one additional set of three test specimens shall be conducted. Sampling for additional tests is carried out similarly to the requirements of 7.4.1.6.

7.4.1.8 If any test specimen has not satisfied a test only due to an improper weld profile or to the presence of surface defects, crater cracks inclusive, two additional test specimens for each one that failed shall be machined for re-testing. Sampling for re-testing is carried out similarly to the requirements of 7.4.1.6.

7.4.1.9 If any test specimen has not satisfied a test due to the presence of permissible slag, gas or non-metallic inclusions, one additional test specimen shall be machined for re-testing. Sampling is carried out similarly to the requirements of 7.4.1.6.

7.4.1.10 The results of re-testing are accepted as final. Where the results obtained in re-testing are unsatisfactory if only on one test specimen, the welding

procedure, in accordance with the requirements of 7.4.1.6 to 7.4.1.9, is considered to be unfit for use until the modifications ensuring the appropriate quality of welded joints metal are made.

7.4.2 Requirements for test assemblies examination, test specimens machining and test results assessment criteria for butt joints.

7.4.2.1 In order to determine the properties of welded butt joints, the following test specimens shall be used:

tensile test specimens according to Fig. 4.2.3.2.2 with the reinforcement relieved or with the weld reinforcement according to the requirements of national standards;

specimens for the static bend test of the weld surface and root according to Fig. 2.2.5.1, Part XIII "Materials" and 4.2.3.2.3 of the present Part;

specimens for the static bend test of the weld side surface according to Fig. 2.2.5.1, Part XIII "Materials" and 4.2.3.2.3 of the present Part;

macrosections prepared and etched on one side to clearly reveal the base metal, fusion line, heat-affected zone and the weld including the build-up of runs;

microsection prepared and etched on one side to include the heat-affected zone, fusion line and weld metal into the work area.

7.4.2.2 The test results of tensile and static bend test specimens shall meet the requirements of Table 7.4.2.2.

The transverse macrosections shall be free from prohibitive defects. The defects close to a weld including 10 mm of the base metal outside of the heat- affected zone shall be taken into account.

In macrosections examination, it shall also be checked the compliance of the priority and sequence of weld runs performance with the pWPS requirements.

The analysis of welded joints microstructure is carried out according to the program agreed with the Register in each particular case. In microsections examination, it shall be confirmed the absence in the welded joint metal of zones containing components or admixtures, which are potentially dangerous in terms of efficiency, and static strength of the welded joint (brittle interlayers, inclusion segregations etc.).

Table 7.4.2.2

Base metal		Grade of welding consumable	Properties of welded joints (at least)		
Grade	Temper condition		Tensile strength	Static bend[1]	
			R_m, MPa	Ratio d/t_s[2]	Angle of bending, deg.
International alloys					
5754	O, F, H111, H24	RA/WA	190	4	180
5086	O, F, H111, H116, H32, H34	RB/WB	240	6	180
5083	O, F, H116, H321	RC/WC	270	6	180

5383, 5456	O, H111, H116, H321	RC/WC	290	6	180
5059	O, H111, H116, H321	RC/WC	330	6	180
6005A	T5, T6	RD/WD	165	7	180
6061	T4	RD/WD	165	6	180
	T5, T6	RD/WD	165	7	180
6082	T4	RD/WD	170	6	180
	T5, T6	RD/WD	170	7	180
National alloys					
1530	O, H111, H112				
	$t_s \leq 12.5$ mm	R1/W1	185	4	180
	$t_s > 12.5$ mm		165	4	180
1550	O, H111, H112	R2/W2			
	$t_s \leq 12.5$ mm		275	6	180
	$t_s > 12.5$ mm		255	6	180
1561	O, H111, H112	R3/W3	305	6	180
1561H	H32, H321	R3/W3	305	6	180
1575	O, H111, H112	R4/W4	360	6	180
[AlSi1MgMn]	T5, T6	R5/W5	165	7	180

[1] At assessment of the test results the following shall be taken into consideration:
after the specimen bending through the required angle, no defects more than 3 mm in length shall appear on its surface;
defects on the specimen edges may be neglected if they were not caused by poor fusion.

[2] d — diameter of punch or inner roller, mm;
t — bend test specimen thickness, mm.

7.4.3 Requirements for test assemblies examination, test specimens machining and test results assessment criteria for fillet and tee-joints.

Sampling of macro- and microsections from welded joint test assemblies complying with Figs 7.3.2.3 and 7.3.2.4.1 shall be carried out similarly to the requirements of 7.4.2.1. Static fracture test specimens from a tee-joint test assembly shall be sampled and tested according to the 4.2.5. In this case, both fillet welds of the total length of at least 200 mm on the opposite sides of the joint shall be tested.

The analysis of macrosections and welds fracture surface shall confirm the absence of prohibitive internal defects including the lack of root penetration (decrease of effective throat thickness with the irregular form of base metal fusion).

Insignificant defects like pores and slag inclusions may be permitted if their relative area does not exceed 1 % of the controlled weld section.

7.5 RANGE OF APPROVAL FOR WELDING PROCEDURE BASED ON QUALIFICATION TEST RESULTS

7.5.1 General.

Specifying the range of approval for a welding procedure, the requirements given below shall be met. Changes intro-

duced into a WPS by a manufacturer, and which are outside of the ranges specified shall require a new welding procedure test.

The approval of a welding procedure by the Register obtained by a shipyard or welded structures manufacturer is valid for welding in all workshops or sites of that shipyard/manufacturer under the same technical and quality control of the manufacturer.

7.5.2 Base metal-related requirements on range of approval.

7.5.2.1 Tests carried out on the aluminium alloy of one of the groups in Table 7.2.2 qualify the welding procedure for the other alloys of the same group with equal or lower tensile strength, which are part of a welded joint, according to Table 7.4.2.2.

For shipbuilding alloys, the range of approval of a welding procedure by the grades of base metal is identical to that for welding consumables according to the requirements of Tables 4.7.1.2-1 and 4.7.1.2-2.

Approval therewith also covers all the combinations of alloy grades within the range of approval.

7.5.2.2 Tests for welding procedure approval conducted on test assemblies having the nominal thickness *t* are valid for the thickness range according to Table 7.5.2.2.

The determination of the nominal thickness *t* for different joint types shall be carried out in accordance with the following requirements:

for butt joints, t is the thickness of the thinner material;

for fillet joints without bevelling, t is the thickness of the thicker material;

for tee-joints of bevelled plates, t is the thickness of a bevelled component (welded-on element);

for fillet joints with bevelling, t is the thickness of the thinner material;

Table 7.5.2.2

Thickness of test assembly in qualification tests *t*, mm	Range of approval by base metal thickness	
	Single- and two-run procedure	Multi-run procedure
$t \leq 3$	From 0.8*t* to 1.1*t*	From *t* to 2*t*
$3 < t \leq 12$	From 0.8*t* to 1.1*t*	From 3 mm to 2*t*
$12 < t \leq 100$	From 0.8*t* to 1.1*t*	From 0.5*t* to 2*t*, (max 150 mm)
$t > 100$	–	From 0.5*t* to 1.5*t*

Note: If the WPS is provides for the use of a combination of two or more welding procedures/processes, the thickness of the welds that was registered during the tests and that is made by each of procedure/process can be used as the basis when determining the range of approval for a par- ticular welding procedure/process.

for joint assemblies of pipes like the "blind" welded-on adaptors, t is the welded-on element wall thickness;

for joint assemblies of pipes in the form of a through or straight-run welded-on element, t is the thickness of a main pipe or plate.

7.5.2.3 Depending on the fillet weld thickness *a* of tested assemblies (refer to 1.7.5.1, Part II "Hull"), the welding procedure approval covers welded joints with design throat thickness of fillet welds from 0.75*a* to 1.5*a* inclusive. In so doing, the tests on assemblies with the fillet weld thickness $a \geq 10$ mm qualify for welded joints with design throat thicknesses of fillet welds from 10 mm and over.

For the fillet welds made in a vertical downward position (position PG), the range of approval covers the fillet weld design throat thicknesses from 0.75*a* to 1.1*a* inclusive.

For fillet welds, in parallel with the standardisation of the range of approval by the *a* value, the restrictions on the range of approval for the base metal thickness and external pipe diameter are also applied.

7.5.2.4 The range of approval as to the external diameter of welded pipes or branch pipes of joint assemblies shall be specified in relation to the external pipes diameter during approval tests according to Table 7.5.2.4.

7.5.2.5 In tests for welding procedures approval which are associated with the welding of pipe joint assemblies, the range of approval as to the angle α_1 between the axes of pipes to be joined shall be specified in relation to the angle α during the tests proceeding from the condition $\alpha \le \alpha_1 \le 90°$.

Table 7.5.2.4

Diameter of test assembly *D*, mm[1, 2]	Range of approval
$D \le 168.3$	From 0.5*D* to 2.0*D*
$D > 168.3$	$\ge 0.5D$ and plates[3]

[1] *D* — the outside diameter of the pipe.

[2] Approval for welding of plates can also be extended to welding of pipes with $D \ge 500$ mm subject to compliance of other requirements for the range of approval.

[3] Refer also to 7.5.3.3.

7.5.3 Range of approval requirements relating to the welding process.

7.5.3.1 Welding process and type.

The approval of welding type is valid only for the welding process and type used during approval tests.

Where the welding procedure used is the combination of several processes/types (e.g., a consumable electrode automatic welding to fill a groove and a non-consumable electrode manual welding to make a weld root), the approval range is limited by the welding process combination used in approval tests. In this case, the test procedure may be carried out according to either the combined (as the combination on one test assembly) or separate (on separate test assemblies for each process/type) scheme. In this case, the test procedure may be carried out according to either the combined (as the combination on one test assembly) or separate (on separate test assemblies for each process/type) scheme.

7.5.3.2 Welding positions.

The range of approval for the welding positions for manual and semi-automatic welding shall meet the requirements of Tables 7.5.3.2-1 and 7.5.3.2-2.

The automatic welding procedure shall be tested for each of the positions in which it will be used in production.

In case of approval of the automatic welding procedure for butt joints simultaneously for multiple positions, selection and tensile and bend testing of specimens only for the most difficult welding position is allowed in order to reduce the extent of testing.

7.5.3.3 The range of approval for the types of welded joints in relation to the types used in approval tests shall meet the requirements of Tables 7.5.3.3-1 and 7.5.3.3-2.

7.5.3.4 The welding procedure approval is valid for welding consumables of that grade, which passed the tests in the course of approval.

The issue of the approval range extension for the welding consumables of higher grades (which provide the higher indices of welded joint strength) is, in each case, subject to the special consider- ation by the Register.

7.5.3.5 The approval of a welding procedure is valid only for that type of current and polarity, which were used in tests.

7.5.3.6 If the value of linear power consumption during welding is specified in pWPS, the requirements for the approval range of this parameter within ±15 % of the value shown during the approval tests shall be observed.

Table 7.5.3.2-1 **Range of approval for welding procedures according to welding positions for different weld joints (plates)**

Type of weld in welding the test assembly	Weld position[1] of the test assembly	Approved weld positions and weld joints[2]		
		Butt weld	Fillet weld	
			With bevelling	Without bevelling
Butt weld/plate. Assembly according to Fig. 7.3.2.1	PA	PA	PA, PB[3]	–
	PC	PA, PC	PA, PB[3]	–
	PG	PG	PG[3]	–
	PF	PA, PC, PF	PA, PC, PF[3]	–
	PE	PA, PC, PE, PF	PA, PB, PD, PF[3]	–
Fillet weld/plates without bevelling. Assembly according to Fig. 7.3.2.3	PA	–	–	PA
	PB	–	–	PB
	PG	–	–	PG
	PF	–	–	PF
	PD	–	–	PD
Fillet weld/plates with bevelling. Assembly according to Fig. 7.3.2.3	PA	–	PA	–
	PB	–	PA, PB	–
	PG	–	PG	–
	PF	–	PA, PC, PF	–
	PD	–	PA, PB, PD, PF	–
Butt/pipes. Assembly according to Fig. 7.3.2.2	PA	PA	–	–
	PC	PA. PC	–	–
	PG	PG	–	–
	PF	PA, PC, PE, PF	–	–
	H-LO45	PA, PC. PE, PF	–	–
Fillet/pipes. T, Y, K joints for pipes without bevelling. Assembly according to Fig. 7.3.2.4.1	MW and SA welding processes; vertical pipe axis	–	–	All except PG
	Welding process A: pipe axis according to WPS	–	–	–

Fillet/pipes. T, Y, K joints for pipes with bevelling. Assembly according to Fig. 7.3.2.4.1	MW and SA welding processes; vertical pipe axis	All except PG	All except PG	–
	Welding process A: pipe axis according to WPS	–	–	–

End of Table 7.5.3.2-1

[1] Designations of welding positions during tests comply with ISO 6947.

[2] Requirements of this table apply to manual and semi-automatic welding. Automatic welding is covered by 7.5.3.2.

[3] With consideration of additional restrictions established by 7.3.2.3.

Table 7.5.3.2-2 **Range of approval for welding procedures according to welding positions for different weld joints (pipes)**

Type of weld in welding the test assembly	Weld position[1] of the test assembly	Approved weld positions and weld joints[2]		
		Butt weld	Fillet weld	
			With bevelling	Without bevelling
1	2	3	4	5
Butt weld/plate. Assembly according to Fig. 7.3.2.1	PA	PA[4]	PB stationary[4, 3]	–
	PC	PA, PC[4]	PB stationary and PB turning[4, 3]	–
	PG	–	–	–
	PF	–	–	–
	PE	–	–	–
Fillet weld/plates without bevelling. Assembly according to Fig. 7.3.2.3	PA	–	–	–
	PB	–	–	PB[4.3]
	PG	–	–	–
	PF	–	–	–
	PD	–	–	–
Fillet weld/plates with bevelling. Assembly according to Fig. 7.3.2.3	PA	–	PB turning[4, 3]	–
	PB	–	PB stationary and PB turning[4, 3]	–
	PG	–	–	–
	PF	–	–	–
	PD	–	–	–
Butt/pipes. Assembly according to Fig. 7.3.2.2	PA	PA	PB turning[4, 3]	PB turning[3]
	PC	PC	PB stationary and PB turning[4, 3]	PB stationary and PB turning[3]
	PG	PG	PG[3]	PG[3]
	PF	PA, PF, PC	PB, PF, PD[3]	PB, PF, PD[3]
	H-LO45	All except PG	All except PG[3]	All except PG[3]

Fillet/pipes. T, Y, K joints for pipes without bevelling. Assembly according to Fig. 7.3.2.4.1	MW and SA welding processes; vertical pipe axis	–	–	All except PG
	Welding process A: pipe axis according to WPS	–	–	Pipe axis orientation[5]

End of Table 7.5.3.2-2

1	2	3	4	5
Fillet/pipes. T, Y, K joints for pipes with bevelling. Assembly according to Fig. 7.3.2.4.1	MW and SA welding processes; vertical pipe axis	All except PG	All except PG	–
	Welding process A: pipe axis according to WPS	–	Pipe axis orientation[5]	–

[1] Designations of welding positions during tests comply with ISO 6947.

[2] Requirements of this table apply to manual and semi-automatic welding. Automatic welding is covered by 7.5.3.2.

[3] With consideration of additional restrictions established by 7.3.2.4.2 and 7.3.4.3.

[4] Approval is valid only for pipes with outside diameter D > 500 mm.

[5] Pipe axis orientation ±30° from the angle during tests.

7.5.3.7 The minimum preheat temperature for the range of approval of a welding procedure shall be consistent with the nominal temperature of a test assembly before welding during approval tests.

If the preheat is not used in general practice, the range of approval is:

the minimum ambient temperature, at which welding is permitted, and/or

specific conditions when the preheat may be needed (low temperature, the welding of large thickness etc.).

7.5.3.8 If a welding procedure does not provide for an additional heating, the restriction of the range of approval on a maximum inter-run temperature shall comply with an actual inter-run temperature during the welding of a test assembly in approval tests. For welding procedures with an additional heating, the restriction of the range of approval on a minimum inter-run temperature shall comply with an actual inter-run temperature during the welding of a test assembly in approval tests.

7.5.3.9 Post-weld heat treatment or ageing.

The deviation of heat treatment parameters including heat treatable hardening (in the direction of both increase and decrease), from those set during tests for the welding procedure approval is not allowed.

The range of approval shall be limited to the temperature interval used in approval tests.

If provided in WPS, the heating and cooling rate shall be additionally specified in the range of approval, as well as the soaking time of a welded joint at the check temperature.

In so doing, it is not permitted to supersede heat treatable hardening with natural ageing at the room temperature

and vice versa, depending on the WPS requirements.

Table 7.5.3.3-1 **Range of approval by types of welded joints (plates)**

Type of welded test assembly in approval tests			Plates (P)						
			Butt weld joints				T-joints (BW)		Fillet bead welds without bevelling (FW)
			One-sided welding		Both-side welding		One-sided welding	Both-side welding	
			With backings (mb)	Without backing strips (nb)	With gouging (gg)	Without gouging (ng)			
Butt weld on plates (BW)	One-sided welding (ss)	With backings (mb)	*	–	x	x	–	x	x
		Without backing strips (nb)	x	*	x	x	x	x	x
	Both-side welding (bs)	With gouging (gg)	–	–	*	x	x	x	x
		Without gouging (ng)	–	–	–	*	–	x	x
Butt weld on pipes[1] (BW)	One-sided welding (ss)	With backings (mb)	x	–	x	x	–	x	x
		Without backing strips (nb)	x	x	x	x	x	x	x
T-joint of plates with bevelling (BW)	One-sided welding (ss)		–	–	–	–	*	x	x
	Both-side welding (bs)		–	–	–	–	–	*	x
Fillet (gauge) weld (FW)	Plates (P)		–	–	–	–	–	–	*
	Pipes (T)		–	–	–	–	–	–	x

Symbols:

* means types of welded joints, for which WPS is approved directly by test results;

x means types of welded joints, for which WPS may be approved by the range of approval (without additional tests);

– – means types of welded joints, for which WPS are not subject to approval.

[1] For piping joint assemblies with bevelling, the range of approval by joint type shall be set similarly to pipe butt joints.

Note: designations in parentheses correspond to Fig. 7.2.2

Table 7.5.3.3-2 **Range of approval by types of welded joints (pipes)**

Type of welded test assembly in approval tests			Pipes[1] (T)		
			Butt weld joints		Fillet (gauge) weld (FW)
			One-sided welding		
			With backings (mb)	Without backing strips (nb)	
Butt weld on plates (BW)	One-sided welding (ss)	With backings (mb)	–	–	x
		Without backing strips (nb)	–	–	x
	Both-side welding (bs)	With gouging (gg)	–	–	x
		Without gouging (ng)	–	–	x
Butt weld on pipes[1] (BW)	One-sided welding	With backings (mb)	*	–	x
		Without backing strips (nb)	x	*	x
T-joint of plates with bevelling (BW)	One-sided welding (ss)		–	–	x
	Both-side welding (bs)		–	–	x
Fillet (gauge) weld (FW)	Plates (P)		–	–	x
	Pipes (T)		–	–	*

Symbols:

* means types of welded joints, for which WPS is approved directly by test results;

x means types of welded joints, for which WPS may be approved by the range of approval (without additional tests);

– – means types of welded joints, for which WPS are not subject to approval.

[1] For piping joint assemblies with bevelling, the range of approval by joint type shall be set similarly to pipe butt joints.

Note: designations in parentheses correspond to Fig. 7.2.2

7.5.3.10 The range of approval for the welding procedure of consumable electrode inert gas welding (131) shall be limited by:

the group of the standard composition of inert gas (refer to Table 4.7.1.4), which is identical to the group with gas composition used in qualification tests;

the system of welding wire feed, which is identical to the one used in approval tests (single- or multiple-electrode welding).

7.5.3.11 The range of approval for the welding procedure of inert-gas non-consumable (tungsten)-electrode arc welding (141) shall be limited by the group of the shielding gas standard

composition (refer to Table 4.7.1.4), which is identical to that with the gas composition used in approval tests to protect a welding bath and a weld root as well (with backing gas).

7.5.3.12 The range of approval for the welding procedure of plasma arc welding (15) shall be limited by the group of the shielding gas standard composition (refer to Table 4.7.1.4), which is identical to that with the gas composition used in approval tests:

as plasma-forming;

for welding bath protection;

for weld root protection (with backing gas).